On improving service provision through the use of customer-centric semantic service models

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Βελτιώνοντας την παροχή υπηρεσιών χρησιμοποιώντας πελατοκεντρικά σημασιολογικά μοντέλα

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Acknowledgments

To my father, who left early and unexpectedly, for all that he taught me, for all that he gave me…

This Thesis is the result of a long journey, my very own journey to Ithaca. It taught me a lot; foremost to think analytically, to link theory with practice and to appreciate quality even in the detail.

I would have never have completed this journey if it hadn't been for the patience and the moral support of my family and close friends, the guidance of my supervisor Prof. K. Tarabanis and the coaching of Dr. Vassilios Peristeras. I truly and heartily thank all of them.

About me

I was born in Athens, Greece on 27 September 1982. After studying Computer Science (2004) at the Athens University of Economics and Business and completing an MSc in Information Systems (2006) at the same university, I started flirting with the idea of pursuing a PhD. In the same year, I joined the team of Prof. Tarabanis at the Information Systems Lab of the University of Macedonia. Spending my time between Thessaloniki and the Digital Enterprise Research Institute at the National University of Ireland in Galway, I worked on a number of research projects which allowed me to progress on my work, develop my research and analytical skills and learn by working with world-class experts in my field. Since August 2012, I joined PwC Technology Consulting in Brussels, where I am currently working as a senior manager. The transition from research to industry helped me apply my knowledge in real-world problems. My professional experience up to now allowed me to build a solid understanding of problems related to data and service management, with a focus on interoperability. I am an active member of my research field with numerous scientific publications and talks in international conferences.

Find more about me at http://nikosloutas.com and follow me on twitter @nikosloutas.

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Abstract

After World War II the global economy has been gradually dominated by services. The development of the service economy has stimulated great interest in the study of service both from a business and a technological viewpoint.

But what does service mean? This a fundamental question that we answer in this work by studying service from different viewpoints, i.e. that of the provider and – primarily – that of the customer; taking also into account the definition of service in different disciplines, such as marketing, operations management, computer science and information systems. As detailed in our work, the majority of contemporary definitions of service converge on a service being an intangible value-creating activity or complex task provided by a service provider to a customer.

Information and communication technologies (ICT) have revolutionised service provision in the 21st century. In this work, we focus our attention on services whose provision is supported by ICT, e.g. through the use of enterprise information systems or Web-based service oriented architectures. Service Oriented Architecture (SOA) is nowadays the prevalent paradigm for the design, development and implementation of such enterprise information systems. Traditional service industries, such as tourism, health and government, are now able to deliver services more efficiently, through different channels, customised to the diverse needs of customers. As a consequence, an increasing number of services are delivered electronically over the Web in the form of e-services, forming what is generally referred to as the Web of Services.

Service provision has gone a long way. There is no doubt about this. However, we have identified in our work two limitations that pose roadblocks to the realisation of customer-oriented, personalised service provision, especially in the context of the Web of Services: the understated role of the customer and the existence of numerous competing or overlapping, but yet not complete, standards and vocabularies for modelling and representing services.

Although business-related disciplines, such as marketing and operations management, evangelise the importance of involving the customer throughout the service lifecycle, and pay particular attention to the evaluation of services by customers, this co-production interaction has been up to now by and large ignored in the Web of Services. IT-minded professionals in the Web of Services tend to assume that the customer has a passive role, limited to the consumption of the services, and that the description of the service is created exclusively by the service provider, thus missing out on valuable information and insights coming from customers.

To make things even more complex for providers and consumers alike, people's tendency to reinvent the wheel led to numerous overlapping models for describing service, none of which takes input from customers into account. It is hard to agree on a common, technology-independent model to unify the existing ones, and at the same time ensure that such a model will also reflect the customer's perspective. Interestingly, consensus on a common view on service has not been reached, despite the numerous active service standardisation initiatives.

Within this problem formulation, we identified in this *Thesis* two opportunities for realising the promise of customer-oriented, personalised service provision.

1. Unifying the variety of provider-driven, heterogeneous and non-interoperable vocabularies for service.
2. Enhancing service models with concepts expressing the view of the customers (e.g. perceptions, expectations and feedback).

Our goal is to develop a holistic representation of service which engulfs both the service provider's and the customer viewpoints which will effectively allow customers to find, adapt and personalise, integrate and work with services. In this vein, the following objectives drive the research work carried out in the context of this *Thesis*.

Objective I: To study and conceptualise service in order to create a common vocabulary for service – in the form of a Unified Service Model.

Initially, we need to understand and formally model service. Related literature in this field is very rich and we do not want to create yet another model. Our intention was to identify the similarities, the overlaps and the gaps between different service modelling efforts and conclude on a common – all encompassing – representation of service.

We therefore carrried out a cross-disciplinary review of service and studied service in a domain- and technology-independent context. This *Thesis* studies service from both the technical (e.g. computer science) and the business side (e.g. marketing and operations management). We examine service as a value-creating activity and as a transformation, and then investigate technology-enabled services. This way, we develop a holistic view of service and identify the main conceptual elements (e.g. classes, relationships and interactions) of service, both from the provider's and the customer viewpoint. Broadening our literature review beyond computer science and information systems is essential. Other disciplines covered by Service Science, such as marketing, have been discussing customer-oriented service provision for years. It was therefore important to bring these views, perspectives and elements into our modelling work. As a result, this analysis allowed us to define a common representation of service building upon and generalising existing service modelling efforts.

Objective II: To enhance the Unified Service Model in order to accommodate the customer viewpoint, i.e. information related to how the customer relates to service.

In order to incorporate in the Unified Service Model the customer viewpoint, i.e. the way that customer understands and experiences service, we extended the Unified Service Model and revisited its conceptual elements where necessary. We build our understanding of this also by turning to literature on service and the customer's participation in service coming from business-related disciplines, such as management and marketing. Interestingly, the customer viewpoint, which is left out of service modelling approaches in computer science, is very well elaborated in service definitions stemming from business-related disciplines. The role and the participation of the customer in service provision has been studied extensively in these disciplines; for example marketing research has investigated in deep the use of techniques for service evaluation in order to elicit customers' requirements and opinions, and has developed frameworks and methodologies for using these to personalise existing products and/or services, or for developing new ones. Similarly, in business-related disciplines, key concepts such as perceived value and customer expectation have been defined. These existing practices, allows us to transfer knowledge and modelling elements in order to enrich the representation of service in the Web of Services, and bridge the gap between the customers' and the providers' vocabularies.

This common customer-centric and –aware representation of service formally models among others customers' feedback, perceptions and expectations regarding the different elements of service, e.g. quality, outcome, and required input. It therefore allows us to extend existing service descriptions by incorporating the customer-oriented descriptions of services, thus tapping into the rich knowledge about services that emerges directly from the customer.

Objective III: To validate and evaluate the rigor, the usability and the usefulness of the models proposed in the *Thesis* by developing proof-of-concept prototypes that incorporate the Unified Service Model and the customer-oriented modelling elements in order to address the needs and the requirements of a demanding service industry, that of public administration.

In the context of the four prototypes developed in this *Thesis*, we focus on the use of the Unified Service Model and the Customer Service Model and the customer-oriented modelling elements to build richer, machine-readable service descriptions, which contain customer-provided information, such as opinions and feedback. These richer service descriptions facilitate service search, recommendation and personalisation.

As a result, the main theoretical outcomes of this *Thesis* include:

1. **The lifecycle of the service from the customer viewpoint**, which illustrates our understanding of customers' participation in service and presents service provision as experienced by the customer. It comprises 5 phases, namely need realisation; service search; service personalisation; service delivery; and service evaluation.
2. **The Unified Service Model** which puts in place a common vocabulary shared among the different service models and definitions studied in the literature, all of which implicitly approach the modelling of service from the provider viewpoint, i.e. the way that service providers perceive, understand and model service. Consequently, the Unified Service Model expresses the service provider viewpoint of service.
3. **The Customer Service Model**, which constitutes a representation of service from the customer viewpoint. The model emphasises customer participation in service delivery by introducing concepts such as sacrifice, customer expectation, service feedback and perceived value, and organises them according to the Who, Why, What, and Where and When views of the Zachman framework. The Customer Service Model is an extension of the Unified Service Model.
4. **Social descriptions**, as a new service description paradigm, which expresses customer expectations and feedback, and introduces the bottom-up annotation of services, implicitly or explicitly, by the customers, complementing or even replacing (in case they do not exist) the service descriptions created by the providers in a top-down fashion.

These theoretical outcomes were then applied in the context of a four proof-of-concept implementations. We first created a machine-readable representation of the Customer Service Model in RDF and then used it in four proof-of-concept prototypes that address the needs and the requirements of a demanding service industry, that of public administration. More specifically the four prototypes, discussed in the previous section, demonstrate:

- The use of the Unified Service Model and the Customer Service Model for pull and push service search, and service evaluation; and
- The use of the Unified Service Model and the Customer Service Model for service personalisation.

Push service search is improved for two reasons: on the one hand social descriptions of the Customer Service Model allow customers to search for services using their own vocabulary, which is now integrated in the authoritative description of a service; on the other hand the Unified Service Model can harmonise the representation of services, hence services described using different formalisms can be found using a common approach.

Service recommendation (seen also as push service search) is made more accurate as there is a positive correlation between the quality and completeness of the description of a service and the accuracy of recommendations made to the customer. More complete service descriptions, which comprise the customer viewpoint, collected through explicit service evaluation and service mining, match better against the customer's profile and context, hence more relevant services are recommended.

Service personalisation is made more efficient and the appropriate service versions can be identified with less effort from the customer because of the modelling approach that we follow for service versions and service rules, i.e based on a customer dialogue-based approach, which gives priority to the validation of eligibility rules, guarantees that the customer will not have go through the whole service personalisation process if it is not certain that she is eligible for the service. Additionally, it ensures that irrelevant or mutually exclusive service variant rules will not be validated and the respective questions will not be prompted to the customer. Hence, on average, less steps are required for a service to be personalised.

Concluding, the main theoretical implications of this *Thesis* are summarised in the following:

- It contributes to the conceptual modelling of service, diving into customer-centric service modelling, which continues being an open and active research field, and works towards a harmonised view on service, covering both the modelling of service itself and the service lifecycle.
- It is an enabler towards the implementation of the customer-centricity requirement for services, which is prevalent both in the Web of Services and in Service Science, by emphasising and studying customer participation in the service lifecycle, and approaching the modelling of service from the customer viewpoint materialised through the definition of theoretical concepts such as perceived value, customer expectation and service feedback.
- It is one of the few efforts which span across the borders of a particular discipline, e.g. information systems or marketing. It combines fruitfully and brings together two major fields that study service, namely Service Science and the Web of Services, and transfers knowledge from the one to the other.
- By introducing a common model for service, which aligns all existing efforts, it lowers the semantic interoperability barriers and contributes to the semantic interlinking and reusability of existing services which are described using different semantic service models. Apart from benefiting customers and improving service provision in the Web of Services, this last point

can also play a role in encouraging the industrial uptake of semantic services, which up to now remains low.

This *Thesis* opens up a great potential for future research initiatives towards service modelling and standardisation as well as towards the development of service-based applications that will exploit social descriptions of services to realise real-life scenarios, in the following areas:

- Service modelling and standardisation;
- Next-generation service provision and applications;
- Linked services;
- Collection of social descriptions through social media; and
- Management of service portfolios.

Επιτομή

Μετά το 1950, η παροχή υπηρεσιών ξεκίνησε να συμβάλλει σημαντικά στην παγκόσμια οικονομία. Ως αποτέλεσμα, η ανάπτυξη της οικονομίας των υπηρεσιών τόνωσε το ενδιαφέρον για τη μελέτη και τη μοντελοποίηση της *έννοιας της υπηρεσίας* τόσο από επιχειρησιακή όσο και από τεχνολογική άποψη.

Πως ορίζεται όμως η έννοια της υπηρεσίας; Πρόκειται για ένα θεμελιώδες ερώτημα που απαντάται σε αυτή τη διατριβή έχοντας μελετήσει την υπηρεσία από διαφορετικές οπτικές, δηλαδή αυτή του παρόχου και αυτή του πελάτη, λαμβάνοντας παράλληλα υπόψη τον ορισμό της υπηρεσίας σε διάφορους κλάδους, όπως το μάρκετινγκ, το μάνατζμεντ, η επιστήμη των υπολογιστών και τα πληροφοριακά συστήματα. Όπως περιγράφεται στην παρούσα εργασία, η πλειοψηφία των σύγχρονων ορισμών συγκλίνει στο ότι η υπηρεσία είναι μια άυλη δραστηριότητα που δημιουργεί αξία ή σύνθετο έργο και η οποία παρέχεται από έναν πάροχο υπηρεσιών σε έναν πελάτη.

Οι τεχνολογίες πληροφοριών και επικοινωνίας (ΤΠΕ) έφεραν επανάσταση στην παροχή υπηρεσιών. Σε αυτή την εργασία, θα εστιάσουμε την προσοχή μας στις υπηρεσίες των οποίων η παροχή υποστηρίζεται από ΤΠΕ, π.χ. μέσω της χρήσης των πληροφοριακών συστημάτων των επιχειρήσεων ή μέσω του διαδικτύου.

Οι υπηρεσιοστρεφείς αρχιτεκτονικές (Service Oriented Architecture – SOA) είναι σήμερα το κυρίαρχο πρότυπο για το σχεδιασμό, την ανάπτυξη και την εφαρμογή τέτοιων πληροφοριακών συστημάτων. Παραδοσιακοί κλάδοι υπηρεσιών, όπως ο τουρισμός, η υγεία και η δημόσια διοίκηση, είναι πλέον σε θέση να παρέχουν τις υπηρεσίες τους πιο αποτελεσματικά, μέσω διαφόρων διαύλων, προσαρμοσμένων στις ανάγκες των πελατών τους. Κατά συνέπεια, ένας αυξανόμενος αριθμός υπηρεσιών παρέχεται ηλεκτρονικά μέσω του διαδικτύου, διαμορφώνοντας αυτό που αναφέρεται στη βιβλιογραφία ως *διαδίκτυο των υπηρεσιών (Web of Services)*.

Η παροχή υπηρεσιών έχει προχωρήσει αναμφίβολα σε μεγάλο βαθμό. Ωστόσο, εντοπίστηκαν δύο προβλήματα που εμποδίζουν την εξατομικευμένη παροχή υπηρεσιών προσανατολισμένων στον πελάτη, ιδίως στο πλαίσιο του διαδικτύου των υπηρεσιών:

i. Την περιορισμένη συμμετοχή των πελατών, ιδιαίτερα στην μοντελοποίηση και στην περιγραφή των υπηρεσιών, και
ii. Την ύπαρξη πολλών ανταγωνιστικών ή επικαλυπτόμενων προτύπων και μοντέλων για υπηρεσίες, τα οποία εντέλει δεν είναι πλήρη.

Επιστήμες, όπως το μάρκετινγκ και το μάνατζμεντ, ευαγγελίζονται τη σημασία της συμμετοχής του πελάτη καθ' όλη τη διάρκεια του κύκλου ζωής των υπηρεσιών και δίνουν ιδιαίτερη σημασία στην αξιολόγηση αυτών από τους πελάτες. Παρατηρήσαμε όμως ότι οι αρχές αυτές δεν τηρούνται στην παροχή υπηρεσιών στο διαδίκτυο. Οι ερευνητές στο διαδίκτυο των υπηρεσιών υποθέτουν ότι ο πελάτης έχει συνήθως έναν παθητικό ρόλο, που περιορίζεται στην κατανάλωση των υπηρεσιών και όχι απαραίτητα και στο σχεδιασμό τους. Θεωρούν ότι η μοντελοποίηση και η περιγραφή της υπηρεσίας δημιουργείται αποκλειστικά από το πάροχο. Έτσι χάνονται ή δεν εκμεταλλεύονται επαρκώς πολύτιμες πληροφορίες, γνώμες και ανατροφοδότηση που προέρχονται από τους πελάτες.

Παράλληλα, διαφορετικές προσπάθειες προτυποποίησης και μοντελοποίησης των υπηρεσιών δημιούργησαν επικαλυπτόμενα, και συχνά διαφορετικά (μη-διαλειτουργικά), μοντέλα για την περιγραφή τους, κανένα από τα οποία δεν λαμβάνει υπόψη την οπτική των πελατών.

Στόχος της παρούσας εργασίας είναι να αναπτυχθεί ένα ολιστικό μοντέλο δεδομένων για την υπηρεσίας που θα συνδυάζει τόσο την οπτική του παρόχου όσο και αυτή των πελατών. Πιο συγκεκριμένα, οι στόχοι της εργασίας είναι:

I. Να μελετηθεί και να αναλυθεί η έννοια της υπηρεσίας, προκειμένου να δημιουργηθεί ένα κοινό βασικό μοντέλο δεδομένων.

Η πρόθεσή είναι να εντοπιστούν οι ομοιότητες, οι επικαλύψεις και τα κενά μεταξύ των διαφόρων προσπαθειών μοντελοποίησης των υπηρεσιών και να εξαχθεί ένα κοινό μοντέλο δεδομένων. Για τον λόγο αυτό, μελετήθηκε η υπηρεσία τόσο από την τεχνική σκοπιά (πληροφοριακά συστήματα) όσο και από την επιχειρηματική (μάρκετινγκ, μάνατζμεντ…). Εξετάστηκε η υπηρεσία ως μια δραστηριότητα που δημιουργεί αξία και ως ένας μετασχηματισμός (υλικών και άυλων) πόρων που παράγει μια εκροή. Δόθηκε ιδιαίτερη έμφαση στην βιβλιογραφία που προέρχεται από την περιοχή των υπηρεσιών που υποστηρίζονται από ΤΠΕ, όπως τα (διαδικτυακά) πληροφοριακά συστήματα και οι υπηρεσιοστρεφείς αρχιτεκτονικές.

II. Να επεκταθεί το κοινό βασικό μοντέλο δεδομένων, προκειμένου να συμπεριλάβει την μοντελοποίηση της οπτικής του πελάτη για την υπηρεσία, δηλαδή πληροφορίες σχετικά με το πώς ο πελάτης την αντιλαμβάνεται και τη βιώνει.

Είναι ενδιαφέρον ότι η οπτική του πελάτη δεν έχει ενσωματωθεί έως τώρα στα μοντέλα των υπηρεσιών που αναπτύχθηκαν στην περιοχή των πληροφοριακών συστημάτων. Για το λόγο αυτό, στραφήκαμε στο μάρκετινγκ και το μάνατζμεντ προκειμένου να συλλέξουμε πληροφορίες και απαιτήσεις για την οπτική, το ρόλο και τη συμμετοχή των πελατών στην παροχή και την αξιολόγηση των υπηρεσιών. Στις επιστήμες αυτές, ο ρόλος και η συμμετοχή του πελάτη έχει μελετηθεί διεξοδικά. Για παράδειγμα, έχει ερευνηθεί σε βάθος η χρήση τεχνικών για την αξιολόγηση των υπηρεσιών,

προκειμένου να συλλεχθούν οι απαιτήσεις και οι απόψεις των πελατών, και έχουν αναπτυχθεί πλαίσια και μεθοδολογίες για τη χρήση αυτών ώστε να βελτιωθούν υπάρχοντα προϊόντα ή/και υπηρεσίες, ή για αναπτυχθούν νέα. Το αποτέλεσμα αυτής της ανάλυσης είναι η δημιουργία ενός πελατοκεντρικού μοντέλου δεδομένων για την υπηρεσία, το οποίο ενσωματώνει έννοιες σχετικές με τις γνώμες, τις αντιλήψεις, τις προσδοκίες και την ανατροφοδότηση των πελατών αναφορικά με τα διάφορα χαρακτηριστικά της υπηρεσίας, π.χ. ποιότητα, εισροές, εκροές, κόστος… Το μοντέλο αυτό γεφυρώνει το κενό μεταξύ της οπτικής του παρόχου και της οπτικής του πελάτη για την υπηρεσία.

III. Να αξιολογηθεί η πληρότητα, η χρηστικότητα και η χρησιμότητα του προαναφερθέντος μοντέλου υπηρεσιών μέσω την ανάπτυξης πιλοτικών εφαρμογών που το χρησιμοποιούν προκειμένου να ικανοποιήσουν τις απαιτήσεις αναφορικά με την αναζήτηση και την εξατομίκευση υπηρεσιών στην περιοχή εφαρμογής της δημόσιας διοίκησης.

Στο πλαίσιο των τεσσάρων πιλοτικών εφαρμογών που αναπτύχθηκαν σε αυτή την εργασία, εστιάζουμε στη χρήση των μοντέλων προκειμένου να υποστηριχτεί η δημιουργία πλουσιότερων περιγράφων υπηρεσιών, οι οποίες περιέχουν πληροφορίες που προέρχονται τόσο από τους πελάτες όσο και από τους παρόχους. Οι περιγραφές αυτές μπορούν να επεξεργαστούν αυτόματα και να χρησιμοποιηθούν, προκειμένου να βελτιστοποιηθεί η αναζήτηση και η εξατομίκευση των υπηρεσιών.

Τα βασικά θεωρητικά αποτελέσματα αυτής της εργασίας περιλαμβάνουν:

1. **Το μοντέλο του κύκλου ζωής της υπηρεσίας από την οπτική του πελάτη.** Απεικονίζει τη συμμετοχή των πελατών κατά τις διάφορες φάσεις μιας υπηρεσίας. Περιλαμβάνει πέντε φάσεις, ήτοι: συνειδητοποίηση αναγκών, αναζήτηση, εξατομίκευση, παροχή και αξιολόγηση υπηρεσίας.
2. **Το κοινό βασικό μοντέλο δεδομένων για την υπηρεσία** *(Unified Service Model)*. Αποτελεί τον κοινό τόπο μεταξύ ενός πλήθους διαφορετικών αλλά και συχνά επικαλυπτόμενων μοντέλων τα οποία επιχειρούν την αναπαράσταση των υπηρεσιών από τη οπτική του παρόχου.
3. **Το πελατοκεντρικό μοντέλο υπηρεσιών** *(Customer Service Model)*. Αποτελεί μια επέκταση του κοινού βασικού μοντέλου, προκειμένου να συμπεριλάβει την μοντελοποίηση της οπτικής του πελάτη για την υπηρεσία. Το μοντέλο εισάγει έννοιες όπως η θυσία, η προσδοκία του πελάτη, η ανατροφοδότηση και η αντιλαμβανόμενη αξία. Οι έννοιες του μοντέλου μελετώνται και οργανώνονται βάσει των οπτικών του πλαισίου Zachman.
4. **Το παράδειγμα των κοινωνικών περιγραφών υπηρεσιών** *(social descriptions of services)*. Μια νέα έκφανση για την περιγραφή υπηρεσιών προερχόμενη από τον πελάτη. Οι

περιγραφές αυτές εκφράζουν τις προσδοκίες και την ανατροφοδότηση των πελατών, και ενσωματώνουν πληροφορίες από την αξιολόγησή των υπηρεσιών από τους πελάτες. Οι κοινωνικές περιγραφές των υπηρεσιών συμπληρώνουν τις περιγραφές που δημιουργούνται και διατηρούνται από τους παρόχους.

Οι βασικές θεωρητικές συμβολές της εργασίας συνοψίζονται στα εξής:

- Συμβάλλει στην μοντελοποίηση της υπηρεσίας, η οποία εξακολουθεί να αποτελεί ένα ενεργό ερευνητικό πεδίο και ένα απαιτητικό πεδίο εφαρμογής, μέσω της ανάπτυξης ενός ολιστικού, πελατοκεντρικού μοντέλου, καλύπτοντας την μοντελοποίηση τόσο της ίδιας της υπηρεσίας όσο και του κύκλου ζωής της.
- Συμβάλλει στην ικανοποίηση της απαίτησης για πελατοκεντρικές υπηρεσίες, η οποία είναι μια από τις βασικές αρχές που διέπουν το διαδίκτυο των υπηρεσιών.
- Τοποθετημένη στην περιοχή της Επιστήμης των Υπηρεσιών *(Service Science)* συνδυάζει τη μελέτη της υπηρεσίας τόσο από την τεχνική σκοπιά (επιστήμη υπολογιστών) όσο και από την επιχειρηματική (μάρκετινγκ, μάνατζμεντ…), μεταφέροντας έτσι γνώση από το ένα πεδίο στο άλλο.
- Με την εισαγωγή ενός κοινού βασικού μοντέλου για την υπηρεσία, το οποίο καλύπτει όλες τις υφιστάμενες προσπάθειες, μειώνει τα σημασιολογικά εμπόδια διαλειτουργικότητας και συμβάλλει στην σημασιολογική διασύνδεση των υπηρεσιών, καθώς και των υφιστάμενων περιγραφών τους που κατασκευάζονται χρησιμοποιώντας διαφορετικά σημασιολογικά μοντέλα.

Τα αποτελέσματα της παρούσας εργασίας μπορούν να χρησιμοποιηθούν και να επεκταθούν περαιτέρω στα πλαίσια προσπαθειών στις ακόλουθες περιοχές:

- μοντελοποίηση και προτυποποίηση υπηρεσιών,
- διασυνδεδεμένες ηλεκτρονικές υπηρεσίες στα πλαίσια του διαδικτύου των υπηρεσιών,
- αξιολόγηση υπηρεσιών μέσω συλλογής και ανάλυσης περιεχομένου των κοινωνικών δικτύων,
- διαχείριση χαρτοφυλακίων (ηλεκτρονικών) υπηρεσιών,
- υλοποίηση νέων εφαρμογών για την αναζήτηση, εξατομίκευση, αξιολόγηση και σύγκριση υπηρεσιών…

Chapter 1
Problem statement

The aim of marketing is to know and understand the customer so well the product or service fits him and sells itself.
Peter Drucker

1.1 Introduction

Chapter 1 starts with a detailed discussion on the motivation for this *Thesis*, followed by a definition of the problem space (section 1.3). It continues with the definition of the research objectives (section 1.4) and an overview of the research methodology that was followed in order to identify the problems and to design and develop the research outcomes of this *Thesis* (section 1.5). Chapter 1 concludes with a description of the structure of the *Thesis* (section 1.6).

1.2 Motivation

After World War II the global economy has been gradually dominated by services (OECD 2010; Spohrer, Demirkan et al. 2011). Tien and Berg (2003) claim that every country goes through three stages of economic evolution: the mechanical, the electrical and the service stage. All developed countries are currently in the service stage. According to the Organisation for Economic Co-operation and Development (OECD), major post-industrial economies, such as the US and the UK, have become service-driven, and (Vargo and Lusch 2004; Vargo and Lusch 2008) concur that nowadays "all economies are service economies". In April 2015, service industries accounted for about 77% of the UK economy[1]. This transformation of the global economy into a knowledge-based service economy means that all areas of business and community life are now supported and facilitated by services, which in turn are based on and require an increasing amount of human knowledge and intelligence. The rapid growth of the service economy is also significantly boosted by the catalytic impact of information and communications technologies (ICT).

The development of the service economy has stimulated great interest in the study of service both from a business and a technological viewpoint. Once a marginal research domain, the study of service

[1] http://www.markiteconomics.com/Survey/PressRelease.mvc/eea7d1909f424b1183ca33dba0220983

grew extensively in importance and Service Science was born (Chesbrough and Spohrer 2006) (Spohrer, Gregory M. et al. 2010). By definition, Service Science should not be perceived as a basic science, but as a multidisciplinary construct that aims to bring together and integrate a number of disciplines, such as computer science, cognitive science, economics, organisational behaviour, human resources management, marketing and operations research, in order to analyse, model, manage and interpret complex service phenomena.

But what does service mean? This a fundamental question that we answer in this work by studying service from different viewpoints, i.e. that of the provider and – primarily – that of the customer; taking also into account the definition of service in different disciplines, such as marketing, operations management, computer science and information systems. As detailed in chapter 2, the majority of contemporary definitions of service converge on a service being an intangible value-creating activity or complex task provided by a service provider to a customer. Services are knowledge-intensive and require specialised competencies and high levels of education and labour specialisation (OECD 2010) (Spohrer, Demirkan et al. 2011).

Since services are provided and consumed in the context of different social and business structures, e.g. in a family, in a city or in a business/organisation, every individual is essentially both a producer and a consumer of service. For example, we provide service in the form of labour, e.g. consultancy, cooking or house-keeping, either on a mandatory or on a voluntary basis. We consume services, among others, to educate and entertain ourselves, e.g. attending university lecture or watching a movie, to fulfil our everyday needs and live healthy, e.g. dining or receiving medical treatment, to fulfil our obligations towards others, e.g. paying tax, and to take care of ourselves, e.g. getting a haircut or buying clothes.

ICT have revolutionised service provision in the late 20th and 21st centuries. In this work, we focus our attention on services whose provision is supported by ICT, e.g. through the use of enterprise information systems or Web-based service oriented architectures.

ICT enablement has facilitated the way that intra- and inter-enterprise operations are implemented (Spohrer, Demirkan et al. 2011), often leading to reengineering and significant improvement of service operations, but also to the development of new service species, e.g. services that support the online collaboration of professionals and online social networking services. A service is transformed through ICT into a mass commodity and both service providers and consumers benefit from economies of scale.

Service Oriented Architecture (SOA) is the prevalent paradigm for the design, development and implementation of such enterprise information systems. The introduction of Web Services (WS) in the

late 90's contributed significantly to SOA's commercial uptake and boosted the adoption of SOA by the industry (Pizette, Semy et al. 2009). Overall, nowadays service-orientation is the prevalent computing paradigm as everything (i.e. resources, data, software, platform and infrastructure) can be made available "as a service". This is primarily expressed through the massive uptake of Cloud Computing by businesses, governments, researchers and academia (Pallis 2010). In fact, Cloud computing and the rising "as a Service (aaS) paradigm" is at the moment the prevalent expression of servitisation of IT related products, such as hard disk space, computing power and software.

Generally, SOA follows the generic brokerage model proposed by IBM (Gottschalk, Graham et al. 2002; Open Group 2006; OASIS SOA Reference Model TC 2009), which identifies three basic entities: *the Service Provider*, the *Service Client* (termed customer in our work) and the *Service Registry* or *Broker* (Figure 1).

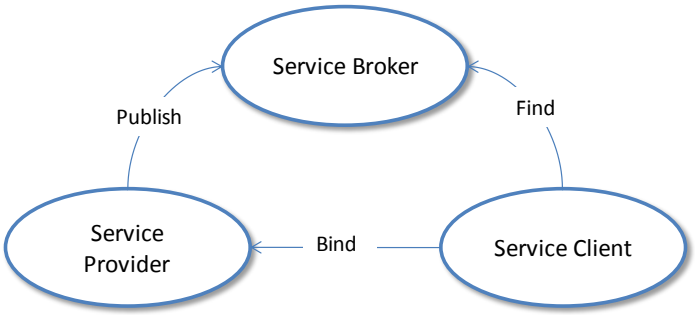

Figure 1: The SOA brokerage model (Gottschalk, Graham et al. 2002; Open Group 2006; OASIS SOA Reference Model TC 2009)

The *Service Provider* is the organisation that develops and provides the service, the service description and offers any technical or business support required.

The *Service Client* (referred to as customer in this *Thesis*) is either a program or application or agent (human or machine) within or outside the enterprise or a human customer that consumes the specific service.

The *Service Registry* or *Broker* is a centralised, searchable directory where service descriptions are published by the *Service Providers* so that they can be easily accessible and findable. *Service Clients* use the *Service Broker* in order to search for service descriptions, which should contain sufficient information for contacting the service provider or binding to the service.

SOA has influenced the business models of service provision and the development of enterprise information systems and has improved their flexibility and adaptability. A significant benefit of SOA is that it enables businesses to be innovative and competitive in their service offerings through the reuse and integration of services and resources (Abrams and Schulte 2008; Malinverno 2008). However, current SOA implementations still face longstanding problems and limitations, related to governance

(Schulte and Abrams 2007; Vinoski 2006; Altman and Thomas Manes 2010) and delivery of benefits to the business (Bhiri, Gaaloul et al. 2008; Altman and Thomas Manes 2010).

In this *Thesis*, we looked into the limitations of SOA that relate to the limited consideration of the participation of customers in service delivery and the discovery and integration of different services. Specifically, the following limitations have been identified in these areas:

- ***The role of customers*** *(Service Clients in SOA terminology)* ***is understated***; although SOAs are supposed to be primarily customer-centric, the opportunities for the customer to participate in service delivery are quite limited, usually restricted to the discovery and use of services, e.g. excluding the customer from actively participating in the delivery of services, as it happens in traditional service industries, such as hospitality and healthcare services where the customer actively contributes to the service experience by providing own resources, input and real-time feedback (Soriano et al., 2008; Chang et al., 2006).
- ***Failure of the SOA brokerage model for publishing and searching for services****;* especially in the case of central Web-based service registers, such as UDDI-based registries for Web services, that never gained broad (Web-scale) acceptance (Michlmayr, Rosenberg et al. 2007; Schroth and Christ 2007; Soriano, Lizcano et al. 2008). Interestingly, the SOA brokerage model was rarely implemented, and in practice service-oriented service provision was reduced to bilateral (point-to-point) agreements and communications between service providers and customers (Michlmayr, Rosenberg et al. 2007).
- ***Limited integration and discovery of different services due numerous competing – yet not expressive enough - service standards***; i.e. the incapability of technical – syntactic - standards, such as WSDL, to express business and domain semantics and the use of competing standards which lead to semantic interoperability problems between different services (McIlraith and Martin 2003; Haller, Gomez et al. 2005; Martin and Domingue 2007; Bhiri, Gaaloul et al. 2008; Natis 2003; Elfanbaum 2009).

Despite being heavily discussed, customer-orientation in SOA is in practice questioned (Chang, He et al. 2006; Soriano, Lizcano et al. 2008). Although the tenth foundational principle of Service-Dominant logic draws a direct line between service-orientation and customer-orientation by saying that a service-centred view is inherently customer-oriented (Vargo and Lusch 2008), this is not practically reflected in SOA.

The customer is limited only to the search, selection and invocation of services, but is usually not actively engaged neither in their design and nor in their description; hence service descriptions in SOAs are created by service providers with no input from the customer. In fact, SOA service descriptions,

i.e. WSDL files, are provider-oriented constructs that ignore completely the customer's perspective of the service. Even though from a business perspective the customer's view is desired, technological efforts seem to ignore it and do not support it in their conceptual models, leaving aside certain opportunities for improved and participatory service provision.

Moreover, WSDL descriptions, being by definition syntactic, cannot incorporate rich service-related information and domain-specific semantics that could be utilised in order to improve the quality of service provision both for the service provider and the consumer (McIlraith and Martin 2003; Haller, Gomez et al. 2005; Martin and Domingue 2007; Bhiri, Gaaloul et al. 2008). For example, (Hobbs, Becha et al. 2008) identify the inability of SOA to define most of the non-functional characteristics of services, e.g. performance, scaling, management, security, privacy, availability and reliability. As a result, SOA service descriptions contain no information regarding the customers' perception of the service and their expectations from it.

Along the same lines, customer feedback on the service is also not accommodated in SOA service description. Omitting the customer's perspective in the description of a service is in fact a paradox, considering that the customer (*Service Client*) is one of the three fundamental entities in the SOA brokerage model.

All inclusive service descriptions play a determinant role in service provision, primarily in the relationship between the service providers and customers. Service descriptions contribute to and leverage service search, composition and bundling (O'Sullivan, Edmond et al. 2002). Service descriptions are cornerstone element of service portfolio management, hence supporting the evolution of services[2]. Service descriptions improve service search by enabling more flexible and personalised methods. They enable customers to compare similar services and select the best matching. Service descriptions make it easier for service providers and customers to compose services for developing new ones and to group services into service bundles. (O'Sullivan, Edmond et al. 2002) claim that service descriptions may be enriched with information coming from the customer and the service context, thus contributing to the evolution of a specific service and potentially leading to the development of new services.

It is remarkable that despite the significant work already conducted towards capturing the customers' needs and translating them into services, e.g. (Akkermans, Baida et al. 2004; Kinderen and Gordijn 2008; ESD Standards 2010), involving the customer in the description of services still remains unexploited.

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[2] http://www.itil-officialsite.com/

In order to create richer and interoperable descriptions of services, the Semantic Web (Berners-Lee, Hendler et al. 2001) community proposed the application of semantics to enhance service descriptions (Martin and Domingue 2007; Martin and Domingue 2007). Semantically-enhanced service descriptions are bound to enable and to facilitate the dynamic discovery, invocation, execution, composition and monitoring of services. This led to the definition of various semantic service frameworks which provide expressive and comprehensive models and technologies for describing services, reviewed in detail in section 2.3.

However almost a decade after their inception, semantic services have still not taken off (Klusch and Zhing 2008). The following problems and limitations prevent them from fulfilling their full potential:

- ***Semantic technologies are complex and have a steep learning curve*** (Korth, Hirsch et al. 2008; Nixon, Hench et al. 2009; Lewis, Smith et al. 2010); (Xuan 2007); (Klusch and Zhing 2008); and
- ***Semantic descriptions of services remain provider-oriented constructs*** (Tsai, Bingman et al. 2006; Kuropka, Troger et al. 2008; AbuJarour and Naumann 2010); thus failing to bridge the gap between the customers' and the providers vocabularies, i.e. the different ways that each expresses, defines and describes service (Fernandez, Hayes et al. 2008).

Existing semantic service frameworks share similar objectives and exhibit many common characteristics, but the expressivity supported, the depth of detail that can be achieved by each of them as well as the technologies that they employ differ (Lara, Roman et al. 2004; Cabral, Domingue et al. 2006). The variety of choices for implementing semantic descriptions results in a variety of heterogeneous semantic services. Heterogeneity lies both in technical and in semantic terms, but technical aspects, such as incompatible protocols and programming languages, are out of the scope of this work. Due to a lack of agreement on a uniform representation of service (discussed in Chapter 2), semantic services cannot be handled in a unique manner and are non-interoperable.

The high complexity of the semantic service frameworks discourages both technical and business people from adopting such solutions (Korth, Hirsch et al. 2008; Nixon, Hench et al. 2009; Lewis, Smith et al. 2010). Consequently, there has been so far no real large-scale application of semantic services in industry (Xuan 2007). (Klusch and Zhing 2008) claim that semantic services have ill-defined semantics and that service ontologies usually describe the semantics of WSDL interfaces, which are different from the semantics of the service. As such existing semantic service approaches, contrary to what they promise, do not yet support automated discovery, matchmaking and composition.

The main limitation of semantic services, when it comes to customer-orientation, is that similar to SOA, they perceive service descriptions as provider-oriented constructs that do not take the

customers' perspective into account (Fernandez, Hayes et al. 2008). They assume again that the customer has a passive role and that the semantic description of the service is the sole responsibility of the service provider (Tsai, Bingman et al. 2006). For example, existing semantic service descriptions do not offer a placeholder to store information related to the reason a customer used a service (e.g. booked a flight), the situational context (e.g. a flight as part of the general "travelling context") or the experience acquired (e.g. in terms of quality of services). Additionally, a vast amount of customer-related information that is produced during the service provision remains unexploited – simply because it is not effectively captured - despite its potential to improve the, usually incomplete, service descriptions (Kuropka, Troger et al. 2008; AbuJarour and Naumann 2010) and consequently increase the value of the service and improve the service provision. Among others, in this work we provide the modelling elements for capturing and representing this information in machine-readable formats.

Not allowing the customers to describe services in their own terms had a direct impact on the efficiency of service discovery. This problem is termed ***service discovery gap*** customer (Fernandez, Hayes et al. 2008), caused by the breakdown between the customer's vocabulary and the provider-oriented service description, i.e. the terminology that providers use for representing services which is often more complex and may also contain vocabulary and jargon that is not understandable by the customer. This mismatch means that the customer may not have a suitable vocabulary to formulate queries to find relevant services, or to put it otherwise the customer may search for services in her own terms which may differ from the vocabulary put forward by the service provider.In case, this boils down to the customer not finding what she needs.

The electronic provision of services is continuously evolving. The Web of Services, an ecosystem of thousands of services, interconnected data, humans and devices, emerged at the point where SOA, the Semantic Web and the Social Web meet (Schroth and Janner 2007; Taylor and Tofts 2008). The Web of Services advocates the active participation of the customer in electronic services through customer-centric portals and applications (Davies, Domingue et al. 2009; Domingue, Fensel et al. 2009). There is no clear line of separation between service providers and customers, as the latter interact on the Web not solely as information receivers, but as content providers as well. The Web of Services capitalises largely on collective intelligence, which contextualised in service provision means that customers' feedback and expectations derive in a bottom-up fashion, directly from the customers, usually in the form of tags, free-text comments and posts on social media, and ratings. This collective intellignence can be formalised and embedded in service descriptions, thus enriching them. Actively involving the customers so as to elicit their needs and to design services that facilitate customer-centric service search, customer-to-service matchmaking and personalisation are among

the open research issues that the Web of Services is dealing with (Davies, Domingue et al. 2009; Domingue, Fensel et al. 2009; and also section 2.3.3).

We observed that in the Web of Services a new service description paradigm emerges, where customers contribute opinions and views on the services that they have used in an ad-hoc and bottom up fashion. Tags and posts on social media are very popular examples of this semantics that source directly from the customers. Unlike top-down defined semantics, coming usually from formal models and ontologies, social semantics, such as tags, social media posts and ratings, have practically no hierarchy, if not processed by means of lexical, semantic and sentiment analysis, and are therefore sparsely linked. We introduce the term *social descriptions* of service to refer to this new type of service-related information contributed directly by the customers.

An increasing number of research efforts argue that SOA should be extended with such social aspects, e.g. (Schroth and Janner 2007; Taylor and Tofts 2008). (Li and Chen 2010) argue that services computing is becoming social; as a result service classification and clustering, service recommendation, services discovery, composition and publishing should now be rethought in this new social context. All these activities relate directly to these new aspects of service description. Providing the constructs for and creating rich annotations as part of the service description that incorporate the customer's perspective is an open research issue. From the Service Science perspective, the development of high-quality, comprehensive service descriptions remains one of the main research challenged to be faced (Song and Chen 2008).

We demonstrate in this *Thesis* that the service discovery gap can be closed by means of social descriptions, namely by enriching the service descriptions using terms coming from the customer. These terms can be derived by analysing customer expectations and feedback on service. We observe that all sorts of services are now marketed and advertised online. Customers discuss online about services that they consume offline, see for example how travellers share feedback and opinions about hospitality services on Tripadvisor. This trend is currently ignored by semantic service modelling efforts. For example, (Sampson and Froehle 2006) argue that customers provide feedback and opinions on a service thus contributing to its evolution, while (Lusch, Vargo et al. 2010) suggest that feedback is one of the three types of interactions in a service system that creates value. It's interesting that semantic service modelling efforts ignore the vast amount of work that has already been produced by marketing and operations management researchers with regards to the importance of customer feedback and customer participation in service provision, and fail to reuse and reapply existing knowledge, techniques and good practices. Then again, works originating in marketing and operation management, usually do not go deep into modelling the customer viewpoint of the service and certainly leave machine-readable service models and respresentations out of scope.

Our work aims to bridge the gap between these two areas of work to create value for service delivery. Collective intelligence, i.e. customers' feedback, expectations and opinions on service, can drive service innovation, results in improved service quality and richer service experiences. It is interesting that the rapid growth of this online service ecosystem has an obvious impact not only on services delivered electronically, but also on services that are provisioned using traditional ways, i.e. physically. Therefore, the work presented in this *Thesis* benefits all types of services alike.

1.3 Problem definition

This *Thesis* focuses on treating the following two roadblocks, which hinder the customer-centric provision of services:

1. ***Unifying the variety of provider-driven, heterogeneous and non-interoperable vocabularies for service***. As discussed earlier (in detail also in Chapter 2), numerous service models exist. People's tendency to reinvent the wheel and the lack of agreement on standards are the main reasons for this. People tend to come up with new terms for representing services, rather than reusing equivalent terms from existing vocabularies. The reluctance to adopt models and vocabularies developed by others, sometimes even standards, can be boiled down either to the potential academic credits or commercial benefits that could derive from a new vocabulary or to the lack of trust in the publishers of existing models and vocabularies (Ayers 2009). All these overlapping models put forward a number of competing vocabularies for describing service, making it is thus hard to agree on a common, technology-independent model to unify the existing ones.
2. ***Enhancing service models with concepts expressing the view of the customers (e.g. perceptions, expectations and feedback)***. There is a need for a number of modelling elements which can express how the service is perceived from the perspective of the customer. To do this, a deep understanding of the service lifecycle as experienced by the customer is needed and the identification of the key activities in this context in which the customer partakes are required, e.g. service search and evaluation. This allows us to model concepts such as perceived value, customer expectation and feedback and their relationship to other key conceptual elements of service.

As discussed previously in this chapter, these two problems have a negative impact on different aspects of service provision, including limited service search, recommendation and service personalisation capabilities.

1.4 Research objectives

The following objectives drive the research work carried out in the context of this *Thesis* and contribute to addressing the two roadblocks discussed in the previous section. Our goal is to develop a holistic representation of service which engulfs both the service provider's and the customer viewpoints which will effectively allow customers to find, adapt and personalise, integrate and work with services.

Objective I: To study and conceptualise service in order to create a common vocabulary for service – in the form of a Unified Service Model.

Initially, we need to understand and formally model service is. Related literature in this field is very rich and we did not want to create yet another model. Our intention is to identify the similarities, the overlaps and the gaps between different service modelling efforts and conclude on a common – all encompassing – representation of service.

We therefore carried out a cross-disciplinary review of service and studied service in a domain- and technology-independent context. This *Thesis* studies service from both the technical (e.g. computer science) and the business side (e.g. marketing and operations management). We examine service as a value-creating activity and as a transformation, and then investigate technology-enabled services. This way, we develop a holistic view of service and identify the main conceptual elements (e.g. classes, relationships and interactions) of service, both from the provider's and the customer viewpoint. Broadening our literature review beyond computer science and information systems is essential. Other disciplines covered by Service Science, such as marketing, have been discussing customer-oriented service provision for years (see section 2.2 for a detailed review). It was therefore important to bring these views, perspectives and elements into our modelling work. As a result, this analysis allowed us to define a common representation of service building upon and generalising existing service modelling efforts.

Objective II: To enhance the Unified Service Model in order to accommodate the customer viewpoint, i.e. information related to how the customer relates to service.

In order to incorporate in the Unified Service Model the customer viewpoint, i.e. the way that customer understands and experiences service, we extended the Unified Service Model and revisited its conceptual elements where necessary. We built our understanding of this also by turning to literature on service and the customer's participation in service coming from business-related disciplines, such as management and marketing. Interestingly, the customer viewpoint, which is left out of service modelling approaches in computer science (see section 2.2 for a detailed review), is very

well elaborated in service definitions stemming from business-related disciplines. The role and the participation of the customer in service provision has been studied extensively in these disciplines; for example marketing research has investigated in deep the use of techniques for service evaluation in order to elicit customers' requirements and opinions, and has developed frameworks and methodologies for using these to personalise existing products and/or services, or for developing new ones. Similarly, in business-related disciplines, key concepts such as perceived value and customer expectation have been defined. These existing practices, allows us to transfer knowledge and modelling elements in order to enrich the representation of service in the Web of Services, and bridge the gap between the customers' and the providers' vocabularies.

This common customer-centric and –aware representation of service formally models among others customers' feedback, perceptions and expectations regarding the different elements of service, e.g. quality, outcome, and required input. It therefore allows us to extend existing service descriptions by incorporating the customer-oriented descriptions of services, thus tapping into the rich knowledge about services that emerges directly from the customer.

Objective III: To validate and evaluate the rigor, the usability and the usefulness of the models proposed in the *Thesis* by developing proof-of-concept prototypes that incorporate the Unified Service Model and the customer-oriented modelling elements in order to address the needs and the requirements of a demanding service industry, that of public administration.

In the context of the four prototypes developed in this *Thesis*, we focus on the use of the Unified Service Model and the Customer Service Model and the customer-oriented modelling elements to build richer, machine-readable service descriptions, which contain customer-provided information, such as opinions and feedback. These richer service descriptions facilitate service search, recommendation and personalisation.

1.5 Research methodology

To ensure the quality of the research work carried out in the context of this *Thesis* as well as the rigor of its results, we draw upon the design science research methodology (Peffers, Tuunanen et al. 2008). The steps of the methodology are defined as follows:

Problem identification and motivation. This step elicits the research problem of this *Thesis* and justifies the value of the proposed solution. Justifying the value of the proposed solution accomplishes two things: it motivates the researcher and the audience of the research to pursue the solution and to accept the results and it helps to understand the reasoning associated with the researcher's

understanding of the problem. Deep knowledge of the state of the problem and of its significance is required for this step. This step is realised in Chapters 1 and 2.

Objectives of the *Thesis*. This step infers the objectives of the proposed solution from the problem definition. The objectives set outline the development of solutions to the problem statement, not hitherto addressed. This step is realised in section 1.4.

Design and development. This step specifies and develops the artifacts of the proposed solution, i.e. models and their instantiations, and specifies the overall architecture that will address the aforementioned objectives. In this vein, we conduct a cross-disciplinary survey on service in order to identify the main conceptual elements, emphasising on customers' perceptions of service, expectations from service, feedback on service. This leads to: *(i)* a common representation of service, i.e. the Unified Service Model, building upon and generalising existing service modelling efforts; and *(ii)* a service model from the customer viewpoint, i.e. the Customer Service Model, which extends the Unified Service Model and revisits conceptual elements where necessary, in order to express how customer's understand service. This step is realised in Chapters 2 to 4.

Demonstration and evaluation. This step demonstrates the use of the developed models to build richer, machine-readable service descriptions, which contain customer-provided information, such as opinions and feedback. These richer service descriptions contribute to closing the service discovery gap and facilitate service search, recommendation and personalisation. It involves the development of four different (but still complementary and interlinked) case studies. This step is realised in Chapter 5.

1.6 Structure

The remainder of this *Thesis* is structured as follows:

Chapter 2 reviews the state of the art in the area of service models and frameworks. The objective of Chapter 2 is to investigate how other researchers have modelled service. It is divided in two major parts:

- Section 2.2 "Service definitions and models" reviews how service is modeled by different disciplines, i.e. operations management, marketing, Service Science, computer science and information systems. The analysis revealed significant overlaps between different modelling efforts and emphasises the lack of formal modelling of the customer viewpoint.
- Section 2.2 "Semantic descriptions of services" studies existing frameworks for creating semantic descriptions of services. We found that existing service descriptions frameworks do

not model aspects of services that emerges from customers' feedback, perceptions and expectations regarding the different elements of the service, e.g. quality, outcome, required input etc.

Chapter 3 studies the service lifecycle from the customer viewpoint and highlights the participation of the customer in the different phases. We define there the main phases of the lifecycle and the main interaction within the lifecycle where customers play the leading role. We conclude the chapter with a number of high-level requirements concerning the modelling of service from the customer viewpoint, which will drive the modelling work of Chapter 4.

Chapter 4 elaborates the customer-centric nature of service provision and models service from the customer viewpoint by studying and modelling the participation of customers throughout the service lifecycle. It is divided in three major parts:

- Section 4.2 "Methodology" describes the model development methodology that we applied for developing the Unified Service Model and the Customer Service Model. We analysed the concepts and relationships in existing service models and grouped the most common ones under semantically related terms.
- Section 4.3 "Core service concepts" introduces a set of reusable concepts and relationships that capture the fundamental characteristics of a service. It comprises a number of concepts which are shared between service models defined in the literature. Effectively, the Unified Service Model expresses the way that service providers understand, model and describe service.
- Section 4.4 "Customer Service Model" introduces a model for service which expresses how the service is perceived from the perspective of the customer, hence modelling the customer viewpoint. The Customer Service Model extends the Unified Service Model by introducing a number of concepts and relationships that express the customer viewpoint.

Chapter 5 presents four research prototypes that focus on how the Unified Service Model and Customer Service Model helps to facilitate push and pull service search, service evaluation and service personalisation. It is organised as follows:

- Section 5.2 "General development themes" presents the foundations of the research prototypes. Hence, section 5.2.1 presents the implementation of the two service models in a single linked open vocabulary, while section 5.2.2 demonstrates the implementation of service feedback in existing semantic service models, in order to bring the customer viewpoint in semantic descriptions of services.

- Section 5.3 “Demonstrating the Unified Service Model and the Customer Service Model for pull and push service search, and service evaluation” starts by showing, in section 5.3.1, how push and pull service search can be implemented using social descriptions of services, focusing on service feedback collected in the form of tags. Service tag clouds are formed and are combined with semantic descriptions of services, in order to compute service similarity which in turn enables pull and push service search.

  Section 5.3.2 introduces “A service portal for customer-centric service delivery: MyPortal.gov” based on the Unified Service Model and the Customer Service Model (focusing on *service input, service outcome, customer, service provider, service feedback, service effect, service rule, legal context, service stakeholder, service bundle* and *service relationships*). MyPortal.gov facilitates the creation of social descriptions of services (see section 4.4.3.10). Hence, citizens can actively participate and contribute to the description of public services using their own terms. Lightweight semantics are used to annotate the public descriptions; thus making them machine-readable. MyPortal.gov facilitates keyword search, tag cloud-based search and visual browsing of the underlying public service description repository. Public service recommendation mechanisms (i.e. push service search) have also been implemented.

  Section 5.3.3 presents the “Semantic Service Search Engine (S3E)” that proposes a uniform interface for finding semantic services in the Web of Services based on service concepts the Unified Service Model and the Customer Service Model, i.e. *service input, service outcome, service provider, service feedback, service bundle* and *service relationships* (defined in Chapter 4). S3E implements a uniform point of access over a set of heterogeneous semantic service descriptions which are homogenised using the Unified Service Model. S3E *(i)* is agnostic to the underlying semantic model used for developing the service description; *(ii)* does not require the service providers to publish their services or their descriptions in a centralised service registry; and *(iii)* exploits the semantic information that exists in semantic service descriptions in order to improve service search. S3E that can be thought of a central point of reference where descriptions about services provided by different organisations from different domains are available, whereas MyPortal.gov corresponds to the portal that a single organisation would use in order to provide information about the services they provide. Service descriptions made available by MyPortal.gov as Linked Data, are crawled by S3E’s crawlers and are then discoverable in S3E.

- Section 5.4 “Demonstrating the Unified Service Model and the Customer Service Model for service personalisation” starts with defining, in section 5.4.1, a customer-dialogue model and an approach for dialogue-based service personalisation.

Section 5.4.2 presents "A semantic, dialogue-based portal for public service personalisation (S-PSP)" which facilitates the personalised provision of public services based on an ontology-driven dialogue that exploits detailed semantic public service descriptions. The public service descriptions of S-PSP are based the Unified Service Model and Customer Service Model, implementing mainly *customer*, *service version, service rules, service input* and *service outcome*. S-PSP *(i)* informs users whether they are eligible for a specific public service; *(ii)* identifies the specific public service version that matches the profile of the user; *(iii)* provides complete and well-structured information for the public service; and *(iv)* allows users to invoke public services that are available online (if a service execution environment is in place) independent of the semantic technology and the Web service protocol used.

Section 5.4.3 introduces "A semantically-enhanced, dialogue-based expert system for public service personalisation" based on the Unified Service Model and the Customer Service Model, implementing mainly *customer*, *service version, service rules, service input* and *service outcome*. Similar to the S-PSP, this research prototype aims to inform citizens whether they are eligible for a specific public service and to identify the specific public service version that matches the profile of the citizen. The main difference between this research prototype and S-PSP lies in the technologies selected for implementing the two prototypes, i.e. an OWL reasoner in the case of S-PSP, versus a hybrid approach combing semantic and expert system technolologies, i.e. ontologies and a Prolog rule engine for supporting the dialogue between the customer and the system.

Finally, Chapter 6 summarises the main results of this *Thesis* and elaborates on its main contributions. Future research directions and open questions emerging from this work are also discussed.

Chapter 2

State of the Art Analysis

Standards are like toothbrushes, a good idea but no one wants to use anyone elses.
Anita Golderba

2.1 Introduction

In the previous chapter, we scoped and defined the problem that this *Thesis* aims to address and outlined the solution. We said that the goal is to develop a holistic representation of service which engulfs both the service provider's and the customer viewpoints. This will effectively allow customers to find more easily on the Web services that fit their needs and profiles, to personalise services and to compose different services into new complex ones. To achieve this, we need to overcome the roadblocks mentioned in section 1.3.

In order to design our solution, we reviewed the state of the art in the area of service models, service systems and service architectures in order to investigate how other researchers and practitioners have approached the modelling of service. Driven by the roadblocks that we are addressing in this work, we organise our literature review in two main parts:

- Section 2.2 studies existing service definitions and models. In this section, we reviewed how service is modeled by different disciplines, i.e. operations management, marketing, Service Science, computer science and information systems. The analysis revealed significant overlaps between different modelling efforts and emphasises the lack of formal modelling of the customer viewpoint; in other words, we found the vast majority of service modelling efforts up to now are provider-driven and not customer-centric.
- Section 2.2 studies existing frameworks for creating semantic descriptions of services. We found that existing service descriptions frameworks do not tap into the rich knowledge about services that emerges from customers' feedback, perceptions and expectations regarding the different elements of the service, e.g. quality, outcome, required input etc. Even if this knowledge is elicited, it cannot currently be incorporated in existing service descriptions, as the respective modeling elements are not available.

2.2 Service definitions and models

Various definitions of service have been given over the past 50 years. Some of them aimed to draw the line between products and services, others tried to establish a holistic, cross-disciplinary, technology-neutral understanding of service and others to define the meaning of service in the context of a specific domain, e.g. government, healthcare, tourism etc..

Most of these definitions, regardless of their origin, converge on a service being an intangible value-creating activity or (complex) task provided by one entity (usually referred to as the service provider) to another entity (usually referred to as the customer). A service requires resources and specialised competencies, and creates value for all the entities involved – i.e. both the service provider and the customer. Services are delivered through systems which vary in terms of complexity and composition. This section discusses efforts that adopt a socio-techno-economic approach for modelling and understanding service.

Different strands of work also converge on the main characteristics of service. For example, (Fitzsimmons and Fitzsimmons 2006) argue that service is intangible and time-perishable, (Kotler and Keller 2006) claim that it is intangible and does not result in ownership and (Hill 1977) states that the approval of the customer is required for the service to be delivered. Apart from these definitions, several studies have tried to identify the basic characteristics of service, e.g. (Berry 1980), (Mills and Moberg 1982), (Edvardsson, Gustafsson et al. 2005) and (Polter, Verheijen et al. 2008). According to the literature, services share the following characteristics: inseparability, heterogeneity, non-standardisation, perishability and ownership. These are explained further in Table 1.

Adding two interesting characteristics particular to our work, (Polter, Verheijen et al. 2008) state that the consumer takes part in the production of the service and that satisfaction is subjective. They thus highlight that usually the service requires some action(s) from the customer-side for it to be delivered. This way the customer contributes to the overall quality of the service. In turn the quality of service is experience differently by different customers depending on their standards and expectations.

Table 1: Service characteristics

Services share 6 fundamental properties:
1. *Intangibility* which refers to the fact that services are activities and not physical objects (unlike goods). Services are mostly intangible as they are not physical objects, rather they are experiences. Services cannot be felt, seen, tasted or touched. Due to their intangibility services cannot be transported, stored or stocked. However, (Crozier and McLean 1997) argue that services may not be entirely intangible; most of them can be positioned in an intangible-dominant (e.g. tourism services) or tangible-dominant continuum (e.g. retail services) to reflect the strength of the relationship between a service and a good.

2. *Inseparability* reflects the fact that services cannot be disconnected from *(i)* their means of production, e.g. tangible and intangible resources, and the service provider, and *(ii)* the customer's experience, which means that the service consumer is (partially) involved in service delivery, e.g. as co-producer or co-creator, and consumes the rendered benefits.
3. *Heterogeneity* or variability which defines that service quality and experience may vary, depending on: *(i)* service providers and service processes that tend to differ; and *(ii)* the production within a given company that is influenced by the variation of the employees, human inconsistencies and the variation in the needs and expectations of the customers.
4. *Non-standardisation* which denotes that due to its heterogeneous nature, service is by definition very difficult to standardise. In this sense, each service is unique and cannot be exactly repeated in the same way, even if the same customer is involved and the same operant resources are assigned. If managed efficiently, the non-standardisation of service has a great potential as this facilitates the desired customisation of a service.
5. *Perishability* which has a dual meaning: *(i)* the operant resources are assigned for service delivery during a definite period in time and if the consumer does not use the service during this period, the resources might not be available afterwards; and *(ii)* a service that has been consumed irreversibly vanishes and cannot be consumed again. The perishability of services implies that selling the service as soon as it is produced becomes is essential for revenue not to be lost and resources not to be wasted.
6. *Ownership* which also has a dual meaning: *(i)* a service cannot be (re)sold or owned by the consumer; and *(ii)* the service consumer does not take ownership of any of the physical elements and the resources involved in the delivery of a specific service.

In order to understand the meaning of service and the different service species, and to explore the participation of customer in service provision, we review the literature originating from business, operations management, marketing, Service Science and computer science. The analysis of the service literature revealed the following strands of definitions and models:

- *service as a set of value-creating activities*, where customers contribute knowledge, information, belongings and skills, and interact with the service provider, thus co-creating value with the service provider (section 2.2.1).
- *service as a transformation in the state of an entity,* e.g. a person, an economic entity (e.g. an organisation) or a resource, meaning for example that the service changes/adds value to/alters the emotional/psychological/health condition of that entity (section 2.2.2).
- *service as a service system,* namely a complex structure that comprises service providers, customers and other agents who collaborate, by exchanging resources, in order to deliver a service (section 2.2.3). Service systems are not orthogonal to the previous two categories. Effectively any service can be delivered via a service system.
- *technology-enabled services* which focus on modelling service in the context of service oriented architectures and information systems (section 2.2.4). Technology-enabled services are not orthogonal to the previous three categories. Effectively service provision in any of the aforementioned categories could be supported by technology.

For each of them, we will examine (wherever possible): *(i)* how services were modeled and described; *(ii)* what was the role of the customer in service provision (throughout the lifecycle of the service); and *(iii)* how were customers' perceptions, expectations and feedback modeled, expressed and collected.

Finally, we observed that services may be further detailed to capture the special characteristics and peculiarities of a specific service industry, e.g. retail, tourism or government. These precising definitions try to reduce the vagueness of the term service by stipulating what is the meaning of service and its peculiarities in the context of a specific service industry. Each of them defines service from their own perspective (see for example, Table 2). However, the detailed analysis of such definitions of service is out of our scope.

Table 2: Domain-specific service definitons - the case of Public Services

Our work is influenced by the work of (Peristeras and Tarabanis 2008) on public service modelling and our results have been applied to the area of public service provision. (Peristeras and Tarabanis 2008) defined a public service as a set of deeds and acts performed by a public administration entity for the benefit of a societal entity (i.e. a citizen or a business) or another public administration entity. They argued that public services fulfil needs of the societal entities and may be mandatory or not.

Public services are intangible, however in most cases the result of the execution of a public service is documented in the form of a physical administrative document. Public services are inseparable from the service provider and the consumer, who is usually involved in the service delivery often with the role of information provider. Public services are governed by laws and directives. This means that the service process, the inputs and outputs, the entities involved and numerous other parameters are specifically defined. As a result, unlike most other service industries, the services offered by public administration have a lower degree of heterogeneity and are easier to standardise. Public services are perishable, cannot be resold or owned by the consumer, i.e. citizen, business or public agency, and the consumer does not take ownership of any of the physical elements and the resources involved in the delivery of the specific service.

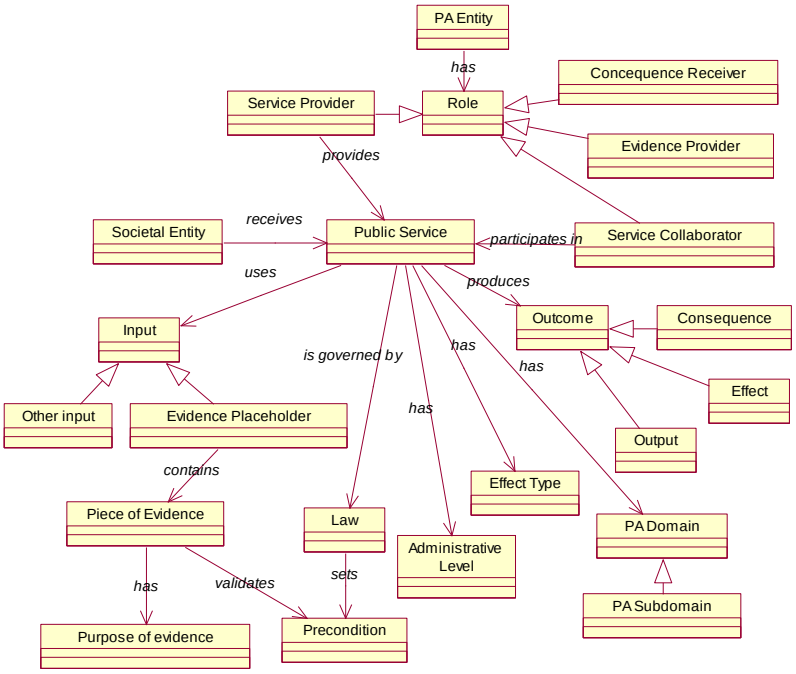

Figure 2: The GEA Public Service Model (Peristeras and Tarabanis 2008)

2.2.1 Service as a set of value-creating activities

This section discusses 19 efforts to define service as a process or a set of activities that creates value and benefits for the customer. The notions of value and benefit as well as the way these are perceived from and expressed by the customer will play a primary role in the service modelling approach introduced by this *Thesis*. In this perspective, concepts and relationships that reveal the way that customers express their perceptions of and expectations from the service will be incorporated in the proposed conceptual service model.

One of the first definitions of a service in this view was developed by the American Marketing Association (AMA). (AMA 1960) defines service as "activities, benefits or satisfactions which are offered for sale, or are provided in connection with the sale of goods". This definition: *(i)* adopts a clear customer-centric position and relates service to customer benefits and satisfaction, and *(ii)* relates products (goods) with services, e .g. after-sales services and customer support, rather than trying to investigate them separately. The study of customer satisfaction and the perception of value delivered by the service to the customer are particularly interesting for our work as both relate directly to customer expectations and feedback.

(Stanton 1981) claimed "services are those separately identifiable, essentially intangible activities which provide want satisfaction and are not necessarily tied to the sale of a product or another service. A service may or may not require the use of tangible goods. However, when such use is required, there is no transfer of title to these tangible goods". This definition starts with an enumeration of some fundamental service characteristics, e.g. intangibility, and similar to AMA's definition, it creates the link between a service and the customer's wants and needs that it satisfies. It also clarifies that a service can have self-value; it is thus not required that all services are related to or dependent on products and/or other services. Finally, it specifies that services may require specific resources (tangible goods), either as input provided by the customer or contributed by the service provider, in order to be delivered.

Murdick et al. (1990) define services as "economic activities that produce time, place, form or physiological utilities". The outcome of the service has in turn value, which could be of economic or emotional nature, for the customer, who enjoys the effects of the service. For example, dining in a restaurant results in the customer feeling relaxed after a busy day at the office. In the same work the authors argue that services produce variable, intangible outputs, they are time-perishable and the customer contributes significantly throughout the service process. Hence, this definition adopts a customer-centric view of service provision.

(Zeithaml and Bitner 2000) consider services as “including deeds, processes and performance”. Deeds are activities that solve problems that customers cannot solve independently. This means that services assists customers to satisfy personal needs and situations. Deeds are implemented through processes. Performance indicates how well the deeds are performed and includes process effectiveness and efficiency. They argue that because services are performances they are intangible, they cannot be inventories and have high variability. The evaluation of performance (particularly by the customers) and the feedback on it are investigated later on in our work. This definition adopts a rather process-centric view of the service.

(Grönroos 2000) defines services as “activities […] of a more or less intangible nature that normally […] take place in interactions between the customer and service employees and/or physical resources or goods and/or systems of the service provider, which are provided as solutions to customer problems”. Grönroos perceives service as an interaction between different stakeholders, including customers, service providers and employees, and physical resources. He adopts a customer-centric view since he argues that a service addresses specific problems of the customer, and defines the customer as an integral part of the service process. The degree of how well the service addressed the customer’s problem relates directly to the customer viewpoint studied in our work.

(Lovelock 2001) perceives service as “as an act or performance offered by one party to another” and continues saying that service is “an economic activity that creates value and provides benefits for customers […] by bringing about a desired change in or on behalf of the recipient” (from this point of view, this definition could also be classified under section 2.2.2). Interestingly, Lovelock scopes service down to economic activities, excluding other types of activities that others encompass in their definitions of service, e.g. cooking for ones family or receiving medical treatment. This definition argues that the outcome of the service results in a transformation of the current state of an entity. The evaluation of performance relates directly to perceptions, expectations and feedback. Lovelock’s definition seems to oversee the fact that an entity may provide a service to itself, e.g. a doctor may also provide medical treatment to herself.

(Dumas, O’Sullivan et al. 2001) define service as “a simple or a complex task or activity, executed within an organisation on behalf of a customer or organisation”. This definition adopts a process-centric view of the service, identifies the context of service provision, i.e. within the service provider, and defines two types of customers, i.e. a physical entity (customer) and a business entity (organisation). The authors argue that e-services can be automatically summoned anywhere, anytime and identify three main service features: services are actions performed by an entity on behalf of another; services have an inherent value that is transferred from the provider to the recipient; and services can be contained within other services.

(O'Sullivan, Edmond et al. 2002) claim that service is "an action performed by one entity on behalf of another. This action involves the transfer of value". This technology-agnostic and abstract definition focuses mostly on the fact that a service results in value created for the entity that requested the service, e.g. for the customer. However, it places customers outside the service boundaries and limits them to giving their approval for the execution of the service to the provider, who henceforth acts on their behalf.

(Kotler and Keller 2006) define service as "any act or performance that one party can offer to another that is essentially intangible and does not result in the ownership of anything; its production may or may not be tied to a physical product". This definition emphasises the nature of service as an intangible act. The assumption made in regards to ownership refers to the fact that performing the service does not result in the customer owning any factors of the service production, such as resources required for the service and contributed by the service provider. However, there are cases when the execution of a service results in the ownership of a tangible good or an intangible right. For example, the sale of a book is a service that results in the customer owning a copy of that book.

(Fitzsimmons and Fitzsimmons 2006) argue that service is "a time-perishable, intangible experience performed for a customer acting in the role of a co-producer". This definition highlights the active participation of the customer in service provision. It also emphasises that the service is provided *for* a customer, meaning that the customer is the main beneficiary of the service. The customer is assigned the role of the co-producer, meaning that customers are actively involved in the service delivery process, e.g. undertake specific parts of the process, thus effectively influencing its quality and efficiency. Service Science researchers have replaced the term co-producer (which dates back to the traditional production of goods) with the term co-creator, which is however more vague.

Service Science researchers have come up with definitions of the service which engulf views on the service coming from all the disciplines that comprise Service Science, i.e. management, marketing, economics, computer science and information systems, cognitive and social sciences, and operations research. (Vargo and Lusch 2004) adopt and extend the definitions of (Zeithaml and Bitner 2000) and define service as "the application of specialised competencies (knowledge and skills) through deeds, processes, and performances for the benefit of another entity or the entity itself". Therefore, the definitions of (Zeithaml and Bitner 2000) for deeds, process and performance are valid in this context too. Deeds are activities that solve problems that customers cannot solve independently. Deeds are implemented through processes. Performance indicates how well the deeds are performed and includes process effectiveness and efficiency. The evaluation of performance and the feedback on it relate directly to what we define later on as customer viewpoint. This definition perceives service as a set of actions that require competencies, skills and knowledge (i.e. operant resources) and create

value for the entity receiving the service, e.g. consumer. (Vargo and Lusch 2004) make explicit in their definition that an entity, e.g. an organisation, may provide a service to another entity, e.g. another organisation or a person, or to itself.

(Spohrer, Maglio et al. 2007) combine the definition of (Vargo and Lusch 2004) with the Unified Service Theory (Sampson and Froehle 2006) to define service as "the application of competences for the benefit of another". They argue that service is a kind of action (appears as deed in (Vargo and Lusch 2004)), performance (see also (Zeithaml and Bitner 2000)), or promise that is exchanged for value between provider and client. Drawing upon the Unified Service Theory, they argue that service is performed in close contact with a client and that the service process depends critically on the participation and the input of the customer, either by providing labour, property, or information". Customers' perceptions, expectations and feedback can be perceived as different types of input provided by the client. Their main contribution lies in their attempt to decompose the service. They argue that all services employ three types of resources: people, technology and shared information. These resources are integrated in different propositions in the context of service systems. Essentially, this definition differs from the rest as it does not aim to answer to what a service is but to which are its fundamental elements.

(De Kinderen and Gordijn 2008) claim that in order to satisfy a consumer need, a bundle of elementary services is required. An elementary service is defined as the entity which is of economic value to the end-consumer, and which is provisioned by a supplier. It is the smallest unit that, from a commercial point of view, can be meaningfully obtained from a supplier. This definition of service is very close to the initial wording of S-D logic's FP1, which claimed that service is the unit of exchange (Vargo and Lusch 2004) (we remind the reader that "unit" has been replaced with "basis" in (Vargo and Lusch 2008)). Service bundles to capture the high variability and intangibility of services and to enable flexible service groupings that can fulfil different customers' needs are also introduced in the OBELIX service ontology (see also section 2.2.4.3). The OBELIX service ontology capitalises on the definitions of service given by (Zeithaml and Bitner 2000), (Grönroos 2000) and (Kotler and Keller 2006).

(IBM Research, 2009) defines a service as "a provider/client interaction that creates and captures value". Both the provider and the client benefit from the service. They highlight that services require assessment, during which provider and customer come to understand one another's capabilities and goals.

(Alter 2008) claims that services are "acts performed for others, including the provision of resources that others will use". Despite being generic enough to cover different types of services, this definition emphasises on services that are provided by one entity to another, but does not refer to services that

an entity might provide to itself. He defines that services are delivered through work systems – a variant of service system - which are environments in which human participants and/or machines perform work using information, technology, and other resources to produce products and services for internal or external customers. For example, an information system and a supply chain are work systems. Alter identifies two types of customers: the direct beneficiaries of the produced service and other customers that are indirectly interested in the service and/or involved in the work system, e.g. in the provision of a public service indirect customers would include the public servant dealing with the citizen (direct customer) and a third-party to which the outcome of the service would have to be communicated. Customers may be individuals or organisations. Other participants, e.g. employees of the service provider and representatives of public authorities, play also important roles service provision. Alter argues that information, such as databases, documents, shared knowledge and latent knowledge, is used and produced during the provision of a service. He also emphasises the use of technology, not necessarily referring to ICT, but rather to technologies and infrastructure that support the service. According to Alter, services are placed and act in specific environments that include organisational culture, regulations and policies, competitive issues, and technical developments. They have to be aligned with the organisational strategies and use infrastructure, including human, information, and technical resources.

(Mora, Raisinghani et al. 2009) followed by (Mora, Raisinghani et al. 2011) argue that service is a three-dimensional concept that can be mapped to an agreed and expected sequence of interactions between a service facilitator (i.e. service provider) and a service appraiser (i.e. a consumer) involving different types of resources, i.e. *(i)* energy, material and knowledge, *(ii)* a property of each entity in the service system that is expected to be positively affected by the service interactions, and *(iii)* an emergent property generated by the service (e.g. outcome), which is valued by the customers and can be measured using objective metrics.

(Lau, Wang et al. 2011) define service as “a process by which the provider fulfills a mission for a client so that value is created for each of the two stakeholders”. They explain that the mission encapsulates the customer’s requirements and expectations that the provider should satisfy. The mission may be realised by the provider or may be co-produced by the customer and the provider. The effort required to accomplish the mission is termed work. The evaluation of whether or not (and how well) the mission has been accomplished directly relates to customers’ perceptions, expectations and feedback. An interesting aspect introduced in this work is the recursive nature of service, as it is often the case that for a service to complete its execution other services may also have to be activated.

2.2.2 Service as a transformation

This section discusses efforts to define service as a transformation in the state of persons, economic entities and tangible and intangible resources, in order to create value for the customer. The following 4 definitions approach value from another viewpoint. Value is now created as a result of the execution of the service and the change(s) that this brings to the state of the customer. In this perspective, concepts and relationships that reveal the way that customers experience service value will be incorporated in the proposed conceptual service model.

(Hill 1977) defines service as "a change in the condition of a person, or a good belonging to some economic entity, brought about as a result of some other economic entity, with the approval of the first person or economic entity". This definition refers mostly to the transformation that resources, let them be human, material or information, are going through during the provision of a service. It specifies that the consumer of a service might be a physical person or a business entity. Finally, it introduces an interesting aspect, the fact that the service can only be executed if the consumer has given their approval, thus raising legal and ethical considerations in service provision.

(Payne 1993) argues that a service "is an activity which has some element of intangibility associated with it, which involves some interaction with customers or with property in their possession, and does not result in a transfer of ownership. A change in condition may occur and production of the service may or may not be closely associated with a physical product." Payne's definition is one of the most complete definitions that we have come across. He specifies that customers are involved in the service process, either directly or indirectly through the provision of their resources (referred to as property by Payne and are given a tangible nature). He links the service with a transformation in the condition of the customer and/or the resource. He clarifies that a service can have self-existence; it is thus not required that all services are related to or dependent on goods. Finally this definition recognizes that services are intangible and that they do not result in transfer of ownerships of the resources that they use.

In the Unified Services Theory, (Sampson and Froehle 2006) perceive service as a production process. The customer provides significant inputs, i.e. labour, property, or information, into the production process. Customers' perceptions, expectations and feedback can be perceived as different types of input provided by the client. They define a production process as a sequence of steps that is modifying inputs in a way that delivers benefis to the customers. This process-centric view of the service emphasises the primary role of the customer in service provision and highlights that the customer is the primary beneficiary of the service and receives the value created through the transformation and integration of the provided inputs.

(Lovelock, Wirtz et al. 2009) argue that services are "time-based performances that bring about desired results in recipients themselves or in objects or other assets for which purchasers have responsibility". Therefore, in exchange for money, time and effort that customers contribute to the service process, they obtain value (expressed as a change in their own state or in the state of one of their possessions) from access to goods, labour, professional skills, facilities, networks and systems which belong to the service provider, normally without any transfer of ownership of the physical elements involved. The evaluation of whether or not (and how well) the service finally delivered the desired results directly relates to customers' perceptions, expectations and feedback.

2.2.3 Service as a service system

Service systems are the prevalent approach for modelling systems that deliver service. Service systems constitute complex structures that comprise of service providers and customers who collaborate in order to deliver a service. Human capital, skills, knowledge, tangible and intangible resources, invested both by service providers and customers, are combined into different propositions for a service to be delivered. In this work, we perceive service systems as an alternative way of modelling service and the different conceptual elements involved in service provision.

(Riordan 1962) was one of the first to use the term "service system". He argued that service systems have a stochastic nature and tried to model it using queuing theory. Stochastic service systems refer to systems whose behaviour is essentially non-deterministic, thus randomness is involved in the development of future states of the system. This means that different outputs, e.g. different final states or differentiated products/services, may be produced from a given initial state. Customers and providers partake in service systems.

The stochastic nature of service systems is expressed through service variability and non-standardisation concluding that the same service is delivered differently to different customers (or even to the same customer at different points in time) depending on their context, profile and personal circumstances, on the operant resources assigned as well as on the activities of the other stakeholders involved in the service provision. For example, two different customers visit a restaurant for dinner. The same service, i.e. dining, is delivered differently to each of them depending on where they will sit in the restaurant, what they prefer to eat, whether they are pleased or not with their waiter and with the quality of the meal etc. However, not all service systems are stochastic; hence Riordan's view cannot be generalised. In many cases, e.g. in public administration service systems, the final states (outputs) of the system can differ and can be many but they are known a priori.

(Tien and Berg 2003) perceive service systems as socio-economic constructs that comprise of service providers and service consumers that interact to create value in the context of complex virtual value

chains. They argue that service systems deliver services that should achieve maximum customer satisfaction at minimum cost. Service providers and consumers can be individuals or business entities, e.g. firms, government agencies or any organisation of people and technology.

According to (Spohrer, Maglio et al. 2007), a service system is defined as a "value co-creation configuration of people, technology, value propositions connecting internal and external service systems and shared information (e.g., language, laws, measures, and methods)". External service systems reflect different organisations or business ecosystems, while internal service systems are integral parts of an organisation or a business ecosystem.

Due to the broadness and the genericity of their definition, Spohrer et al. assume that different real-world constructs may fall under the definition of a service system, hence defining various types of service systems, including individuals, corporations and foundations, organisations and departments in an organisation, cities, countries, and even families. (Spohrer, Maglio et al. 2007) define four types of stakeholders in a service system, namely customers, providers, competitors and authorities.

Along the same line, (IfM and IBM 2008) define a service system as "a dynamic configuration of resources (people, technology, organisations and shared information) that creates and delivers value between the provider and the customer through service".

(Spohrer, Demirkan et al. 2011) introduce holistic service systems and define them as complex super-systems that comprise of interacting self-contained service systems. Examples of holistic service systems include cities, countries, universities, hospitals and hotels. Each of them comprises of other interacting systems, such as buildings, finance, energy, transportation, governance etc. In this vein, they revisited their definition of 2007 and argue that service systems are "complex business and societal systems that create benefits for customers, providers, and other stakeholders, and include all human-made systems that enable and/or grant diverse entities access to resources and capabilities such as transportation, water, food, energy, communications, buildings, retail, finance, health, education, and governance".

(Storbacka and Lehtinen 2001) claimed that any of the following roles can be assigned to a customer in a service system: payer, consumer, competence provider, controller of quality, co-producer and co-marketer. A payer pays the price for using/consuming a specific service. The price is usually defined in monetary terms. After purchasing the service, the state of the customer changes from payer to consumer. The consumer is the main beneficiary of the service. The consumer experiences the service and receives the service output. During the service provision, as discussed also by Service Science researchers, the customer has an active role. Hence, customers are often referred to as co-producers. Customers provide tangible resources as well as competencies and skills (i.e. customer as competence

provider). Through their feedback on the service experience and the service quality customers also act as controllers of quality. Finally, customers can raise the awareness of a service and share their experience with their network of friends and acquaintances; as such customers can act as service co-marketers.

(Kwan and Min 2008) identify the main entities of a service system, namely customer, service provider, and service experience. The customer is defined as a person, a group, an organisation or institution that represents the payer(s) as well as the person(s) who actually enjoy the service experience. The service provider is defined as "the primary purveyor of the service experience to the customer". The service provider invests the required resources and performs the service for a certain price. The service experience denotes that the service is intangible and the customer experiences the service for some duration of time. In the context of a service supply chain, different service systems can interact and collaborate in order to integrate their skills and competencies to deliver a specific service. Kwan and Min argue that the entities of a service system interact through specific actions, thus co-creating value.

Building on Alter's theory, (Ferrario and Guarino 2009) propose an ontological foundation for service systems that represents services as complex systems of commitments and activities, involving real people, organisations, and actual circumstances. They assume that a service system involves interactions with services through complex chains where people and machines partake. During this interaction, value is exchanged between the customer and the service producer.

(Ferrario and Guarino 2009) say that "a service is present at a time *t* and location *l* iff, at time t, an agent is explicitly committed to guarantee the execution of some type of action at location *l*, on the occurrence of a certain triggering event, in the interest of another agent and upon prior agreement, in a certain way". The term agent refers to the specific entity that is active during a service interaction, e.g. a customer or a service trustee. This definition models service as a process comprising of a series of steps and having a spatio-temporal aspect. The whole process is undertaken and guaranteed by the trustee that may coincide with the service provider or not.

Ferrario and Guarino make a distinction between service and the actual delivery of a service to a specific customer. They argue that the same service can be delivered several times and specify that what is actually been delivered to the customer is the content of the service, i.e. the kind of actions the service trustee commits to, and not the service itself. The service trustee guarantees the execution of the service by means of the service producer in the interest of customer at a certain cost and in a certain way. The service trustee may coincide with the service producer or may be delegated by the service provider.

The following conceptual elements that partake in service delivery are defined:

- Agent, i.e. the participant who acts in a particular event.
- Theme/Patient, i.e. the participant who undergoes a particular event. The patient changes its state, while the theme does not.
- Goal, i.e. the desired state of affairs that a particular even is directed towards.
- Recipient/Beneficiary, i.e. the participant who receives the effects of a particular event. It may coincide with the theme/patient or may be different (e.g. in the case when a parent executes a public service on behalf of her child).
- Instrument, i.e. tools or something used in a particular event.
- Location, i.e. the place where a particular event happens.
- Time/duration, i.e. when a particular event happens and how long it lasts.

2.2.3.1 Service value networks

Service value networks are a specialisation of service systems focusing on the value co-created by the actors participating in a service system.

(Bitsaki M., Danylevych O. et al. 2008) argue that service value networks, as a specification of service systems, offer services that are obtained by composing other services provided inside the network. We believe that the notion of service network is very close to that of a service system as in both cases different entities, which can in turn be self-contained, cooperate to provide value to their customers based on services.

(Bitsaki M., Danylevych O. et al. 2008) define that a service network comprises of participants, e.g. service providers and customers, and the relations, i.e. the types of interactions, between them (Figure 3). Two types of relations are defined, namely offering and revenue. Offering relations specify what services, goods or a combination of both are offered by a service provider to the customer. Revenue relations describe the gain that customer has from the service provider in exchange for provided service.

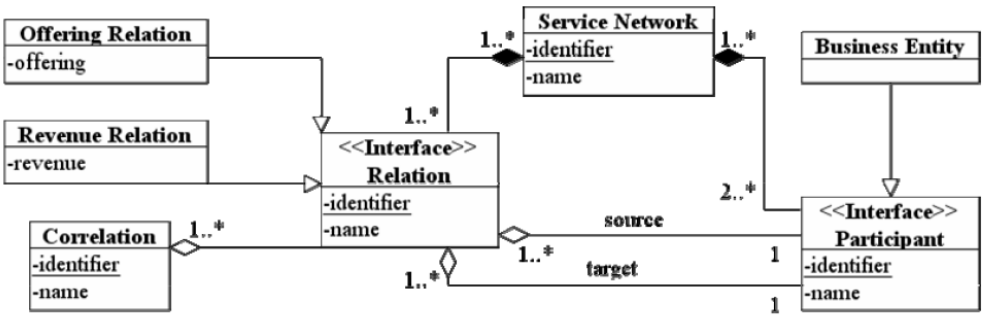

Figure 3: The Service Network Notation Metamodel (Bitsaki M., Danylevych O. et al. 2008)

From a similar perspective, (Basole and Rouse 2008) suggest that service value networks are complex socio-economic ecosystems that include products and services, and propose a conceptual model for representing them. They adopt a node-and-arc representation approach (see Figure 4). According to Basole and Rouse (2008), the creation of value in the service network is the result of complex B2B, B2C, and C2C relationships and is also influenced by the social, technological, economic and political context. The social, technological, economic and political context influences all the actors in the service value network as service activities cannot be separated from the context in which they are performed.

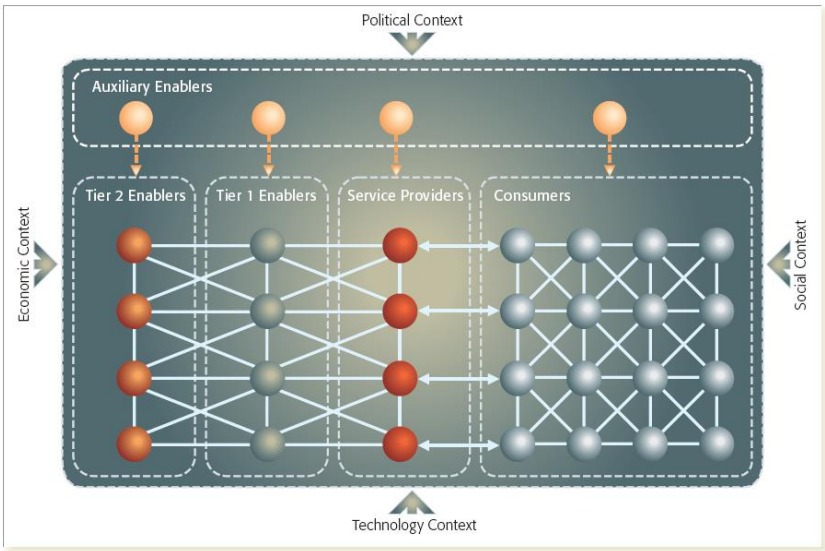

Figure 4: Conceptual model for service value networks (Basole and Rouse, 2008)

Five types of actors are identified in the network, namely consumers, service providers, tier 1 and 2 enablers, and auxiliary enablers.

Consumers are the entities that trigger the activities in the service value network, e.g. purchase goods/services. Basole and Rouse acknowledge that consumers have an active role in service value networks, which goes beyond using the service. Customers ask for customised and personalised services with high-quality standards that meet their preferences, and criteria and participate actively in the personalisation/customisation process. An interesting assumption made by Basole and Rouse, is that customer satisfaction is related to the benefit that the service providers will eventually receive. In other words, value will be created only if the customer is finally satisfied with the service experience.

Service providers are the focal actors in the network and supply the services that fulfil the consumers' needs. The service provider's function may range from aggregator of products and services in a bundled fashion to an enabler (kind of a proxy) to other service providers.

Enablers assist the service provider during the design, development and deployment of a service. The conceptual model defines three types of enablers, tier 1, tier 2 and auxiliary enablers. Tier 1 enablers supply the service provider with goods and services, e.g. other service providers. Tier 2 enablers supply tier 1 enablers with goods and services to tier 1 enablers, e.g. material manufacturers. Auxiliary enablers are essential to the entire service value network and may include government agencies, banks, infrastructure providers etc.

(Blau, Kramer et al. 2009) argue that service value networks "provide business value through the agile and market-based composition of complex services from a steady, but open pool of complementary as well as substitutive standardised service modules by the use of ubiquitously accessible information technology". (Blau, Kramer et al. 2009) define that a service value network comprises of service providers that provide one or more service offers to service requesters. The authors explain that two or more service offers may be substitutes, meaning that they provide the same or similar functionality.

From an Service-Dominant logic point of view, (Lusch, Vargo et al. 2010) describe a value network as "a spontaneously sensing and responding spatial and temporal structure of largely loosely coupled value proposing social and economic actors interacting through institutions and technology, to co-produce service offerings, exchange service offerings, and co-create value". Social actors are usually individuals (humans), while economic actors are usually businesses, organisations and their suppliers.

2.2.4 Technology-enabled services

Technology-enabled services refer to the delivery of the services of a specific service industry electronically, primarily over the Web, using ICT. For example, the traditional sale of a book from a physical bookstore can be performed electronically through and e-bookshop, like Amazon. In the case of pure-play retail, even the associated product can be in electronic form. Technology-enabled services (e.g. e-services) are realised through service oriented architectures which in turn comprise of a set of interworking technical services. As the vast majority of these systems are nowadays Web-based, they rely on Web services.

Technology-enabled services can fully or partially automate the delivery of a particular service, e.g. electronic sales, or partially support the delivery of a real-world service, e.g. use a POS system to manage the stock in a retail store or a restaurant. Interestingly, there exist types of services that cannot be fully automated. For example, services that build upon a particular human competency, skill or talent, e.g. cook a dinner, draw a painting give a haircut or receive medical treatment, cannot be delivered electronically.

A dual relationship exists between services and technology-enabled services (see Figure 5). On the one hand, technology-enabled services comprise of *(i)* software that realises service activities of the real world and *(ii)* information objects, manipulated by the software, which often correspond to real-world entities. For example, a customer class in the CRM of a company models the actual customers of this company. On the other hand, information produced is required by service activities in the real world. For example, the unique id automatically created and assigned by the CRM to each customer might then be required by the employees of the company every time a customer is contacting them in order to cross-check customer identity.

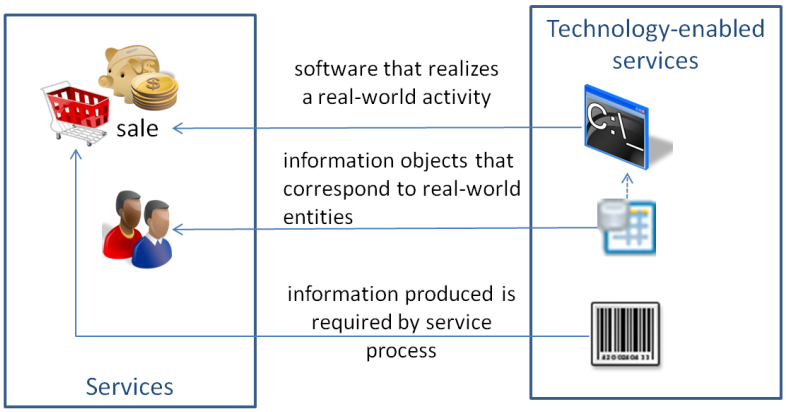

Figure 5: The relationship between services and technology-enabled services

(Brown, Delbaere et al. 2005) state that a service "is generally implemented as a coarse-grained, discoverable software entity that exists as a single instance and interacts with applications and other services through a loosely coupled (often asynchronous), message-based communication model".

An IT service is defined by the (International Organisation for Standardisation 2011) as "a means of delivering value to customers by facilitating outcomes customers want to achieve without the ownership of specific costs and risks". The evaluation of whether or not (and how well) the service finally delivered the desired outcomes directly relates to customers' perceptions, expectations and feedback.

(Polter, Verheijen et al. 2008) elaborate on this definition, saying that an IT service is an output of an IT organisation which comprises of three main elements, i.e. the information system, support and quality specifications, and creates value for the customers. This definition bridges the gap between the way service is perceived by business-related disciplines on the one hand and computer science on the other hand as it creates a link between the creation of value for the customer and the prevalent role of technology towards this direction.

One of the terms used in literature for describing a technology-enabled service is "e-service". However, the term is neither well-established nor standardised and different researchers give

different interpretations of e-service. (Baida, Akkermans et al. 2003) describe an e-service as vague term often referred to an online service.

(Seybold 1999) claims that e-services are internet-based applications that fulfil service needs by seamlessly bringing together distributed, specialised resources to enable complex transactions.

(Piccinelli and Mokrushin 2001) define an e-service as "any asset that is made available via the Internet to drive new revenue streams or create new efficiencies". An asset may refer to knowledge, competencies and skills or to tangible resources and infrastructure. Positioning e-service vis a vi service, the authors claim that e-services "are modular, nimble, units of service made available from a business to other businesses and to consumers".

(Tut and Edmond 2002) use e-service as a synonym of Web service and claim that "electronic services offered over the Internet are also referred to as electronic services, Web services, Internet services, Web-based services or e-services".

(Rust and Kannan 2003) argue that an e-service refers to the provision of service over the Web and electronic networks.

(Mohan and Ramesh 2003) refer to services that are delivered electronically, typically through the Internet as e-services.

(Hultgren and Eriksson 2005) argue that an e-service is "social interaction between a service provider and a customer - and possibly also between customers - through the use of the service provider's IT system and with the aim of providing actions and results for the customers". Social interaction is used to indicate the provision of an e-service does not rely entirely on information system, but also requires communication and collaboration between the service provider and the customer. We argue that customers can be given a chance to express their perceptions, expectations and feedback as part of this bilateral communication.

(Rowley 2006) defines e-services as: "…deeds, efforts or performances whose delivery is mediated by information technology". Rowley considers three main concepts, the service provider, the service receiver and the service channel. For example, in the case of eGovernment services, a public agency is the service provider, citizens are the service receivers, and the Web is the service channel. The evaluation of performance relates directly to perceptions, expectations and feedback.

(Hofacker, Goldsmith et al. 2007) define e-service in a more formal way as "an act or performance that creates value and provides benefits for customers through a process that is stored as an algorithm and typically implemented by networked software". The evaluation of performance relates directly to perceptions, expectations and feedback.

As explained earlier, technology-enabled services (e.g. e-services) are realised through service-oriented architectures which in turn comprise of a set of interworking technical services.

2.2.4.1 SOA service models

This section reports the most influential modelling efforts that aim to deliver standardised representations of a service. Their core concepts are also identified.

(Papazoglou 2003) proposed an extended SOA (eXtended SOA) which is divided into three layers: the basic services, the composite services and the managed services layer (see Figure 6). The layered view separates basic service capabilities provided by the typical SOAs from advanced service functionality needed for service composition and management. Apart from the layered SOA view, this work introduces also new roles who are responsible for these advanced functionalities, i.e. the Service Aggregator, the Service Operator and the Market-maker.

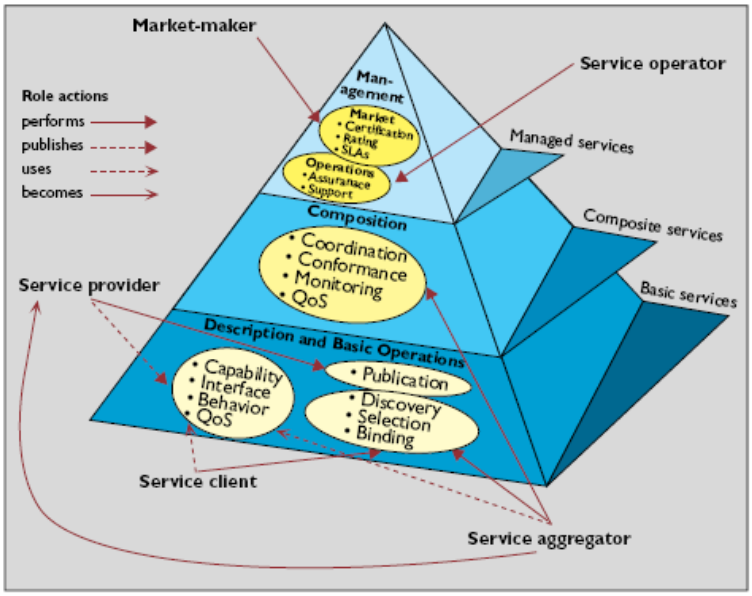

Figure 6: Extended SOA (Papazoglou 2003)

OASIS proposed in 2006 a Reference Model for SOA, which includes a definition of the service, its principal concepts and the relationships between them (OASIS 2006). The OASIS Reference Architecture Foundation for SOA adopts a service ecosystem view which perceives SOA-based systems as socio-technical constructs where people participate to conduct their business, e.g. to provide or to consume services that deliver desired benefits (Estefan, Laskey et al. 2009). A service is defined as "a mechanism to enable access to one or more capabilities, where the access is provided using a prescribed interface and is exercised consistent with constraints and policies as specified by the service description".

In order to model the different types of roles and their interactions in the service, the OASIS Reference Architecture Foundation for SOA proposes three core models that provide a vocabulary of service-related terms and concepts: the Acting in a SOA ecosystem model, the Social Structure Model and the Acting in a Social Context model.

The Acting in a SOA ecosystem model introduces the key concepts involved in actions performed by people and organisations in the service ecosystem (Figure 7). The model identifies different entities acting in the ecosystem, including: actor and its subtypes participant and delegate; stakeholder and non-participant. An actor is an entity capable of performing action. Actors may be human, non-human or organisation of entities. A stakeholder is an individual entity that has an interest in the state of the ecosystem. A participant is a stakeholder whose interests lie in the successful use of services and who is capable of performing specific actions in the ecosystem. Participants are either human or organisations. A delegate is an actor acting on behalf of a participant.

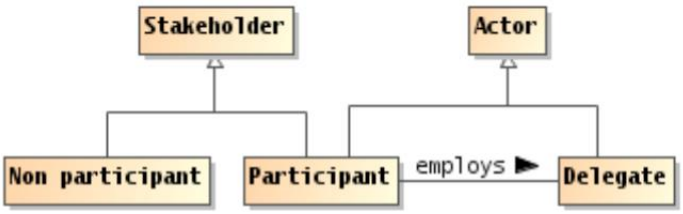

Figure 7: Acting in a SOA ecosystem model (Estefan, Laskey et al. 2009)

As shown in Figure 8, participant has three subclasses, namely service provider, service consumer and service mediator. A service provider is defined as a participant that offers a service that enables some capability to be used by other participants. A service may integrate and expose different capabilities originally provided by entities other than the service provider. The specification explains that apart from the service provider several different stakeholders are involved in the provision of a service, including the provider of the capability (which may be different that the service provider), an entity that exposes the capability as a service (which often coincides with the service provider, but not always), a host entity that supports the service, a government entity that permits and regulates the provision of a service. A service consumer is a participant that usually initiates a service and interacts with it to realise the real world effect that will fulfil her need. A service mediator is a participant that facilitates the offering or use of services in some way, usually by facilitating the communication between service provider and service consumer.

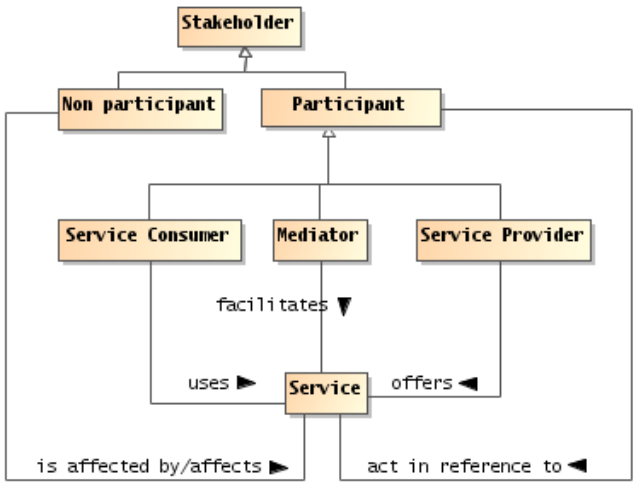

Figure 8: Service participants (Estefan, Laskey et al. 2009)

The Acting in a SOA ecosystem model also defines actions and joint actions. An action is defined as "the application of intent to achieve an effect within the SOA ecosystem". A joint action is "a coordinated set of actions involving the efforts of two or more actors to achieve an effect". Participants act against services to fulfil their needs. In turn, service providers act to satisfy the needs of the participants. Finally, governance parties act to ensure the ecosystem's smooth operation. All actions may be within the ecosystem's boundaries or may span across different service ecosystems.

The Social Structure Model introduces the context in which the actions of the participants are performed. (Estefan, Laskey et al. 2009) claim that social structure "embodies some of the cultural aspects that characterize the relationships and actions among a group of participants". An enterprise or even a country can be examples of social structures. In the context of social structures participants are assigned roles. Each role defines the rights, responsibilities, qualifications, and authorities of the participant within the specific context. Social structures are usually embodied in legal frameworks.

The Acting in a Social Context model connects the other two models and introduces social actions to represent actions performed by service providers, service mediators and consumers in order to achieve some result within a social structure. It specifies that customers have needs which can be fulfilled through the execution of service capabilities and that resources of the participants are utilised in order to provide a specific service.

Summarising, the main concepts of the OASIS Reference Model for SOA are: Service, Service Provider, Service Consumer, Service Description, Visibility, Interaction, Real World Effect, Execution Context, Contract and Policy. The reference model is abstract and not tied to standards or specific technologies, thus being able to provide common semantics independent of specific implementations. The Reference Model specifies that the internal workflow of the service is opaque to the consumer. This

limits the degree of consumer participation in the service. Finally, they argue that the consumer of the service may come up with uses of the service beyond those originally conceived by the provider.

In 2009 OMG released SoaML (OMG 2009). SoaML provides a model and a UML profile which facilitate the formal specification, design and development of services within a SOA. SoaML defines a service as "value delivered to another through a well-defined interface and available to a community (which may be the general public). A service results in work provided to one by another". Essentially, a service is provided by a participant acting as the provider to another participant acting as the consumer (OMG 2009). The main classes of the SoaML model are Participants, Capabilities, Services Interfaces, Service Contracts, Service Data and Port. SoaML is a technology independent effort and is compatible with the OASIS Reference Model for SOAs.

The Open Group defined a formal ontology for SOA that contains classes and properties corresponding to the core concepts of a SOA (The Open Group 2010). The ontology facilitates a model-driven approach to SOA development. The main classes of the ontology are Service, Service Contract, Service Interface, Actor, Task, Effect, Process and Policy. The SOA Ontology refines and formalises some of the concepts of the OASIS Reference Model for SOAs, e.g. Policy and Contract. The SOA Ontology defines a service as "a logical representation of a repeatable activity that has a specified outcome. It is self-contained and is a black box to its consumers". The SOA Ontology models consumers as actors that use services. An actor may be a person or an organisation. It clarifies that the term activity does not necessarily indicate a formal process activity; it can just as well refer to an informal action. However, the fact that the SOA ontology perceives service as a black box to its consumers limits the degree of customer participation in the service.

The Unified Service Description Language (USDL) facilitates the description of services from a business and operational view and aligns this description with the technical view of the service (Unified Service Description Language SIG 2009) focusing on SLA-related aspects. USDL allows expressing business characteristics set by an organisation for providing means for consumers to use business services. A variant of USDL, Linked USDL is also proposed for describing services on the Web of Services (Pedrinaci et al., 2014).

Thus, USDL builds on models for describing business and technical services by adding business information, and creates a unified description of related research efforts, e.g. SWS frameworks. USDL can also be used for the description of manual services that have no technical implementation. The general design principle of USDL is to provide a unified entry point to the set of heterogeneous service metadata. USDL is close to the notion of service system as defined by Service Science researchers, but is still biased towards technology-enabled service modelling. USDL groups the elements of a service

system in nine modules, namely service, interaction, functional, technical, service level, legal, pricing and foundation.

According to USDL a service is “one type of entity provisioned into service networks. It exposes a set of capabilities that can be accessed through the service's own (abstract or technical) interface”. USDL suggests that participants interact with services to create value. The service interactions are conducted in a specified legal context – that may differ depending on the service industry.

Here we focus on the participants module of USDL which identifies the following roles: provider, business owner, intermediary, stakeholder, customer and target (potential) customer (Unified Service Description Language SIG 2011). The provider is responsible for the governance and the operation of a service in terms of organisational structures and business aspects, as well as systems and implementation aspects. The business owner undertakes the interaction between the customer and the provider. The intermediary has a delivery or third-party provisioning role for the service, but has no ownership of the service. A stakeholder is an entity that either regulates the service or is involved in the provision of the service (or resources required for the service or parts of the service), e.g. government agencies and third-party service providers. A consumer models the requirements of consumption of entities interested in using the service. A target consumer is used to capture information about groups of entities that are targeted by the provider or the business owner to consume the service.

The OBELIX service ontology for non-software-based services complements the OWL-S service profile (Akkermans, Baida et al. 2004). It distinguishes three complementary top-level viewpoints:

- The service value viewpoint describes the service from a customer viewpoint. Its core concepts are: customer, demand, sacrifice and service quality. An interesting aspect for our work is that that the following relationships are defined: customer *requires* demand and demand *describes* service quality.
- The service offering viewpoint describes and the service from a supplier’s perspective. Its core concepts are: service element, resource, function and supplier.
- The service process viewpoint describes how the service offering is put into operation.

The OBELIX service ontology perceives service as a co-production of different suppliers and that customers partake in the production process as well.

Additionally, the OBELIX service ontology is the core part of the TEXO Service Ontology. The latter extends it by including modules for pricing, legal, innovation and rating information (Oberle, Bhatti et al. 2009).

2.2.4.2 The Web of Services

The Web of Services (or Service Web or Internet of Services) builds upon the point where the three main computing paradigms discussed in this *Thesis*, i.e. SOA, the Semantic Web and Web 2.0, met and constitutes their natural evolution. As such, the Web of Services combines three dimensions, i.e. Functional, Semantic and Social, as illustrated in Figure 9.

(Korth, Hirsch et al. 2008) define the Web of Services as "a distributed Web of semantically annotated services". In the Web of Services distributed, semantically annotated services are accessible and can be discovered, composed, orchestrated and invoked. Services will be able to deal with queries made by humans, software agents or other services and to create knowledge. Innovation will be empowered by automatic service composition and orchestration.

Services in SOA implementations are usually restricted within closed intra- or inter-enterprise information systems environments with a strong focus on diverse service integration and are subject to well-defined regulatory frameworks (McAfee 2005; Schroth 2007).

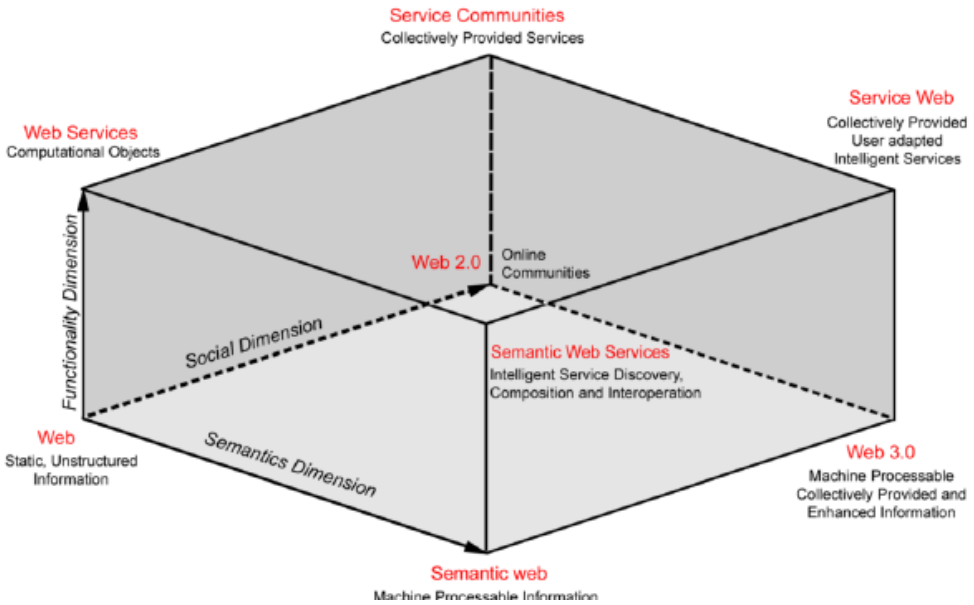

Figure 9: The pillars of the Web of Services (Domingue, Fensel et al. 2009)

In the context of the Web of Services, new types of services appear which do not follow the typical SOA paradigm and are created in a decentralised manner. For example, mashups are introduced as a new way of composing services and combining content from different sources (Thies and Vossen 2008). Web 2.0 services are usually built upon stateless architectures and use simple interfaces, which transmit data over HTTP without an additional messaging layer, e.g., using REST instead of SOAP for invoking services is a common practice (Benslimane, Dustdar et al. 2008).

According to (Schroth 2007), the Web of Services, apart from Semantic Web, Web 2.0 and SOA also encompasses contextual computing, thus being aware of and able to adapt to contextual information about users and their environments. Significant research efforts have been carried out in order to capture and include contextual information in SOA, WOA and Semantic Web applications, e.g. (Sheth and Perry 2008; Dorn , Schall et al. 2009; Yu, Yang et al. 2009; Rong and Liu 2010).

The remainder of this section reviews the most influential model and architectures proposed for the Web of Services. It is particularly interesting to our work, as it is positioned in this field.

(Schroth and Christ 2007) revisited the SOA brokerage model in the context of Web-scale service-oriented systems and conclude in a tripartite model which comprises of the *Resource Provider* (replaces the SOA Service Provider); the *Resource Consumer* (replaces the SOA Service Client) and the *Intermediary* (replaces the SOA Broker). As shown in Figure 10, new operations, such as monitor, test and customise – which is particularly interesting for our work, also come into play.

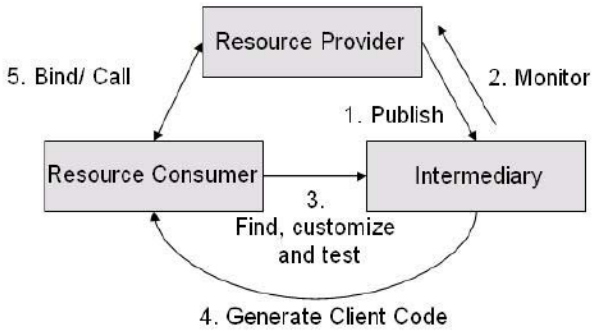

Figure 10: Revised SOA brokerage model (Schroth and Christ 2007)

The evolution of the SOA brokerage model is the result of an effort to extend the limited functionalities and to enhance the user-friendliness of service registries. This was necessary, as in the Web of Services, service-based applications are composed and deployed by customers, who need intuitive user-friendly interfaces in order to find, to evaluate and to customize existing services before finally mashing them into their applications. The new types of intermediaries also provide information about the performance and the quality of resources, which have been evaluated by previous customers.

The Service Web 3.0 initiative[3] proposed a framework which capitalises on the SOA principles, e.g. (Papazoglou 2003), (Sillitti, Desideri et al. 2009), and suggests the extensions of Web, Semantic Web and Web 2.0 technologies towards service-orientation (Benjamins, Davies et al. 2007; Benjamins, Davies et al. 2008). According to the authors, the Web of Services abstracts from underlying technologies and focuses on the functionalities offered by service-based applications. Semantic Web

[3] http://www.serviceweb30.eu/

technologies are then used for implementing intelligent service discovery, mashing and customisation mechanisms. The Web of Services comprises of customisable and context aware services, which are available through different channels, e.g. Web, mobile etc., and will support all aspects of human activity, e.g. professional, personal, leisure. Mass user participation and collaboration is both encouraged and facilitated. Thus everyone is enabled to consume and produce online content, i.e. data and services. Semantic and Web 2.0 services can be aligned and interlinked (Battle and Benson 2008).

(Taylor and Tofts 2008) define the Web of Services as "a complex service system that consists of many interacting services, delivered by both machine and human". The authors argue that, among others, the following research fields should be integrated into the Web of Services in order to allow for a marketplace of service components and related high value services that will exist on Cloud infrastructures:

- Service quality and guarantee to support complex service analysis, design and specification; and
- Customer needs to support service specification and discovery, and requirements expression.

(Schroth and Janner 2007) proposed a conceptual architecture for the Internet (Web) of Services. It comprises of a global, decentralised and loosely-coupled platform which allows (technically unsophisticated) individuals and businesses to find, combine, customize, consume, publish and share interoperable resources using intuitive user interfaces. The resources, let them be data, services, computing power, storage etc., are provided by arbitrary stakeholders. The user interfaces facilitate multichannel access and support tagging and mashing without requiring any (significant) coding effort. Interestingly, being close to the notion of social description of services, the author argue that semantics are expressed in folksonomies, which emerge directly from the users as a means of describing the characteristics and the quality of the resources.

A new species of lightweight services is born, namely linked services (Krummenacher, Norton et al. 2010; Pedrinaci and Domingue 2010; Domingue, Pedrinaci et al. 2011). Linked services refer to the integration of data-providing services and machine-readable (linked) data on the Web, by implementing a service layer on top of such data. Linked services define interface conventions that

are compatible to the linked data principles[4] [5] and are represented by lightweight formal models (such as the ones described in section 2.3.2).

2.2.4.3 Web services definitions

Web services (WS) are the prevailing technology for implementing SOA (Pizette, Semy et al. 2009). Numerous definitions have been given for Web service.

IBM specifies that "Web services are a new breed of Web application. They are self-contained, self-describing, modular applications that can be published, located, and invoked across the Web. Web services perform functions, which can be anything from simple requests to complicated business processes [...]. Once a Web service is deployed, other applications (and other Web services) can discover and invoke the deployed service".

According to the Web Services Primer (Vasudevan 2001), from an n-tier architecture point of view, a Web service is "a veneer for programmatic access to a service which is then implemented by other kinds of middleware. Access consists of service-agnostic request handling and a facade that exposes the operations supported by the business logic. The logic itself is implemented by a traditional middleware platform".

(Nghiem 2002) claims that a Web service is "a piece of functionality (an object, a component, an application, a database call) that can be invoked over a network using a predefined syntax".

(Booth, Champion et al. 2003) define a Web service as "a software system identified by a URI, whose public interfaces and bindings are defined and described using XML. Its definition can be discovered by other software systems. These systems may then interact with the Web service in a manner prescribed by its definition, using XML based messages conveyed by internet protocols".

According to (W3C 2004), a Web service is "a software system designed to support interoperable machine-to-machine interaction over a network. It has an interface described in a machine-readable format (specifically Web Services Description Language). Other systems interact with the Web service in a manner prescribed by its description using SOAP messages, typically conveyed using HTTP with an XML serialisation in conjunction with other Web-related standards", while the (W3C Web Services Architecture Working Group 2004) discusses further that Web services are software elements for supporting the execution of e-service processes. Web services are the means that permit the activation, execution, delivery and coordination of e-service processes.

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[4] http://openlids.org/
[5] http://www.w3.org/DesignIssues/LinkedData.html

2.2.5 Discussion

The study of literature in this section helped us elicit core service elements in Chapter 4. It also helped us prove our initial argument that the customer viewpoint is understated in existing modelling efforts. Despite being heavily discussed, it is rarely modelled explicitly. Our study also helped us understand how Service Science is approaching customer participation in service delivery, mostly by identifying interactions where customers and providers collaborate, and how the foundations are laid for facilitating customer participation (especially in sections 2.2.3, 2.2.3.1 and 2.2.4.2).

Our analysis resulted in the following observations with regards to existing service models and definitions:

- Two prevailing schools have been identified, namely service as perceived by business-related disciplines, e.g. marketing and operations management, and technology-enabled service as perceived by computer science and information systems. The first school, i.e. business-related disciplines, defines service either as a set of value-creating activities or as a transformation in the state of an entity e.g. a person, an economic entity (e.g. an organisation). In some cases they argue that services can be delivered via service systems, including the work systems theory of Alter. The second school, i.e. computer science, always adopts a system-centric view of service. In most cases, the focus is on technology-enabled services, where different families of services are identified, e.g. SOA services and e-services. This is summarised in Table 3.
- Despite introducing and detailing several concepts and relationships, the service models studied earlier are often fragmented and biased. As discussed in the previous sections, the different service modelling approaches not only differ in the way that they define service, but also in the conceptual elements used for modelling service and the granularity of these service models. Business-driven definitions are usually more high level and focus on the value delivered by a service and on the satisfaction of customers' needs, while technology-enabled service definitions and service systems provide detailed service models, often available also in human- and machine-readable formats (e.g. in the form of UML diagrams or ontologies). These differences are also due to the incentives of the different service modelling efforts. Business-driven service definitions are usually conceptual and aim at understanding the meaning of service, who are they key actors and how services serve customers and business needs, whereas technology-enabled services and service systems cross the conceptual sphere and try to solve practical problems, in an effort to improve service discovery, composition and personalisation.

- The fundamental conceptual elements of service, such as customer, service provider, resource, value and outcome, are present and have been defined in the vast majority of the service definitions studied in this work. Hence, building a uniform representation for service as well as building consensus on the meaning of service is feasible.
- Despite emphasising the importance of the customer participation and the need to sense, collect and analyse customers' perceptions, expectations and feedback, these models neither study these concepts in detail nor integrate them in a holistic, cross-disciplinary service model.
- The introduction of service systems reveals a more dynamic aspect of service modelling, as opposed to the static models and definitions discussed in the previous sections. Service systems involve interactions between service providers, customers and other agents. These interactions effectively cover the full service lifecycle, from service discovery and customisation to service activation and the design of new services.

Table 3: A conceptual analysis of service models and definitions

<table>
<tr><th colspan="3">Service</th></tr>
<tr><th>Service as a set of value-creating activities</th><th>Service as a transformation</th><th>Technology-enabled service</th></tr>
<tr><td rowspan="3">(AMA 1960), (Stanton 1981), Murdick et al. (1990), (Zeithaml and Bitner 2000), (Grönroos 2000), (Lovelock 2001), (O'Sullivan, Edmond et al. 2002), (Kotler and Keller 2006), (Fitzsimmons and Fitzsimmons 2006), (Vargo and Lusch 2004), IBM Research (2009), (Alter 2008), Mora et al. (2009) & Mora et al. (2011), Lau et al. (2011), (Dumas, O'Sullivan et al. 2001), (De Kinderen and Gordijn 2008)</td><td rowspan="3">(Hill 1977), (Payne 1993), (Sampson and Froehle 2006), Lovelock et al. (2011)</td><td>(Brown, Delbaere et al. 2005), (International Organisation for Standardisation 2011) & (Polter et al. 2008)</td></tr>
<tr><td>E-service</td></tr>
<tr><td>(Seybold 1999), (Piccinelli and Mokrushin 2001), (Tut and Edmond 2002), (Rust and Kannan 2003), (Mohan and Ramesh 2003), (Baida, Akkermans et al. 2003), (Hultgren and Eriksson 2005), (Rowley 2006), (Hofacker, Goldsmith et al. 2007)</td></tr>
<tr><td colspan="2">Service as a service system</td><td>SOA service</td></tr>
<tr><td colspan="2">(Riordan 1962), (Storbacka and Lehtinen 2001), (Tien and Berg 2003), (Spohrer, Maglio et al. 2007), (IfM and IBM 2008), (Kwan and Min 2008), (Ferrario and Guarino 2009) (Spohrer, Demirkan et al. 2011)</td><td>(The Open Group 2010), (OASIS 2006), (OMG 2009), (Akkermans, Baida et al. 2004), (Unified Service Description Language SIG 2009)</td></tr>
<tr><td colspan="2">Service value network</td><td>Web Service</td></tr>
<tr><td colspan="2">(Bitsaki M., Danylevych O. et al. 2008), (Basole and Rouse 2008), (Blau, Kramer et al. 2009), (Lusch, Vargo et al. 2010)</td><td>(IBM 2000), (Vasudevan 2001), (Nghiem 2002), (Booth, Champion et al. 2003), (W3C 2004), (W3C Web Services Architecture Working Group 2004), (Booth, Champion et al. 2003)</td></tr>
</table>

2.3 Semantic descriptions of services

We define three successive types of service descriptions with increasing richness and expressivity, namely syntactic, semantic and social service descriptions (Figure 11).

Syntactic descriptions map to the WSDL standard and are not reviewed in the context of this *Thesis*.

Semantic service frameworks target at enhancing the service descriptions with formal semantics related to the services behavioural and functional characteristics, such as capabilities interfaces, inputs and outputs. Through this, they facilitate (semi-) automated service discovery, composition, publishing and invocation (Martin and Domingue 2007; Verma and Sheth 2007).

Finally, social descriptions of services (which modelling is in fact the ultimate outcome of our work) reflect the customer's view, expectations and feedback. Section 2.3.3 reports grass-root efforts that aim at formalizing this information in order to improve service search, personalisation and recommendation.

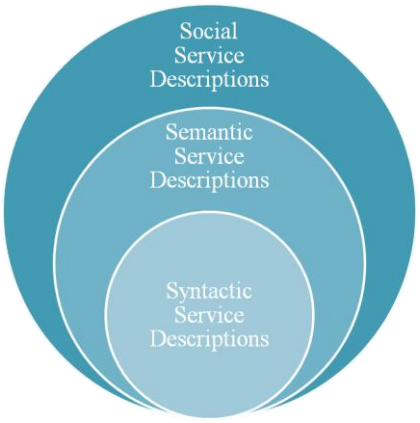

Figure 11: From syntactic to social service descriptions

In the following sections, we focus our discussion on the service ontologies/models of the different semantic Web service (SWS) and lightweight semantic service frameworks. We describe and analyse them, and finally examine whether and how their elements express different aspects of the service description as defined by the five service aspects (see also Table 4).

There are significant efforts for describing and identifying the differences between semantic service frameworks. (Cabral, Domingue et al. 2004) examine how the high-level elements of IRS-II, OWL-S and WSMF facilitate SWS operations, such as discovery and composition, and focus on the architecture, the service ontology and the tools that are offered. For example, they outline that WSMF differentiates from the other two approaches by introducing mediators in the ontology specification to resolve interoperability problems between ontologies (O), Web Services (W) and goals (G). In practice, WSMF mediators are implemented using WSMO Mediators (OO, WW, WG, GG).

(Lara, Roman et al. 2004) compare WSMO and OWL-S. They identify the overlaps and the differences between the two service models and how they are applicable to real environments. They conclude that most of the elements defined in OWL-S can be modeled in WSMO. However, there are aspects, such as the orchestration specification, that are more detailed in OWL-S.

(Martin, Paolucci et al. 2007) perform a comparison between OWL-S and SAWSDL and suggest possible ways of leveraging SAWSDL by using OWL-S constructs as the referents of SAWSDL annotations. They claim that this is required as SAWSDL has limited expressivity. For example, the modelReference of a WSDL interface could refer to an instance of an OWL-S Service Profile class.

(Cabral, Domingue et al. 2006) present the extension points of WSMO that led to IRS-III. These points actually represent how the two SWS frameworks differentiate. For example, IRS-III requires explicit input and output declaration into Goals and Web Services, while WSMO does not introduce such restrictions.

However, these efforts have a different objective than this *Thesis*. The aim of our analysis is not to compare existing semantic service models in order access their expressiveness or their logical and/or epistemological foundations, but to investigate, from a service modelling perspective, the elements that they offer for annotating different aspects of a service and whether they support the customer's perspective.

In order to organise our study, we introduce a service description model, which extends the initial work of (Vitvar, Kopecky et al. 2008), who redefined the traditional notion of a service contract to denote the complementary parts of a service description, namely the information model, the functional descriptions, the non-functional descriptions, the behavioural descriptions and the technical descriptions. This *Thesis* introduces an additional service aspect, namely Social Descriptions, which will engulf information related to the customer expectations, perceptions and feedback.

Table 4: The service description model

Extending the work of (Vitvar, Kopecky et al. 2008), but using the term *service aspect* instead of *service contract* as the latter is very well defined in the SOA literature, e.g. (Papazoglou 2008), we define the provider-driven semantic service description model that comprises of the following *service aspects*:

1. The *Functional Descriptions,* which describe the service's functionalities, namely what a service can offer to its clients when it is invoked. Usually, these functionalities are expressed as capabilities that define the conditions that need to be fulfilled for the service invocation and the effects that the service execution will produce.
2. The *Non-Functional Descriptions*, which define the service's implementation details or the running environment of the service. These descriptions are often expressed as non-functional properties, such as service name, author, URL, identifier, version.
3. The *Behavioral Descriptions*, which define the external behaviour of a service, namely the service's public choreography or the internal workflow of a service.

4. The *Technical Descriptions,* which define details regarding the format of the messages, the communication protocols and the available service's access points. These descriptions are related with the actual communication with the service and finally its execution, and thus usually are given using non-semantic descriptions.

2.3.1 SWS Frameworks

Semantics were applied to SOA as a means to enhance the functionalities of WS architectures and to facilitate flexible business-to-business integration. Semantic services were expected to enable and to facilitate the dynamic discovery, invocation, execution, composition and monitoring of services (Martin and Domingue 2007). By adding semantics to SOA, the three basic entities of SOA as well as the core SOA operations are redefined (Bhiri, Gaaloul et al. 2008). The *Service Provider* continues using WSDL as a standardised interface language, but in addition to that the semantic description of the service has to be developed.

In their turn, *Service Clients* have to formulate their requests in such a way (depending on the formalism followed by the *Service Provider*) that it can be matched with the semantic descriptions of the services. Moreover, it is easier for *Service Clients* to compose semantically described services, as terminological ambiguities and mismatches have been resolved and the transparent exchange of data between the services is achieved (Haller, Gomez et al. 2005; Norton, Pedrinaci et al. 2008).

Finally, the logical data models of *Service Registries* need to be extended so that they can accommodate these richer semantically enhanced service descriptions. In order to support dynamic discovery Service Registries have to be able to represent the capabilities of a service and most important to be able to compute the similarity between the service capabilities and the functionalities requested.

SWS initiatives delivered highly expressive and comprehensive frameworks for describing Web services. Apart from the service model/ontology, *SWS frameworks* as we will refer to these efforts henceforth, also offer a set of tools and mechanisms to support the SWS lifecycle. For example, they provide mechanisms for matchmaking, such as WSMO Goals and OWL-S Service Profiles, discovery and composition mechanisms, and execution environments, such as WSMX. SWS frameworks target the semantic annotation of traditional (SOAP-based) Web Services and the semantic description is decoupled from the WSDL file. As part of our literature review, we have identified the following efforts that belong to this category: OWL-S, SWSF, WSMO and WSMO-Lite.

However, most of these efforts suffer from high complexity as they require specific scientific knowledge and technical expert skills, such as expertise on ontology and rule languages, ontology engineering and first-order logic programming etc. Hence, SWS frameworks are quite demanding in

terms of human resources and computational power. As a result, researchers, service developers and engineers, and business people alike are discouraged from adopting such solutions. Moreover, SWS frameworks were not built upon existing W3C standards (Bournez 2005). This has also a negative impact on their adoption. Despite these, the analysis and the service representations these approaches made available are considered as valuable assets for anyone who tries to model and to implement any type of service system.

The Semantic Web community tried to address the shortcomings by introducing bottom-up lightweight efforts for including semantic annotations in existing standards, such as WSDL and XHTML. We will use the term *lightweight semantic service frameworks* to refer to these efforts in the rest of this *Thesis*. WSDL-S and its successor SAWSDL, SA-REST and MicroWSMO are placed under this category, discussed in the following section.

The Web Ontology Language for Services (OWL-S), formerly known as DAML-S, was introduced in 2003 and submitted to W3C in November 2004 (McIlraith and Martin 2003; Martin, Burstein et al. 2004; Martin, Burstein et al. 2007). Tools, like the OWL-S Editor (Elenius, Denker et al. 2005) are available for supporting the development of OWL-S Services. OWL-S defines four top-level classes in order to describe an upper ontology for services:

- The *Service* which provides the point of reference for a Web Service. It defines three basic properties in order to connect this class to the other classes, namely presents, describedBy and supports.
- The *Service Profile* which defines the functionalities offered by a Web Service. Thus, it is suitable for match-making agents and search engines.
- The *Service Grounding* which specifies how an agent can access the Web Service.
- The *Service Model* which provides information to the client on how to use the Web Service. It facilitates the detailed semantic description of requests, the conditions under which particular outcomes will occur and the process that leads to these outcomes. OWL-S defines services as processes (a process is a subclass of service). A process has inputs, outputs, participants, preconditions, results and effects.

OWL-S provides the means for addressing the four service aspects of Table 4. However, the customer's perspective is not addressed. OWL-S assumes that the semantic description of the service is created and maintained only by the service provider without any contributions from the customers.

Both the Service Profile and the Service Model describe the service's operations and their inputs and outputs and the service's preconditions and effects. Thereafter, both of these classes may be used in order to represent the Functional Descriptions and the Behavioral Descriptions of the service. Still we

need to take into consideration that the Service Profile class constitutes a concise description of the service and may not be too detailed. Service Profiles are used for the discovery process. As a result, they provide only the basic information, i.e. who is the service provider, what function the service computes, and a host of features that specify characteristics of the service, in order to link an instance of a Service Profile with an instance of the service.

The Non-Functional Descriptions can be represented by an OWL ontology, while the Behavioral Descriptions are represented by the OWL-S Process Model. The Technical Descriptions are represented by the Service Grounding which specifies the details on how to access the service.

The Semantic Web Services Framework (SWSF) was introduced in 2005 by the Semantic Web Service Initiative (Battle, Bernstein et al. 2005). It comprises of two major components, namely the Semantic Web Service Ontology (SWSO) (Battle, Bernstein et al. 2005) and the Semantic Web Service Language (SWSL) (Battle, Bernstein et al. 2005).

SWSO presents a conceptual model which specifies how the Web services can be described. There is also a formal representation of that model, which is given in first-order logic and is called First-order Logic Ontology for Web Services (FLOWS). The axioms from FLOWS have been translated into SWSL-Rules, thus resulting in the Rules Ontology for Web Services (ROWS), which relies on logic-programming semantics. SWSF FLOWS, builds on the conceptual model of OWL-S, extends its expressivity and facilitates process interoperability.

FLOWS, as well as ROWS, offer an ontology for service descriptors, a process model ontology and a grounding which relates the message types to WSDL messages. Therefore, the following statements hold true for both.

The service descriptors provide basic information about a Web Service, such as service name, author and contributor. The Non-Functional Descriptions can be represented by the service descriptors. The FLOWS-Core process model provides a formal basis for defining any process models of Web Services. The building blocks of a process model are the atomic processes which constitute atomic activities that come up with input, output, precondition and effect parameters (IOPE). The FLOWS ontology specifies how these are defined and how they are associated with a concrete atomic process. The abstract service descriptions are not coupled with the SWSO groundings in order to enable reusability. Thus, the Functional Descriptions and the Behavioral Descriptions of a service can be expressed by the FLOWS-Core process model.

The abstract service descriptions are not coupled with the SWSO groundings in order to enable reusability. The grounding of a service and the Technical Descriptions are provided by both the SWSO and the WSDL grounding. The two specifications complement each other.

The Web Service Modelling Ontology (WSMO) (Polleres, Bussler et al. 2005; Roman, Keller et al. 2005) was first introduced in 2005 and was submitted to W3C in the same year. WSMO has been developed, used and extended in many research projects such as DIP (Vasiliu, Harand et al. 2004) and SemanticGov (Loutas, Peristeras et al. 2008). In the context of these projects tools have been developed in order to support the development of WSMO Web Services. Some of the most popular ones are WSMO Studio (Dimitrov, Simov et al. 2007), the Web Service Modelling Toolkit (WSMT) (Kerrigan 2005) and the WSMO-PA Service Editor (Loutas, Giantsiou et al. 2008). WSMO is also supported by a SWS execution environment, i.e. WSMX (Bussler, Cimpian et al. 2005; Haller, Cimpian et al. 2005).

Moreover, WSMO provided the conceptual model on top of which the Internet Reasoning Service (IRS-III) was based (Cabral, Domingue et al. 2006). We therefore decided not to discuss IRS-III separately.

WSMO consists of four top-level elements that need to be described in order to define Semantic Web Services. These are the Ontologies, the Web Services, the Goals and the Mediators. As our focus in this work is on service models, we will limit our discussion to WSMO Ontologies and Web Services.

The *Ontologies* provide the means for encoding the necessary semantics per case by defining concepts and relationships between the concepts. The concepts constitute the main elements in an ontology and they represent classes of objects that share one or more attributes and the relations model interdependencies between several concepts. Finally, a set of axioms may be defined in an ontology.

The *Web Service* provides the conceptual model for describing the non-functional properties, the capability and the interfaces of a Web Service. The capability describes the functionality offered by the Web Service and is defined through its preconditions, assumptions, postconditions and effects.

The *preconditions* specify the state of the information that is required before the Web Service's execution (e.g. age>18). The *assumptions* describe the state of the world which is assumed before the execution of the Web Service (e.g. a valid credit card). The *postconditions* specify the state of the information after the execution of the Web Service (e.g. confirmation of a reservation). Finally, the *effects* describe the state of the world after the successful execution of the Web Service (e.g. deduction of the credit card balance).

The Web Service interface is described by defining its choreography and orchestration. The necessary input and output information for each service's capability are described in the *Choreography* of the service. Finally, the *Orchestration* reflects the dependencies of a Web Service with other Web Services.

WSMO provides all the elements in order to define a Web Service according to the four service aspects. The Functional Descriptions are represented by the Web Service capability, where the preconditions, the assumptions, the postconditions and the effects are encoded.

The Non-Functional Descriptions can be represented either using an ontology and/or the non-functional properties of the service.

The Behavioral Descriptions are represented in the Web Service choreography where the necessary information to communicate with the Web Service is provided, while the Technical Descriptions are provided in the WSDL file. Finally, social description of services is not addressed by WSMO. Similarly to OWL-S and SWSF, WSMO assumes that the semantic description of the service is created and maintained only by the service provider without any contributions from the user's side.

WSMO-Lite, which was first introduced in 2007, aims at providing a lightweight approach for semantically annotating a Web Service (Vitvar, Kopecky et al. 2008; Fensel, Fischer et al. 2010). WSMO-Lite is combined with hRESTS for describing RESTful services in the context of the Web of Services (Roman et. al, 2014).

WSMO-Lite identifies a simple vocabulary for semantic descriptions of services (a service ontology) as well as languages used to define these descriptions. Moreover, it defines an annotation mechanism for WSDL using the service ontology. It follows the same structure as WSMO with the difference that it is simplified by leaving Goals and Mediators out of scope. Therefore, the only top-level elements that are defined in the context of WSMO-Lite are Web Services and Ontologies.

The WSMO-Lite service ontology defines the following elements:

- The *Ontology* which specifies a set of assertions about the data model for input, output and fault messages. WSMO-Lite Ontologies are limited to the ontologies that define service information models. WSMO-Lite allows the use of any ontology language with RDF syntax.
- The *Functional Classification root* which describes the Web Service's functionalities. This classification can be considered as a taxonomy which can be used for the functional description of a service.
- The *Non-Functional Parameter* which represents a concrete domain-specific non-functional property.
- The *Conditions* to be fulfilled before the service invocation.
- The *Effects* that come from the execution of the service. The Conditions and the Effects of a service comprise the capability of the service which forms the functional service description.
- The *Axiom* which represents the logical expressions for service's conditions and effects.

The Functional Descriptions are expressed both with the Functional Classification taxonomy and the capability of the service, which is expressed by the service conditions and effects. The Non-Functional Descriptions are represented using Non-Functional Parameters.

The Behavioral descriptions cannot explicitly be associated with any of WSMO-Lite's elements, as it does not explicitly support choreographies. Therefore, in (Vitvar, Kopecky et al. 2008) a way to derive the public part of the Behavioral Descriptions from the Functional Descriptions of the operations of the service is presented. Similarly to WSMO, the Technical Descriptions are not included in the service ontology as they are represented in the respective WSDL file. WSMO-Lite does not consider the social description of services.

SWS Metamodel. OWL-S, WSDL-S, WSMO and SWSF, are reviewed in (Lautenbacher and Bauer 2007) with respect to the logics supported and the ontology language used. They are grouped into three categories: no logic predefined (WSDL-S), description logic (OWL-S, WSMO) and first-order logic (WSMO, SWSF). Additionally, based on the comparison of the four service models, they propose a metamodel for SWS in the form of a UML-profile. The metamodel consists of five main packages, namely Service Provider, Process Flow, Functional, Interfaces and Ontology, each one containing a set of classes. The metamodel is platform independent, but also includes constructs for specific SWS languages, thus allowing code generation.

Functional Descriptions are covered by the Functional and the Interfaces packages, while the Non-functional Descriptions are realised through the Service Provider and the Ontology packages. The Process Flow package addresses the Behavioral Descriptions. The SWS metamodel covers the Technical Descriptions through the Interfaces Package.

2.3.2 Lightweight Semantic Service Frameworks

Lightweight semantic service frameworks aim at lowering the computational complexity and at reducing the effort required in order to annotate a service. Unlike traditional SWS frameworks which are bound to specific ontology languages, e.g. WSMO - WSML and OWL - OWL-S, lightweight semantic service frameworks are more flexible and do not specify a language to represent the semantic models for annotations. Their expressivity, however, is limited as compared to SWS frameworks. For example, most of them do not offer inherent support for modelling the pre- and postconditions of a service. Lightweight semantic service frameworks are expected to boost the adoption of the semantic annotation of services by industry. As argued by (Benjamins, Davies et al. 2008), the provision of Web-based lightweight integration infrastructures will facilitate openness and easy adoption for both service providers and service clients.

In this section we focus our discussion on the service models/ontologies that are proposed by four lightweight SWS frameworks, namely WSDL-S and its successor SAWSDL, MicroWSMO and the Minimal Service Model.

Web Service Semantics (WSDL-S) acts as a meta-model for WSDL 2.0 (Miller, Verma et al. 2004; Akkiraju, Farrell et al. 2005; Akkiraju, Farrell et al. 2006). It was first developed in 2004 in the context of the METEOR-S project (Verma, Sivashanmugam et al. 2005). WSDL-S became a W3C Member Submission in 2005 (Akkiraju, Farrell et al. 2005). It provides a mechanism for creating SWS descriptions by annotating the service and its inputs, outputs and operations. Additionally, it allows specifying and annotating preconditions and effects of SWS. The annotation is performed using semantic concepts referenced from a semantic model, i.e. an ontology.

(Akkiraju, Farrell et al. 2005) identify the specific needs in the WSDL service descriptions and the extensions that satisfy these needs was presented. WSDL-S is an approach to enrich the expressivity of WSDL with semantics while being agnostic to the semantic ontology language. This is a significant difference from the SWS models presented previously, as WSDL-S allows the integration of the semantic and non-semantic description of the Web Service. This is achieved by accommodating the semantic information in the WSDL service. WSDL-S proposes the following five extensibility elements:

- The *modelReference* which enables the binding of a WSDL element to one or more concepts of the semantic model.
- The *schemaMapping* which allows the mapping of the schema elements of the Web Service with elements defined in the semantic model.
- The *category* which allows the inclusion of categorisation information in the service description that may be further used in publishing the service in a services' registry, such as UDDI.
- The *precondition* which comprises of a set of statements that are formed using concepts of a semantic model and need to be validated before the operation's invocation.
- The *effect* which describes the statements that are true after the completion of the operation's execution.

The Functional Descriptions are expressed by the semantic annotations that are embedded in the operation elements of the Web Service. The capability of the service can be reflected by the preconditions and effects of the operations. The Non-Functional Descriptions are represented partially by the category element. Non-Functional Descriptions can also be defined with the use of ontologies.

The Behavioral Descriptions are described by the operations and their input and output elements. WSDL-S, as mentioned earlier, enables the association of these constructs with concepts of the Information Model.

The Technical Descriptions are described sufficiently in the WSDL file. Furthermore, WSDL-S enables the connection of the elements that model the schema mapping with elements defined in the Information Model.

Social description of services is not addressed by WSDL-S. Similar to traditional SWS frameworks, WSDL-S assumes that the semantic description of the service is created and maintained only by the service provider without any contributions from the users.

Semantic Annotations for WSDL and XML Schema (SAWSDL) introduced in 2007 a set of extensions for WSDL in order to include semantic annotations in the Web Services' description (Farrell and Lausen 2007; Kopecky, Vitvar et al. 2007). It is the successor of WSDL-S. SAWSDL introduces a simple and flexible annotation mechanism that relies on an already standardised approach. This helped SAWSDL become quickly a W3C recommendation. It can be considered as a layer on top of WSDL that enables the association of the components with their semantics. The extensions proposed by SAWSDL are:

- The *modelReference* element which associates a WSDL component with a semantic concept. It can be applied to wsdl:interface, wsdl:operation, wsdl:fault, xs:element, xs:complexType, xs:simpleType and xs:attribute.
- The *liftingSchemaMapping* element which specifies the mapping file (by referencing its URI) for the transformation of the XML data from a Web Service message to the underlying semantic model. It can be applied to xs:element, xs:complexType and xs:simpleType.
- The *loweringSchemaMapping* element which specifies the mapping file (by referencing its URI) that should be used for transforming the data from a semantic model to an XML message. It can be applied to xs:element, xs:complexType and xs:simpleType.

Although, SAWSDL wins in simplicity and flexibility, there are also voices that support that SAWSDL is of very little use unless there is an additional specification of conventions and guidelines for what can be referred to in some particular semantic framework (Sheth 2007).

Although SAWSDL provides a way to semantically annotate service's operations by applying model references to wsdl:operation elements, it provides no means to specify operations' preconditions and effects.

The Behavioral Descriptions may be represented by WSDL related specifications for choreography and workflow descriptions. Similarly, the Non-Functional Descriptions can be provided by using WSDL related specifications.

SAWSDL provides no elements for representing any of the Behavioral, Non-Functional. Similarly to WSDL-S, social annotation of services is not addressed either.

Semantic Annotations in REST services (SA-REST) (Lathem, Gomadam et al. 2007; Sheth, Gomadam et al. 2007) proposes a lightweight approach for adding semantics to RESTful services. It is the first effort made for annotating RESTful services. SA-REST assumes that the service provider creates a XHTML service description. It then suggests using RDFa or GRDDL to include semantics (in the form of RDF triples) in this XHTML description. The service provider is free to decide where and how to embed the triples. However, the subject of the triple should always be the URL at which the service can be invoked, the predicate should be one of SA-REST's predicates and the object should be either a URI to a resource or a literal. SA-REST defines the following predicates:

- *operation* which annotates the operations of a service.
- *input* which annotates the inputs of an operation.
- *output* which annotates the outputs of an operation.
- *domain-rel* which models the domain of a service.
- *method* which refers to the method used for accessing the service, i.e. GET or POST.
- *p-lang-binding* which describes the programming languages supported by the service.
- *sem-rel* which describes a link in a service.
- *sem-class* which acts as a placeholder for a link to some ontology/taxonomy/schema. This is actually the element that facilitates the inclusion of formal semantics in the HTML description.
- *data-format* which enables the description of data formats, e.g. XML, RSS.
- *protocol* which refers to the protocol used for invoking a service, i.e. SOAP REST.
- *lifting* which associates a service with the file that is responsible for lifting data from XML to a semantic model.
- *lowering* which specifies the file that is responsible for transforming the data that come from a semantic model to XML.

The external behaviour of a service can be identified by its inputs and outputs. The service's inputs and outputs specify the required information in order to communicate with the service, thus a direct mapping to the Information Model exists.

The Functional Descriptions of a service may be represented by its operations. However, SA-REST does not provide a way to model the conditions and effects of each operation.

Both the Behavioral Descriptions and the Functional Descriptions are weakly defined in SA-REST, because it aims at providing a lightweight approach for service descriptions thus sacrificing its expressivity.

Technical information can be represented by the method and protocol elements, while, Non-Functional Descriptions can be derived from the domain-rel, sem-class and sem-rel elements.

Social description of services is not addressed by SA-REST.

MicroWSMO (Kopecky, Vitvar et al. 2009) was proposed in 2008 by the WSMO Group and extends hRESTS (HTML for RESTful Services). hRESTS allow for creating machine-readable descriptions of Web APIs. The hRESTS microformat describes main aspects of services, such as operations, inputs and outputs. MicroWSMO allows the inclusion of semantic descriptions that adopt the WSMO-Lite service ontology. The following classes are defined in the context of hRESTS microformat definition:

- The *Service* which annotates the service description.
- The *Operation* which annotates a description of a specific operation.
- The *Address* which specifies the URI of a specific operation.
- The *Method* which specifies the HTTP method used by a specific operation.
- The *Input* which indicates the description of the inputs of an operation.
- The *Output* which indicates the description of the outputs of an operation.
- The *Label* which specifies a textual description for a service, an operation or a message.
- The *Mref* which associates a service description with an ontological class.

MicroWSMO addresses the same service aspects as SA-REST and in a similar manner. Although it provides the means for defining the Functional, Behavioral and Technical Descriptions, the classes that are given towards this purpose do not capture the full expressivity provided by the SWS frameworks. More specifically, the preconditions and effects of an operation cannot be associated with any of the specified classes. MicroWSMO does not address the social annotation of services.

Minimal Service Model. iServe, a search engine for semantic Web services, has introduced a Minimal Service Model (MSM) to support the annotation of both SOAP and Restful services (Pedrinaci and Domingue 2010). The elements of the minimal service model derive from hRESTS and WSMO-Lite. It thus defines Services which have a number of Operations. Operations in turn have input, output and fault MessageContent descriptions. MessageContent may be composed of mandatory or optional MessageParts. MessageParts support finer-grained input/output discovery, as available in SAWSDL, OWL-S and WSMO.

Functional Descriptions are covered by Capability, while the Non-functional Descriptions are realised through ontologies and/or non-functional properties. Behavioral Descriptions are not explicitly supported and the Technical Descriptions are left to be defined in the WSDL file.

2.3.3 Social Descriptions of Services

In the context of the Web of Services, an increasing number of research efforts argue that SOA should be extended with social aspects, e.g. (Schroth and Janner 2007; Taylor and Tofts 2008). Researchers support that bottom-up user-defined data can be collected and used for creating or enriching existing service descriptions.

Different approaches exist with respect to the collection of customer-provided service information. Some researchers propose the direct (explicit) collection of the customers' feedback using tags or rating that are widely used in the Web of Services for annotating content and media. Others suggest the development of social descriptions of services through the indirect (implicit) collection and processing of service usage data and posts of customers on social media (a habbit becoming increasing popular). Finally, some hybrid approaches exist that combine both implicit and explicit customer feedback for the social description of services.

These efforts lay the ground for the models that will be introduced later on in this *Thesis*. They clearly show that the new service description paradigm, i.e. social descriptions, is steadily increasing its popularity. However, most of these efforts are ad hoc and bound to specific implementations. They do not rely on (or propose) a generic, reusable model that can support a systematic approach for extending existing service models with social descriptions.

(Meyer and Weske 2006) enable users to describe services using tags in order to capture the real world aspects of service usage and to close the gap between the provider-oriented service description and the real world service usage. The tags provided by the users refine the categorisation of the services (initially developed by the service provider) and facilitate service search.

Seekda[6] and ProgrammableWeb[7] also allow their users to tag the service descriptions that they view, thus including the customer's perspective. They then exploit user-generated tags to facilitate service browsing and search.

(Leitner, Michlmayr et al. 2009) capitalise on users' feedback to facilitate Web service selection. Two different types of feedback are defined: unstructured and structured. Unstructured feedback is given

[6] http://webservices.seekda.com/
[7] http://www.programmableweb.com/

in the form of tags. Unstructured feedback is used to characterise the Quality of Experience(van Moorsel 2001) provided by a service in a very open form. Structured feedback is in the form of numerical ratings between 1 and 5 to numerically rank services for selection. They authors also introduce a Feedback Model to formally represent structured and unstructured feedback. The core elements of the model are: interaction, rating, interaction tag, client, trust and identity.

In BioCatalogue[8] users can describe, tag, recommend and comment on the indexed Web services. Therefore, they are able to *(i)* define the purpose of the service, *(ii)* describe the input and the output of the service and provide examples, and *(iii)* categorise the service based on its functions. An implicit service model is used comprising of the following elements: service, service provider, input and output, service category and function.

(Gawinecki, Cabri et al. 2010) model service functionality according to three facets: input, output, and behaviour. They employ collaborative tagging techniques to describe each of them. To address the cold-start problem, they propose initially to assign system tags manually by a service broker either on the base of parameter names (input and output tags) or of the WSDL documentation (generic functional categories). They use the tag-based descriptions of the services to facilitate service matchmaking, i.e. to match user's requests to available services.

(AbuJarour, Naumann et al. 2010) propose the description of services with tags that are automatically generated – and not provided by the users. They generate tags by processing the textual (i.e. HTML) descriptions of services.

(AbuJarour and Naumann 2010) describe services using tags that are automatically generated – once again not provided by the users. They generate tags by processing the responses, e.g. SOAP messages, of Dynamic Data Web Services, e.g. news, events, offers and promotions services. Tags are extracted and then ranked. Finally, the most relevant terms are selected as service tags.

(Xuanzhe, Zhao et al. 2010) use of tags in order to describe the services available in a mashup editor. Users can attach tags to describe the inputs and outputs of a service. Tag-based service descriptions are then utilised to improve service discovery, recommendation and composition.

(Birukou, Blanzieri et al. 2007) developed a recommendation system that collects data during the interaction of application developers with the system and utilizes this data to improve service discovery and recommendation (in this case developers are considered to be the users of the service system). The whole process of service usage data collection is transparent to the user. As such, users

[8] http://www.biocatalogue.org

are not explicitly asked to describe or evaluate services. Appropriate services are recommended using a task description and the history of previous decisions made for similar objectives. The recommendation of related services is based on the similarity between observed actions (e.g. submit_request or invoke), which is in turn determined by the similarities of names, attributes, and objects.

(Treiber, Kritikos et al. 2009) talk about socially oriented mashups. They propose a service mashup model which includes context information and human related QoS attributes that can be exploited during the execution of the mashup. This information is then used to facilitate the composition of services in the mashup editor.

In a similar line of work, (Chan, Gaaloul et al. 2010) propose to utilize service usage data in order to recommend related services. They argue that traditional service recommendation approaches, e.g. based on query strings or semantic service descriptions, are underperforming as they do not capture the user's view and interests. Hence, they track the users' behaviour and apply collaborative filtering techniques to discover latent relationships between services. The knowledge generated could be used beyond service discovery and recommendation in order to enhance the description of these services.

(Zhang, Zettsu et al. 2010) exploit services application background and usage history for describing services made available through their Web service search engine. They develop a context model to formally express service usage information. Based on the model, they build a services' collaboration graph and analyse the collaboration structure to rank services depending on their usage goodness, thus improving the results of the Web service search engine.

(Fernandez, Hayes et al. 2008) argue that the social description of services, e.g. using tags and/or service usage data, can close the service discovery gap, thus allowing users to search for services using their own terms and not the predefined vocabulary (jargon) of the service provider.

(Averbakh, Krause et al. 2009) employ user feedback to improve the quality of Semantic Web services search. They propose a method for processing user feedback and incorporating it in the matchmaking process. They propose a matchmaking process that uses previously provided user feedback in order to improve the quality of the retrieved results. They consider both explicit and implicit feedback. They say for example, that if an application uses services to generate recommendations, then users can be asked if they consider the given recommendations appropriate. Based on the assumption that services delivering high quality recommendations are better matches for this task, the application can infer the relevance of a service, and pass this information as a user rating to the matchmaking service.

(Zheng, Ma et al. 2009) developed a Web service recommender system based on *(i)* QoS information contributed directly by the users and *(ii)* a hybrid collaborative filtering algorithm for QoS value

prediction. Collaborative filtering allows predicting the QoS performance of a Web service for an active user by employing historical QoS information from other similar service consumers, who have similar historical QoS experience on the same set of commonly-invoked Web services.

(Schott, Burns et al. 2010) model services and their APIs as social objects. They propose that services and APIs can described by their users via tags, which are then used to facilitate service search, discovery and recommendation. They also imply that services can also be described and linked with each other by monitoring the customers' behaviour (e.g. harnessing service usage data). (Schott, Burns et al. 2010) assume that the users of the service are service developers themselves, but differentiate them from the service provider. They propose a simple service model that includes the customer's perspective of the service. It comprises of the following elements: service name, service description, service owner, service documentation, service definition, service location, service creation date, service version, tags, applications using the service, developers using service, service discussion, service followers, and social networking community.

(Zhao, Ma et al. 2010) introduce HyperService, a platform for service consumption, exploration and navigation based on Web 2.0 and semantic technologies. HyperService allows users to describe the services they use using tags. Moreover, they monitor the behaviour of the users in order to discover hidden service relationships. The service model of HyperService includes two following two elements that include the customer's perspective in the service: *TA* that refers to the tags of a service and *UB* that is the statistical analysis result based on the user behaviour records of the service (e.g. usage count, the rating score, etc.).

2.3.4 Discussion

This section summarises the analysis of section 2.3. For each SWS framework we identified which of the service aspects are addressed and how this is accomplished. We observe that all SWS frameworks define explicitly the elements of the service description that are used for the Functional Descriptions. Preconditions and effects are thus common in all frameworks. As expected, differences in the terminology exist. Most of the SWS frameworks recommend the use of ontologies for defining the Non-Functional Descriptions. With regards to the Behavioral Descriptions, WSMO defines the service's choreography for describing the public behaviour of the service, while WSMO-Lite does not explicitly support choreographies. OWL-S perceives a service as a process and uses a Process Ontology for its definition. Similar to OWL-S, SWSF provides the FLOWS-Core Process Model in order to define a service's process models. Regarding the Technical Descriptions, WSMO and WSMO-Lite map between the ontological data of the WMSO service and its representation as XML input/output messages of the WSDL service. Both OWL-S and SWSF provide explicit mappings to WSDL, through OWL-S and

SWSO grounding respectively. Finally, none of the SWS frameworks deals with the social description of services. This finding was rather expected as SWS perceive service descriptions as provider-oriented constructs.

The lightweight semantic service frameworks offer less complex ways of creating semantic descriptions and can be considered as an effective solution for describing services. However, most of them, with the exception of WSDL-S, lack in expressivity compared to the SWS frameworks. With regards to the definition of the service's functionalities, WSDL-S, SAWSDL, SA-REST and MicroWSMO describe operations, but do not propose the use of a specific language for the definition of preconditions and effects. Moreover, the behaviour of a service may be derived from its operations and inputs and outputs elements. The different states and the transition through these states are not modeled by any of the five models. The technical descriptions are given in SA-REST and MicroWSMO via attributes and classes that were defined for this purpose, whereas WSDL-S and SAWSDL utilize the WSDL specification. Finally, none of the five lightweight semantic service frameworks support the social description of services. This finding was rather expected as in this case as well service descriptions are perceived as provider-oriented constructs. The discussion so far is summarised in Table 5 and is further detailed in the work of Loutas et. al (2011).

Table 5: Analysis of semantic service frameworks

	Functional Descriptions	Non-Functional Descriptions	Behavioral Descriptions	Technical Descriptions
SWS frameworks				
OWL-S	Service Profile or Service Model	OWL Ontologies	Service Model	Grounding
SWSF	FLOWS-Core Process Model	Service Descriptors	FLOWS-Core Process Model	SWSO Grounding
WSMO	WSMO Capability	Non-Functional Properties	WSMO Choreography	- (defined in the WSDL binding and WSDL service)
WSMO -Lite	Capability	Ontology or non-Functional Properties	Not explicitly supported	covered by the non-semantic description in WSDL
SWS Metamodel	Functional and interface packages	Service Provider and Ontology packages	Process Flow package	Interfaces Package
Lightweight semantic service models				
SAWSDL	modelReference in wsdl:operation (preconditions and effects are not defined)	No	modelReference in wsdl:operation, wsdl:interface and xsd:element	defined in WSDL binding and WSDL service

SA-REST	operation (preconditions and effects are not defined)	domain-rel, sem-class, sem-rel	input, output, operation	method, protocol
Micro WSMO	operation (preconditions and effects are not defined)	address, label	operation, input, output	method
MSM	Capability	ontologies and/or non-functional properties	No	defined in WSDL binding and WSDL service

The works on the social description of services discussed in section 2.3.3 are summarised in Table 6. They are organised according to the way that customer-provided service information is provided, i.e. implicitly, explicitly or following a hybrid approach. Although all of them support the need for social description of services, most of these efforts are implemented in an adhoc manner and none of them took the extra step to model service from the customer viewpoint and understand what this new species of service descriptions will actually comprise; thus being able to incorporate the customers' perspective in service descriptions.

Table 6: Summary of efforts towards the social description of services

	Explicit (e.g. tagging)	Implicit (e.g. service usage data)
(Meyer and Weske 2006)	☑	
Seekda	☑	
ProgrammableWeb	☑	
(Leitner et al., 2009)	☑	
BioCatalogue	☑	
(Gawinecki, Cabri et al. 2010)	☑	
(Xuanzhe, Zhao et al. 2010)	☑	
(AbuJarour, Naumann et al. 2010)	☑	
(AbuJarour and Naumann 2010)	☑ (dynamic)	
(Birukou, Blanzieri et al. 2007)		☑
(Treiber et al., 2009)		☑
(Chan, Gaaloul et al. 2010)		☑
(Zhang, Zettsu et al. 2010)		☑
(Fernandez, Hayes et al. 2008)	☑	☑
(Averbakh, Krause et al. 2009)	☑	☑
(Zheng et al., 2009)	☑	☑
(Schott, Burns et al. 2010)	☑	☑
(Zhao, Ma et al. 2010)	☑	☑

Chapter 3
The service lifecycle from the customer viewpoint

You never really understand a person until you consider things from his point of view.
Harper Lee

3.1 Introduction

In this *Thesis*, we emphasise the customer-centric nature of service provision and extend service models with customer-oriented concepts in order to reflect this. The first step towards this direction is to understand customers' participation in service provision and elicit modelling requirements that will allow us to formally represent the customers' viewpoint in the service model that we develop in the next chapter.

Services are by definition designed and delivered in order to satisfy needs of their customers. It is therefore vital for service providers to understand what customers expect from a particular service and how they perceive it and how are customers involved in all stages of the service lifecycle. We group customer expectations, perceptions, views and roles under the overarching term *'customer viewpoint of the service'*.

TOGAF defines that a viewpoint is "where you are looking from - the vantage point or perspective that determines what you see[9]". A viewpoint can be effectively expressed using a conceptual schema or a data model like the ones introduced in this chapter.

Despite the importance of the customer, which is acknowledged by the vast majority of related efforts (see also Chapter 2), service literature has focused up to now on modelling service from the viewpoint of the service provider (discussed in the previous chapter). SOA service models in particular, such as the OASIS Reference Model for SOA and the SOA ontology discussed in section 2.2, perceive service as a given to the customers, thus limiting the degree of customer participation in the service. This practically means that these service models focus on the functional, non-functional, behavioural and

[9] http://pubs.opengroup.org/architecture/togaf9-doc/arch/

technical aspects of a service from the provider viewpoint (as defined in Table 5 of section 2.2.5), leaving aside the modelling of the customer viewpoint.

In order to model the customer viewpoint, we study in the remainder of this chapter how customers participate in all stages of the service lifecycle. As we discuss later, the customer viewpoint is expressed mainly through the expectations that customers contribute when searching for a service and the feedback they give when evaluating a service that they have just used. However, as we explain in the next section, the participation of the customer is not limited to service search and evaluation, but spans across the service lifecycle. We therefore define the way that customers perceive and experience the service lifecycle in the following section.

But is there a difference between the way that service providers and customers view service? The answer is definitely positive. (Heinonen, Strandvik et al. 2010) confirm that the customers' viewpoint of the service is often different from that of the service provider. This divide concerns both the how the service itself is perceived, understood and experienced, and how the overall service lifecycle is experienced. Similar to how we define the customer viewpoint in our work, they argue that the customer viewpoint is formed based on emotional factors and experiences that do not consist only of cognition, calculation and overt behavior, but are by nature also subjective. The customer's view point according to the research of (Heinonen, Strandvik et al. 2010) is not formed based on the consumption of a single service, but is influenced by prior experiences, by word of mouth and interactions with other customers, as well as by the post-service support activities provided (if required) by the service provider.

One of the main factors that widen the divide between the service provider's and the customers's viewpoints is that in many cases the provision of (new) services is driven not by customer's needs and demand but by technological innovation, marketing and the wish of providers to expand their market share. Hence, there is a gap between supply and demand. In this inverse situation, service providers end up trying to create demand for their services.

Providers do not always have a clear view of customers' needs and expectations, although nowadays, mainly due to the extended use of social media, customers do express openly their needs and expectations of service. This happens because of often service providers limit their view on the actuall provision of a service and do not take into account (or ignore) prior experiences and contexts of customers, their reputation among their target audience and the opinions of customers on their service. Take for instance Tripadvisor and its impact on hospitality services. Providers of such services can receive close-to-real-time feedback and evaluation of the quality of service that they provided to their customers. Feedback is openly expressed and is available to everyone, including competitors and

potential new customers. Therefore, responding to and acting upon the suggestions and the comments received is imperative, given also that prospective customers base their decision to consume a service or not on the experienes and the advice of others. There are other service domains however where *feedback mechanisms* that would enable the efficient communication between providers and customers are not in place and therefore valuable information about the customers' experience with the service never reaches the provider.

In order to bridge this consumer-provider gap, Heinonen and Strandvik argue that service providers and marketing experts should understand customers' needs and intentions and come up with specific services to serve them. We believe that understanding the customer viewpoint of the service and sensing customer satisfaction are main enablers of service innovation and primary drivers of the perpetual enhancement of service quality and improved customer satisfaction.

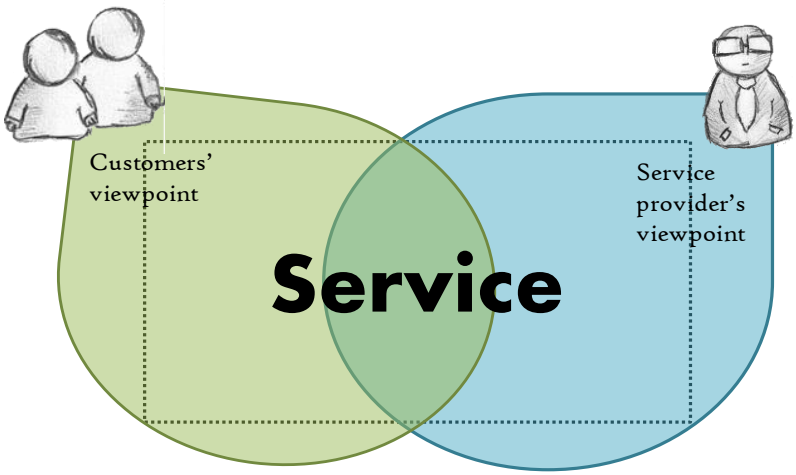

Figure 12: Service provider and customers – two complementary viewpoints

In our view, both viewpoints are equally important and have to be considered together for having a complete view of a service. As shown in Figure 12 above, the service provider and the customer viewpoints are indeed complementary. The service provider viewpoint on the right comprises factual/objective information about the service, including among others what the service offers, who is the target audience, what is the required input and information about the guaranteed service quality levels. The customer viewpoint, on the left, comprises, as discussed above, subjective information related to how the customer understands the services, what she expects from it and what she thinks after having used it (in terms of feedback). The part where the two viewpoints overlap expresses the degree of convergence between the two viewpoints. For service provision to be more customer-centric, this overlapping area should be maximised, to ensure that customers and service providers share a common view over key aspects of the service and that service providers truly understand and meet the needs of their current and potential customers. Our work helps towards this direction.

The remainder of this chapter is organised as follows:

In section 3.2 we study the service lifecycle from the customer viewpoint and highlight the participation of the customer in the different phases. We define the main phases of the lifecycle and the main interaction within the lifecycle where customers play the leading role.

In section 3.3 we elicit a number of high-level requirements concerning the modelling of service from the customer viewpoint, which will drive the modelling work of Chapter 4.

3.2 Studying the lifecycle of the service from the customer viewpoint

This section introduces our study of the service lifecycle. Our analysis focuses mainly on the way that customers experience service, and elaborates on the customer-driven service activities and on activities where the customer has significant participation. As it deals with behavioural aspects of customer-centric service provision, where customers play a leading role, we perceive the service lifecycle as the realisation of the *"How view"* of service provision.

A number of different models for the lifecycle of service have been proposed, particularly in the field of technology-enabled services. We observed that such service lifecycle modelling approaches usually study service over two consecutive phases, namely design-time and runtime. For instance:

- The conceptual architecture for semantic SOA proposed by (Preist 2004; Preist 2004) provides a conceptual model for designing and implementing applications based on semantic service technologies. It defines 'service outsourcing' and 'composition' as part of design-time, and 'discovery', 'contract agreement' and 'service delivery' as part of run-time.
- Oracle's shared service lifecycle defines 'identify business process', 'service modelling' and 'build and compose' as part of design-time, and 'publish and provision', integrate and deploy', 'secure and manage' and 'evaluate' as part of runtime.
- ITIL's service lifecycle[10] defines 'service strategy', 'service design' and 'continual service improvement' as part of design-time, and 'service transition' and 'service operation' as part of runtime.
- Following a SOA-driven approach, Papazoglou and van den Heuvel (2006) define 'service analysis' and 'service design' as part of design-time, and 'service construction', 'service test', 'service provisioning', 'service deployment', 'service execution' and 'service monitoring' as part of runtime.

[10] http://www.itil-officialsite.com/Qualifications/ITILQualificationLevels/ITILLifecycleStream.aspx

- (Haller, Gomez et al. 2005) proposed a 5-stage SOA lifecycle model. Their model focuses on the run-time phase and defines the following stages as part of it: 'matchmaking', 'filtering', 'agreement negotiation', 'contract agreement' and 'service delivery'.

The difference between these approaches and the one developed in our work lies in the viewpoint from which service is seen. Providers have a systemic view of service and the service lifecycle is for them a key tool for managing and governing service. Putting it simply, a service provider needs a structured governance approach for managing the creation, deployment, maintenance and withdrawal of services. For customers however, the lifecycle of service corresponds to different phases of their service consumption experience. We elaborate on this in the remainder of this section.

We define a 5-phased lifecycle for service from the customer viewpoint comprising of the following phases (detailed in section 3.2.3):

1. The need realisation phase;
2. The service search phase;
3. The service personalisation phase;
4. The service delivery phase; and
5. The service evaluation phase.

Each phase comprises a number of service activities (see section 3.2.1), i.e. atomic steps within a service phase carried out by the customer, the service provider and/or other service stakeholders. We focus in this chapter on the discussion of co-production interactions, where the customer has a protagonistic role and collaborates with the service provider (or undertakes completely) a specific activity in the context of the provision of a particular service. We discuss the 5 phases and the co-production interactions that they entail in the following sections. Our analysis in the following sections will help us identify actors, roles and other modelling elements that will then be included in the Customer Service Model of section 4.4.

3.2.1 Service activity

A service activity is an atomic step carried out as part of a phase of the service's lifecycle. The customer, the service provider and/or other service stakeholders may participate in a service activity. We define three types of service activities, namely:

- Basic activities;
- Management and governance activities; and
- Co-production interactions (discussed in the next section).

We limit the discussion in this section to basic activities and management and governance activities, in both of which the participation of the customer is limited. In the next section, we elaborate on co-production interactions, where the customer plays a leading role.

Basic activities, i.e. the tasks that have to be completed by the service provider and/or other actors that participate in a service for the service to be delivered. Basic activities do not require the participation of the customer. For example, the following are considered to be basic activities: the exchange of information between the service provider and one of its suppliers; the interactions between two persons/systems working for the service provider; or even supply chain management related activities. Basic activities are particular to the specific service being modelled.

Management and governance activities that essentially ensure that the service is conducted and delivered properly, that resources are efficiently managed and that failures are taken care of. For example:

- *Monitor a service.* This management activity refers to all the actions that are taken by the actor responsible for the service, in most cases the service provider, throughout the service lifecycle in order to ensure that the service process proceeds without problems and that the communication and collaboration between the different actors is smooth. This activity entails the communication and the exchange of information - regarding performance, quality and availability indicators - between the service provider and the rest of the stakeholders participating in the service process. In case errors are discovered the service provider needs to trigger service recovery actions.
- *Recover a service*. When a service failure is identified, then a set of service recovery actions need to be taken in order to avoid disruptions or to resume the service process that create feelings of dissatisfaction to the service customer and lack of trust in the service provider. Recovering the service means that the service outcome will be realised.
- *Change management*. Throughout the service lifecycle, a number of issues and suggestions for improvement for the service are collected, either from the customers or as a result of service monitoring. These issues are filtered and analysed, and some of them will be grouped into change requests which will be implemented in the new releases of the service. Therefore coordinated and well organised change management contributes directly to the evolution and the improvement of the service. ITIL provides detailed guidelines for change management[11].

[11] http://www.itil-officialsite.com/

The sequence of service activities is defined by means of *behavioural rules*. Behavioural rules define and control the workflow of the service, e.g. the customer must express her preferences before the service provider can recommend to her the appropriate service version. We refer the reader to section 4.4.3.4 for a detailed discussion on service rules.

The concepts discussed in this section are summarised in Figure 13. Detailed modelling of service activities falls under (business) process modelling and is, therefore, out of scope of this *Thesis*.

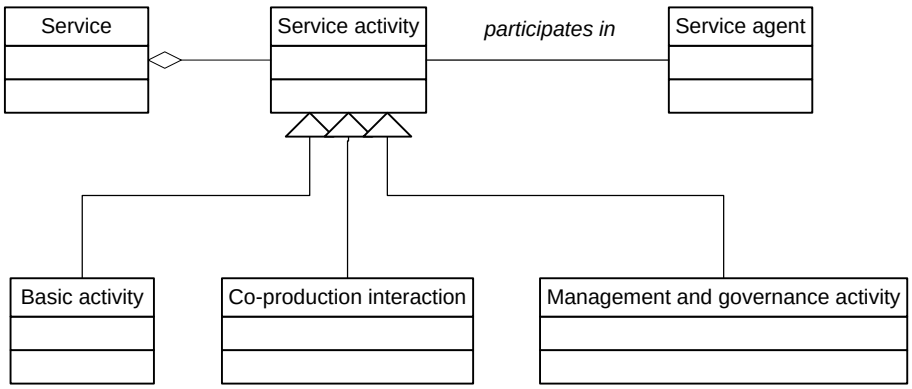

Figure 13: Service activity and related concepts

3.2.2 Co-production interactions

As introduced in the previous section, the participation of customers in service provision is materialised in the context of *co-production interactions*. We decided to name them co-production interactions instead of activities in order to emphasise the active participation of the customer, which is realised through the exchange of information and resources between customers and service providers (or other stakeholders; see section 4.3.3).

(Cermak, File et al. 1994) define customer participation as the specific behaviours, and the degree of customer's effort and involvement, both mental and physical, that relate to the production and delivery of a particular service, while (Dabholkar 1996) defines customer participation as "the degree to which the customer is involved in producing and delivering the service". Customer participation influences service quality and helps formalising the overall service experience (Ostrom, Bitner et al. 2010).

The active role and participation of the customer in service provision is a key requirement of Service Science. The first foundational premise of S-D logic states that the customer is always a co-creator of value (Vargo and Lusch 2008) or put slightly differently a co-producer of service (Fitzsimmons and Fitzsimmons 2006), while (Zhang and Chen 2008) argue that enabling customer participation is the way to satisfy personalised demands.

In our work, we argue that the participation of customers is maximised in the context of co-production interactions. Co-production interactions entail a dual communication, a discourse, and close collaboration between the service provider and the customer, which requires resources, computational, environmental, physical etc., coming from both agents to be exchanged and integrated.

We identify eight co-production interactions, which cover both the design-time and the runtime phases of the service lifecycle. Based on our analysis of different service lifecycles, these interactions are the among the most common and generic service activities. Specific co-production interactions may also exist that will depend on the nature of a particular service. The study of those specific co-production interactions is out of scope of this work.

The definitions of the eight generic co-production interactions are given in the next section, in the context of the phase in which each interaction takes place. We organise them in the following two categories, depending on who takes the lead, i.e. the one that is initiating the interaction and has the main role throughout:

- Customer-driven co-production interactions, namely activities in the service lifecycle where the customer has the primary role (and usually is the one who initiates the activity); and
- Provider-driven co-production interactions, which are interactions initiated by the service provider but still require significant input and contribution by the customer, otherwise they cannot be completed successfully.

A summary of the co-production interactions in the form of a taxonomy is illustrated in Figure 14. This *Thesis* focuses on the detailed modelling and piloting of three of the customer-driven co-production interactions, namely:

- Service search;
- Service personalisation; and
- Service evaluation.

Chapter 5 demonstrates how the modelling elements proposed in Chapter 4 can be used in the development of a number of pilot applications for supporting the three aforementioned co-production interactions.

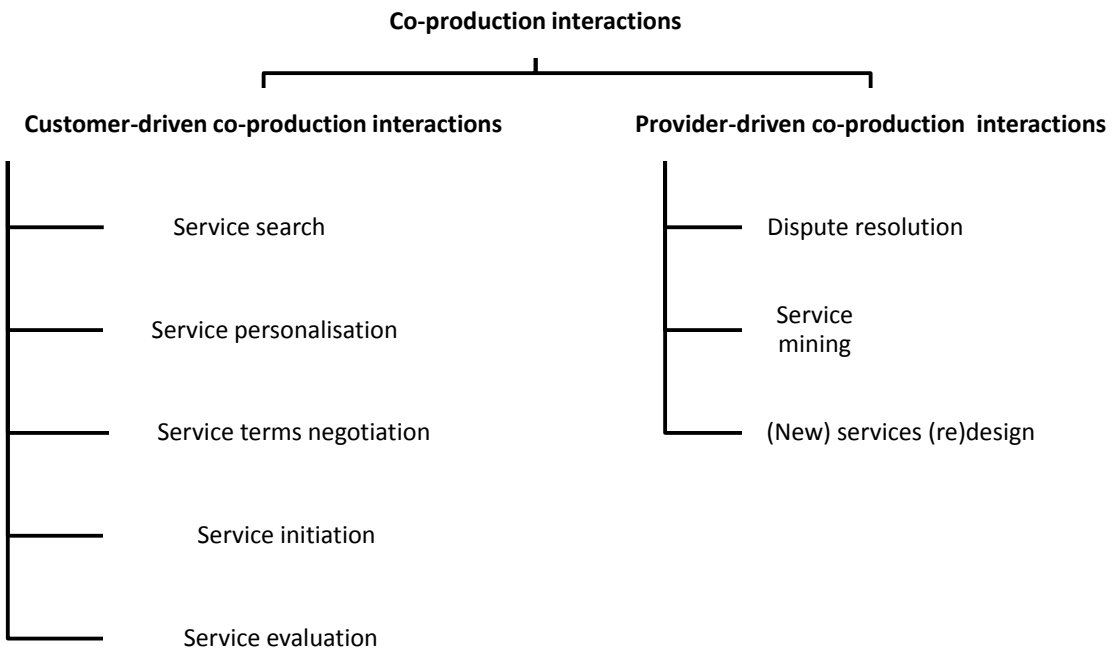

Figure 14: Typology of generic co-production interactions

3.2.2.1 Customer-driven co-production interactions

The following generic customer-driven co-production interactions are defined:

Service search. The service search co-production interaction involves a bidirectional exchange of information between the customer and an entity, e.g. a service provider, a service registry, a Web search engine or even a friend. This exchange of information helps the customer identify alternative services (if any) that can, through their outcome, satisfy her need and meet her expectations, e.g. with regards to quality, needs, service experience, cost etc.. This co-production interaction will ideally result in a list of alternative services accompanied by high-quality descriptions which reflect both the service provider and the customer viewpoints to help the customer take an informed decision. There are cases however when no alternatives exist or when no service in general exists that can fulfil a specific need. Assuming that the service search has yielded a list of alternative services, the customer can select one and move on with personalising it to her profile and context (see section 3.2.3.3). Because of this, service search results in the first actual contact between service providers and customers.

We identify two cases of service search, namely *pull* and *push* service search.

In the case of *pull* service search, the customer has an active role and initiates the service search interaction, e.g. by contacting a service broker or directly the service provider, in order to find out whether a service that addresses her need exists. Pull service search entails an iterative process during which the customer describes her need using a vocabulary that can be understood by the service

provider, goes through service descriptions and requests from the service provider information about candidate services. At the same time, the service provider tries to elicit information from the customer in order to help find the service that she needs. Pull service search is demonstrated in the prototype implementations of this *Thesis* in section 5.3.

Push service search is not directly triggered by the customer, but can be triggered automatically by a change in the customer context or by a (real-world) event, in the form of recommendations for related relevant services pushed to the customer. This event may be a life event in the customer's life, e.g. having a new child or getting married, or another service or may be part of the service provider's marketing strategy. Services that match any of the following would be retrieved in the case of *push* service search:

- The customer's profile, e.g. when the customer updates' her employment status to unemployed, services related to unemployment benefits are recommended to her.
- The customer's service usage patterns and habits, e.g. the customer's footprints in a service system (e.g. a Web portal) are mined in order to recommend services that users with similar behaviour also used.
- Social network analysis results, e.g. recommending to the customer services that were used by other people with similar profiles, or friends/followers of the customer.
- Implicit or explicit relationships between services, e.g. recommending to the customer services that need or should be executed before or after the unemployment benefit service (for example, because their outcome is required as input for the latter) by traversing service links.

Push service search is demonstrated in the prototype implementations of this *Thesis* in section 5.3.

***Service personalisation*.** Services have a high-degree of variability and are thus specialised into different service versions (see also section 4.4.3.5). Service personalisation involves a bidirectional exchange of information between the customer and the service provider. During this communication the service provider tries to collect the required information, regarding the customer's personal needs, characteristics, situation and context, in order to decide if the customer is entitled to use the service (eligibility check) and, if so, which is the service version that best matches her profile and circumstances. This is accomplished by using the information collected by the customer in order to validate service business rules which decide eligibility and define service versions (see section 4.4.3.5).

We model this as a structured customer dialogue which comprises of two phases (see also section 5.4.1):

- *Eligibility check* which entails validating the eligibility rules. We assume that the eligibility rules are validated before the service variant rules (see section 4.4.3.4 for the definitions of the different types of rules). Hence, no service variant-related questions are asked in case the user is not eligible for the service. This saves the customer from providing unnecessary information and minimises the length of the dialogue between customer and service provider.
- *Service version identification* where service variant rules are triggered and evaluated in order to identify the best-matching service version (see also section 4.4.3.4).

***Negotiation of the service terms*.** After a desired service is found, the customer contacts the service provider in order to negotiate the terms of service provision. During this co-production interaction the customer expresses her requirements and limitations (mostly) with regards to service quality, e.g. reliability, availability etc., and to the price, and she expects from the service provider to offer a service able to match these requirements. When such a negotiation takes place, the service personalisation phase concludes when both service provider and customer have agreed on the service provision terms in a formal service contract and/or a service level agreement, e.g. expected level of quality, cost, compensation of the customer in case of a service failure. Negotiation is in fact optional as in many cases there is no formally agreed-to service contract between provider and customer. However, in some cases, for instance when the impact of a potential service failure is too high, e.g. a Cloud service that goes down unexpectedly, or when the service has legally binding implications, e.g. because it entails the transfer of ownership of a good or an asset, then service personalisation becomes highly relevant.

***Service initiation*.** During this interaction the customer asks from the service provider to start the delivery of the service (implement the service activities). It may follow the purchase or it may take place at a later point in time. During this interaction the customer also provides to the service provider all the required service inputs, including preferences, money, information and other types of resources, e.g. documents. Service initiation kicks off the service delivery phase of the service lifecycle.

Service evaluation. In the case of service evaluation, customers express directly and consciously their expectations of and/or feedback on a service. Customer expecations, defined in section 4.4.3.8, refer to what a customer anticipates to receive from a services, how she expects to benefit by consuming it. Customer expectations are expressed and captured before the actual delivery of the service. Service feedback, defined in section 4.4.3.9, referes to opinions and judjements of the customer on the actual service that she is experiencing. Service feedback is expressed and captured during and after service delivery.

Customers base their evaluation of the services that they consume on emotions, personal opinions and assessment of experiences that do not consist only of cognition, calculation and overt behavior, but are by nature subjective.

Service evaluation can happen using different means. People experience things as reactions in their bodies in terms of emotions. A way to elicit this tacit, unstructured information is through subjective reports or is collected during exchanges with the service providers front-office (e.g. customer-facing staff or a web portal). For example, (Lelliot, Hogman et al. 2001) developed a self-assessment instrument to enable users of mental health services to rate their experience. (Desmet 2005) developed a tool to elicit emotional responses of customers. (Yanga, Caib et al. 2005) developed an instrument to measure perceived e-service quality based on a five-dimension service quality instrument involving: usability, usefulness of content, adequacy of information, accessibility, and interaction. Traditional market and user research methods may also be used for collecting explicit service evaluation data, e.g. questionnaires (comprising of open- and/or closed-type questions), interviews with (potential) customers (including open- and/or closed-type questions), follow-up calls and feedback collection forms.

In the context of our research prototypes, we discuss further in section 5.3 how service evaluation can be implemented in the context of the Web of Services.

3.2.2.2 Provider-driven co-production interactions

The following generic provider-driven co-production interactions are defined:

***Dispute resolution*.** This is an optional co-production interaction. It is highly likely that disputes might be raised between service agents that collaborate in service delivery, e.g. because of not respecting an agreed-to contract or a service level agreement. In section 4.3.3, we define three types of service agents, i.e. the service provider, the customer and the service stakeholders.

Disputes need to be resolved in order not to obstruct the service process. Depending on their nature, disputes may be resolved using legal means, compromise, arbitration or other types of negotiation. In any case, resolving a dispute requires a value proposition that will create a win-win situation between the involved service agents. A dispute however might not be resolved at all; in this case this will threat the successful delivery of a service.

Service mining. Service mining refers to the collection of customer expectations and feedback without the customer being necessarily aware of it. Hence this interaction is opaque to the customer. In this case, information about the service and the experience of the customer when consuming it derives mainly through the analysis of service usage patterns of customers using methods for logging and

mining the behaviour of customers throughout the service lifecycle, e.g. searching for services, personalising them and consuming them, and social network analysis. For the sake of privacy, the customer has to be made aware that a service platform is logging her behaviour and collecting data about it, which is then processed in order to support the purposes of the service provider.

Logging the behaviour of customers involves keeping track of all customer activity throughout the service lifecycle by maintaining user logs. The following parameters would be interesting to monitor: recurring customers, services used after or before the consumption of a particular service, customers who are opinion leaders and hence influence the behaviour of others, most/least requested services, the behaviour of not satisfied customers after the consumption of a particular services, time required for completing successfully the provision of a service, reasons why customers interrupt service provision, any delays and bottlenecks in service provision, most/least requested service outcomes, most/least requested service inputs, most/least popular opinions on a service, evolution of customers sentiment on a particular service, contexts in and reasons for which a customer uses a particular service, data related to customer profiling and demographics.

Web analytics refers to the measurement, collection, analysis and reporting of internet data for purposes of understanding and optimising Web usage. Social network analysis refers to the study and the investigation of the relationships between the entities of a social network.

In the context of our research prototypes, we discuss further in section 5.3.1.2 how the service mining can be implemented in the context of the Web of Services.

(New) service (re-)design. In some cases service providers, by analysing customers' needs, expectations and/or feedback, find out that no service exists that can address a particular need of a customer or they may identify gaps in the market that can be filled by:

- integrating existing services in a new service;
- redefining the purpose for which a specific service is used;
- improving the service process and/or delivery (e.g. more efficient, new delivery methods, better technology);
- designing a completely new service.

This co-production interaction practically requires service providers to translate identified needs of customers into services. This interaction has therefore a strong dependency with service evaluation, in order for the service provider to receive all the information required for understanding the needs and expecations of the customers. Depending on the approach followed for (re-)designing a service, the input of the target audience may also be asked and feedback may be collected on intermediate versions of the service to ensure that the final outcome is fit-for-purpose.

The design of a new service is a co-production interaction that involves service providers, customers and possibly other types of collaborators. Apart from organising the roles of the service agents involved and the service process to be followed, design the outcome, and planning of resources required, the service provider should also take care of the service context and invest on a service of high-quality that will meet the expectations of the service clients. The result is a new value proposition, i.e. effectively a new service. The discussion around service redesign has stong links to change management discussed in section 3.2.1.

3.2.3 The 5 phases of the service lifecycle

This section summarises the service lifecycle from the customer viewpoint. We specify that this comprises of the following phases: needs realisation, service search, service personalisation, service delivery and service evaluation. Figure 15 summarises the five phases of the service lifecycle and indicates their sequence.

In the following sections, we discuss each phase separately, including also the co-production interactions that take place per phase. Our discussion:

- Explores the motivation and the rationale behind each phase.
- Identifies the main service agents involved in a phase.
- Lists the co-production interactions that belong in a particular phase and outlines the generic types of information exchanged between the service agents that partake in that phase.
- Positions a phase on the service timeline – namely at pre-service time, during the service execution and at post-service time.

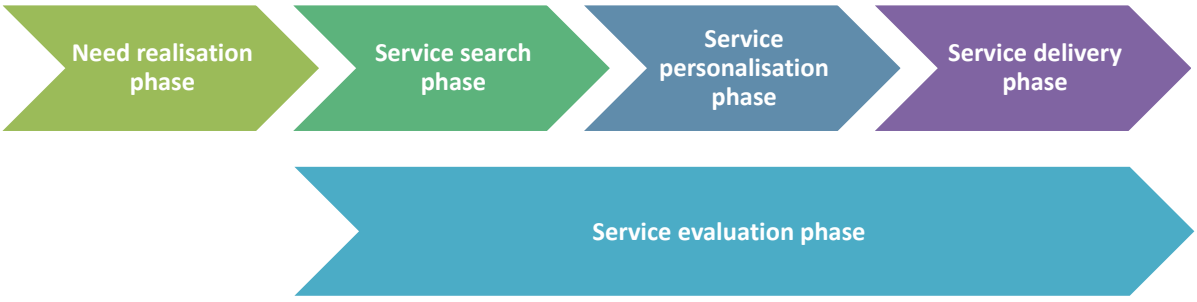

Figure 15: The service lifecycle from the customer viewpoint

3.2.3.1 Need realisation phase

Motivation. During the need realisation phase, a customer understands that she has a particular need or obligation. For example, she may want to travel, to learn a new foreign language or to move to a new country. Once the customer becomes aware of her need, she may decide to look for ways of satisfying that need or she may overlook it, if for example that need is of low priority and can be

neglected or taken care of in the future. During this phase, the customer also forms an initial estimation of the sacrifice that she is willing to make for satisfying her need, i.e. the cost that the customer is willing to pay which can be measured in terms of financial contribution (e.g. a payment) or some sort of in-kind contribution (e.g. contributing a skill or even labour for completing the service). Satisfying a need implies that something brings about a change in the customer's state. In our case, such an effect can be the result of the execution of a service. Hence, once the customer decides that she wants to satisfy her need, she has to find if there exists a service or a set of services capable of doing that. This takes us to the service search phase discussed in section 3.2.3.2.

Service agents. The main actor in this phase is the customer. Other customers, who have previously had a similar need, may also be involved by the customer, mostly for sharing with her their feedback and prior experience. Finally, third-party entities may also be involved in the process of helping a customer realise her need. For example, a doctor may advise his patient to receive a special treatment in case he has diagnosed an illness or a health problem.

Co-production interactions. There is no co-production interaction that takes place during the need realisation phase. The realisation of the need per se is a mental and cognitive process, and modelling it is beyond the scope of our work. What is however important is the fact that the customer has realised that she has a need that must be mapped to a (set of) services, in order to be satisfied.

The need realisation phase is initiated by a trigger, which helps the customer realise her need. This trigger can be:

- A recommendation or request of a third party, e.g. a doctor suggesting to a patient that she has to receive medical treatment.
- An obligation to do something that derives from legislation, e.g. national legislation that requires citizens to declare their income on an annual basis.
- An event that requires from the customer to take action, e.g. a car that broke down and needs to be repaired.
- A personal requirement, desire or consideration, e.g. the customer planning to move to another country or wanting to go on holiday.

During the need realisation phase, there is *no formal* exchange of information between the customer and another service agent. However, there may be *informal* communications between the customer and other service agents involved in this phase. The customer makes use of this prior experience in order to start collecting information about existing services that could satisfy her need. This leads to the initial formulation of the customer expectations.

Timeline. The need realisation phase takes place at pre-service time.

3.2.3.2 Service search phase

Motivation. In order to fulfil their needs, customers need to find matching services by searching among a maze of available services. In fact the first thing that customers need is to find information about a service, in order to be able to take an informed decision as of whether they will be finally consuming the service or not. Such a decision requires finding and accessing trustworthy information about the service, coming from the service provider, from other consumers or other service stakeholders such as service brokers, including also information about the location, physical and/or electronic, where the service is made available from.

Service agents. The following types of service agents are involved in the service search phase:

- The customer looking for a service;
- One or more service providers who make descriptions of their services available, either themselves or through service brokers, so that customers can be informed and decide whether their service fits their need. Service providers must also be able to interpret the needs of customers and link them to existing or new services.
- Service brokers, e.g. from simply yellow page directories to full-fledged service marketplaces, that allow customers to find, access and compare services based on their descriptions.

Co-production interactions. The service search phase comprises the following co-production interaction:

- Service search (see also section 3.2.2.1).

Timeline. The service search phase takes place at pre-service time.

3.2.3.3 Service personalisation phase

Motivation. Already in 2003 Tien and Berg observed a shift from mass production to customisable services, while (Vargo and Lusch 2004) argue that customers use and adapt the service to their individual needs and personal situations. Nowadays services are highly adaptive and customisable in order to respond to the unique needs and peculiarities of each customer, thus meeting customer expectations and improving customer satisfaction.

One-size-fits-all services are no longer enough or adequate. Take for example the case of an e-service for selling airline tickets or holiday packages. The service should be flexible and customisable to allow for experienced or novice customers, customers willing to use their credit card for online purchases or others that prefer paying with cash, customers that wish to receive electronic copies in their email

and customers that prefer having hard copies delivered to them via courier etc. In such a service, customer participation is continuous and contributes significantly to the formulation of the service instance to be finally delivered. It also ensures that the outcome of the service will satisfy the specific needs of the customer thus maximising perceived value (see section 4.4.1.1).

Hence, identifying a service that can satisfy a specific need of the customer is only the first step towards the actual consumption of that service. Before consuming the service, the customer still needs to find out if she is eligible to consume the service, and if so, then to personalise it to her profile and context. There are cases where the consumption of a particular service is restricted to a set of customers that share one or more characteristics; for example public administration offers a set of benefits for people with disabilities, which cannot be consumed by the general public.

Once the eligibility check is successfully completed (i.e. once it is ensured that the customer is eligible to consume the service), the customer still needs to personalise the service to her profile and characteristics. The variability of services makes personalisation valuable for the service experience and for satisfying the customer.

Service agents. The customer, the service provider and/or the service frontstage entity (defined in section 4.3.3.3; in case the provider has assigned all customer-facing communication to that entity) are involved in the service personalisation phase.

Co-production interactions. After selecting the desired service, the customer engages with the service provider (or the service frontstage entity) in a structured conversation which aims to define if the customer is eligible for using the service and to personalise the service to the customers profile and context. The service personalisation phase comprises two co-production interactions (see also section 3.2.2.1):

- Service personalisation (including checking the customer's eligibility for the particular service); and
- Negotiation of the service terms.

Timeline. The service personalisation phase takes place at pre-service time.

3.2.3.4 Service delivery phase

Motivation. The service delivery phase covers the actual execution of the service, i.e. the delivery of the personalised service version to the customer and the acquisition of the service's outcome by the latter.

Service agents. The customer, the service provider and any combination of service stakeholders (such as resource providers, follow-up recipients, service regulators and/or other service stakeholders defined in section 4.3.3.3) may participate in the service delivery phase, depending on the nature and the process of the service delivered.

Co-production interactions. The service delivery phase includes service activities and co-production interactions (see section 3.2.1 and 3.2.2) that realise the instantiation of the personalised service version to the customer. The service delivery phase follows a process defined by the service provider and is regulated by the agreed-to contract (either an implicit or an explicit one). The customer plays a key role during service delivery, as she may have to contribute own resources, skills and competencies, and may have to perform part of the service activities herself for the service to be completed successfully. Regular communication and exchange of information between the customer, the provider and other service stakeholders takes place during the service activities that comprise this phase. This is the time when the customer actually experiences the service. At the end of this phase and in case no problems have arisen, the customer receives the outcome of the service and experiences the benefits delivered by it. Service delivery is thus the central phase in the service lifecycle.

The following two co-production interactions are part of the service delivery phase (see also section 3.2.2.1 and 3.2.2.2):

- Service initiation; and
- Dispute resolution.

Timeline. The service delivery phase is the actual execution of the service, i.e. the consumption of the service by the customer.

3.2.3.5 Service evaluation phase

Motivation. The service evaluation phase is the cornerstone for ensuring the perpetual improvement of service. Understanding and capturing customer expectations, opinions and feedback is required in order to improve customer satisfaction and reach convergence between customers' needs and available services, as information collected during this phase can provide significant input to the (re-)design of services. Studies on service evaluation have shown that both the quality of service outcome and that of the service process, as experienced by the customer, influence the evaluation of the service (Johnson, Zinkhan et al. 1998; Dabholkar and Walls 1999). During the service evaluation phase customers take into consideration both the gain side (e.g. how they benefit from the service, the value

they get out of it) and the loss side (e.g. sacrifice that they have to make for consuming it). Service evaluation has a direct positive impact on service quality and service innovation.

Service quality is improved because problems and deficiencies related to the service process, the service outcome etc. are identified, and solutions and improvements may be proposed directly by the customers. For example, a person dining in a restaurant may complain that the ambience was not pleasant and may propose to the restaurant owner how she personally thinks that it could be improved. Likewise, a customer of an e-service may complain about the lack of personalisation of the service to her situation, which in turn may lead to the service provider taking corrective actions to support this feature in the next release of the service.

Service innovation is improved because, through both the explicit and the tacit knowledge elicited, insights on how to achieve the following may be provided:

i. integrating existing services in a new service or a service bundle;
ii. redefining the purpose for which a specific service is used;
iii. redesigning and improving existing services; and
iv. designing a completely new service to fulfil emerging customer needs.

Service agents. The customer, the service provider, and possibly the service frontstage entity and/or the follow-up recipient (defined in section 4.3.3.3; in case the provider has assigned customer-facing communication to any of these entities), are involved in the service evaluation phase.

Co-production interactions. Customers, either on free-will or because they are asked to, express their opinion of and feedback on a service. The evaluation is mostly related to the quality process of the service itself, the outcome of the service, the overall service experience and the service. We argue that service evaluation may include knowledge about customer expectations and feedback on the service (subjective opinions as defined in sections 4.4.3.8 and 4.4.3.9 respectively).

Service evaluation is an interactive process where information about expectations and feedback is exchanged between customer and provider and runs throughout the lifecycle of the service. In order however to be collected and utilised, this valuable information needs to be structured and modelled. This will take us to the so-called *explicit social descriptions of services*, which offer means for facilitating the expression, collection and structuring of customer expectations and feedback in a ways that can benefit customers, service providers and the overall service provision alike. Hence, we define a strong link between service evaluation and service description, as one feeds the other with valuable information.

The service evaluation phase comprises a set of co-production interactions during which customers either explicitly express their expectations, opinions and feedback on the service, e.g. by commenting on or rating a service, or implicitly, where the service providers analyse service usage data in order to elicit information related to service evaluation, e.g. recurring customers or the behaviour of customers who have not been satisfied with the service. As a result, service evaluation comprises two co-production interactions (see also section 3.2.2.1 and 3.2.2.2):

- service evaluation and
- service mining.

Service providers put in place processes and mechanisms for collecting customer expectations, opinions and feedback and translate it into service requirements, which may lead to new services or to the redesign of existing ones in order to bridge the gap between customer needs and expectations and available services.

When. Unlike the prevailing theory that evaluation is performed after the end of the service process, we argue that the service evaluation phase runs throughout the service lifecycle, meaning that customer expectations and feedback maybe collected at pre-service time, during the service execution and at post-service time.

3.3 High-level requirements

Studying the phases of the service lifecycle from the customer viewpoint and the main co-production interactions discussed in the previous sections helps us elicit a set of requirements for customer-centric service provision. These high-level requirements defined in this section will drive:

i. the modelling work in the following sections, as they reveal core elements of service that need to be formally represented; and

ii. The pilot implementations that demonstrate the usefulness of this modelling work, which are discussed in Chapter 5.

We identified the following requirements for customer-centric service provision:

I. **Meeting customers' needs.** In order to ensure the availability of services that satisfy actual *needs* of the customers, service providers need to put in place the means for collecting needs and requirements of the customers both in terms of desired capabilities of the service, but also with regards to the *expected level of quality* and the *sacrifice* that the customer is willing to make for consuming the service, e.g. the price that has to be paid or the effort that has to

be contributed. It is likely that a *set of services*, and not a single one, may be required in order to satisfy a need.

II. **Machine-readable service descriptions.** In order to facilitate the service search and personalisation, providers should make available *high-quality service descriptions* that encompass both the provider's and the customer viewpoints, and that are grounded to the vocabulary used by customers. These service descriptions should not be only human-readable but also machine-readable in order to facilitate their electronic exchange and sharing, and to allow their reuse in applications that can support service search and personalisation. Service descriptions should be accessible via different channels, e.g. online, via service brokers, such as yellow page directories and online service marketplaces.

III. **Supporting service personalisation.** In order to deal with the great variability of services, providers need to support the personalisation of services and help customers identify the *version* that matches their personal characteristics and *context*. Similar to service search, service personalisation can benefit from high-quality descriptions of services. What needs to be personalised may among others be the *process of the service*, the requested *input* and the *outcome* of the service.

IV. **Collecting customer expectations and feedback.** In order to improve customer satisfaction, the service provider should invest on improving the *quality* and the *perceived value* of existing services, by sensing customer *expectations* and *feedback*. Providers should also maintain the agreed-to levels of quality throughout the service process.

V. **Agreeing on a common service model.** A common way of representing services in machine-readable formats is required in order to be able to:

- Use a common vocabulary for searching for services, independent of underlying technologies; thus minimising the burden on customers who have to get accustomed to different semantically related vocabularies for describing service.
- Identify the latent relationships between services described using different models. In the case of semantic Web services, for example, how can an agent decide that an OWL-S service can produce and output that is required as input by a SAWSDL service?
- Compare services and decide on similar, complementary, or substitute ones.
- Identify whether two services described using different models share common inputs, produce the same outcome, target the same customers or can be used in the same context etc.

The following service elements derive from the analysis of the service lifecycle. These are defined and modelled in detail in the following chapter:

- Customer need
- Customer sacrifice;
- Customer's perceived value of the service;
- Different service agents/stakeholders active in service provision, e.g .fronstage entity, service broker;
- Roles of the customer in service provision;
- Service input and outcome as perceived by the customer;
- Service as perceived by the customer;
- Service versions;
- Service quality;
- Types of resources exchanged in the context of co-production interactions.
- Context of the customer;
- Customer expectations; and
- Feedback on the service.

Chapter 4
Modelling service from the customer viewpoint

When I use a word, it means just what I choose it to mean – neither more nor less.
Lewis Carroll, Alice Through The Looking Glass

4.1 Introduction

As elaborated in section 1.4, the research objectives that drive the work carried out in the context of this *Thesis* are:

- To study and conceptualise service in order to create a common vocabulary for service – in the form of a Unified Service Model.
- To enhance the Unified Service Model in order to accommodate the customer viewpoint, i.e. information related to how the customer relates to service

In order to achieve our objectives, we model service in a domain- and technology-independent context and organise our study in the form of a *conceptual framework for service,* which details the conceptual elements that comprise a service and its relationships. Our conceptual framework for service comprises of the following two complementary models (see Figure 16):

- The Unified Service Model, which introduces a set of reusable concepts and relationships that capture the fundamental characteristics of a service. It comprises a number of concepts which are shared amongst service models defined in the literature. Effectively, the Unified Service Model expresses the way that service providers understand, model and describe service.
- The Customer Service Model, which expresses how the service is perceived from the perspective of the customer, hence modelling and representing formally the customer viewpoint. The Customer Service Model builds upon and extends the Unified Service Model viewpoint. To achieve this, we review and extend the Unified Service Model in order to accommodate concepts and relationships that express the customer viewpoint.

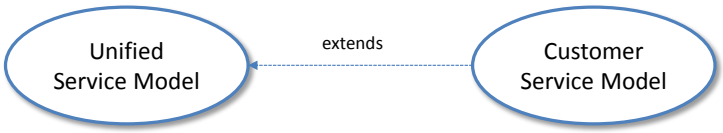

Figure 16: Extending the Unified Service Model to accommodate the customer viewpoint

The remainder of this chapter is organised as follows: Section 4.2 describes the model development methodology that we applied for developing the Unified Service Model and the Customer Service Model. Section 4.3 introduces the Unified Service Model, while section 4.4 introduces the Customer Service Model.

4.2 Methodology

This section presents the model development methodology that we applied for developing the Unified Service Model and the Customer Service Model. The two models are represented in the form of conceptual data models.

Table 7: Basics of conceptual data modelling

Conceptual data model. A conceptual data model describes the semantics of physical or conceptual things by means of a set of interrelated concepts. More specifically, a conceptual data model comprises:

- **Concepts.** A concept is a description of a set of things of the same kind, i.e. a set of things that share the same characteristics, in terms of common meaning, the same properties and the same relationships, e.g. a service or a customer.
- **Properties.** A property is a named, singular characteristic of a concept, for example the title of a service or the last name of a customer.
- **Relationships.** A relationship is a semantic link that shows how concepts are associated with each other, e.g. a customer *(concept A)* has *(relationship)* a need *(concept B)*.

An instance is a particular realisation of a concept. In an instance, properties and relationsips have values. For example, the instance representing 'issuing a birth certificate for Nikolaos Loutas' is an instance of the class 'Service'.

We first ran an abstraction exercise (summarised in Figure 17) in order to study and conceptualise service. When studying related service literature from different disciplines, including management, marketing, computer science and information systems, we observed that often semantically-related concepts, i.e. concepts carrying the same or similar meanings, appear in different definitions under different names, or that in some cases the same meaning is represented as one concept in some works and as more than one concept in others. For example, some refer to the final product of the service as output, while others as outcome. Some also explain that outcome can be further detailed into output and effect.

In such cases, which are discussed – where relevant – in the remainder of this chapter, we applied the abstraction exercise in order to derive core service concepts. A core service concept is a fundamental concept that is essential when modelling a service – as part of a minimum representation of service. A core service concept must be domain-independent and technology-agnostic.

The first phase of this exercise entailed the clustering of elements of the service models in clusters with high intra-cluster similarity and low inter-cluster similarity. This means that all the elements of a specific cluster were conceptually/semantically related despite, for example, differences in terminology. For instance, one of the clusters included all the elements referring to the customers of a service, while another one contained all the elements related to the activities that comprise a service and so on. These clusters eventually evolved into service concepts. This resulted in the development of the Unified Service Model.

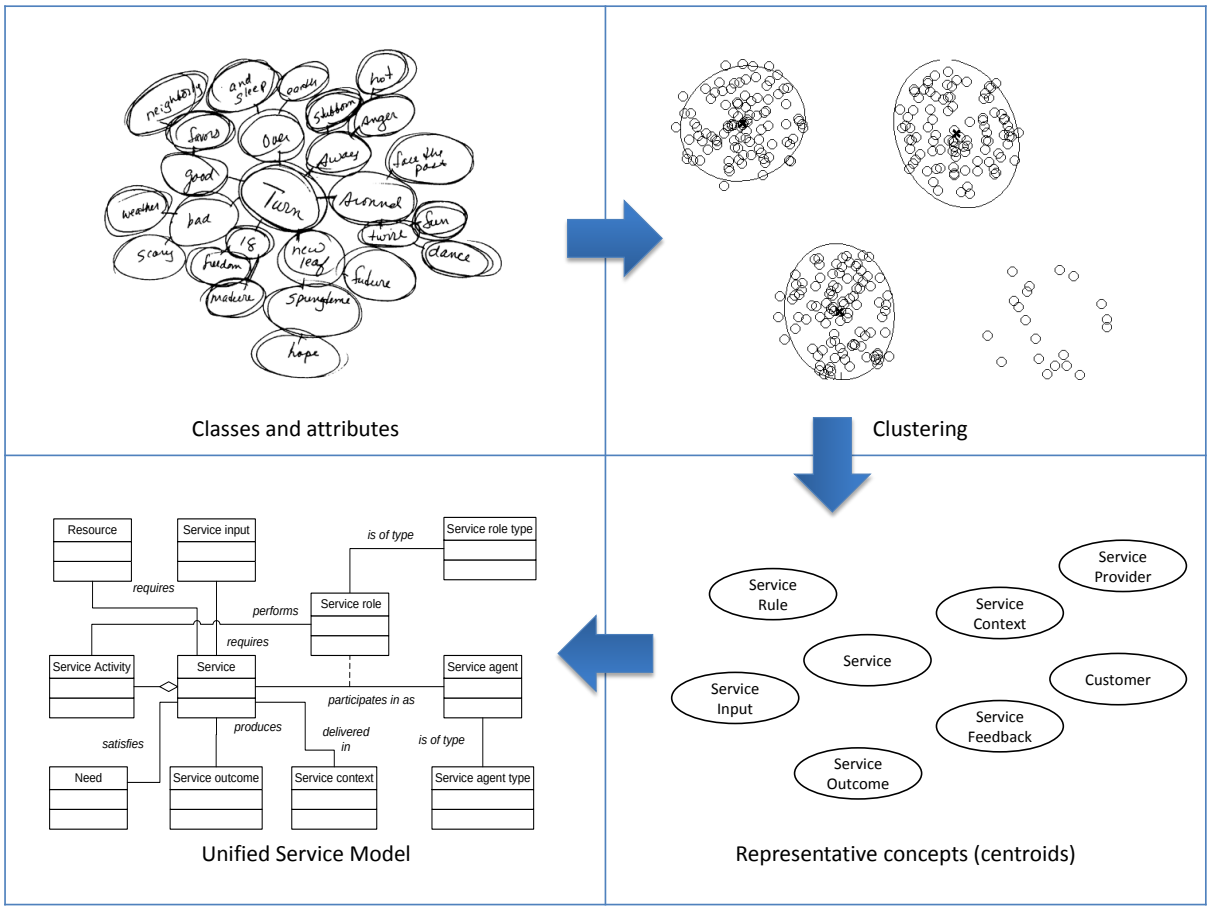

Figure 17: Overview of the abstraction exercise

Afterwards, we extended the Unified Service Model in order to accommodate the customer viewpoint, i.e. information related to how the customer perceives service. Our work there is centred on the role and the participation of the customer in service provision. Hence, a set of related concepts and relationships are identified, many of them are already part of the Unified Service Models, but are now placed in the context of the customer viewpoint. New concepts and relationships are also introduced or existing ones are detailed further, e.g. through sub-classing, to model aspects particular to the viewpoint of the customer, such as the different *roles of customers,* customer expectations and feedback. The outcome of this work resulted in the Customer Service Model, which is the theoretical contribution of this *Thesis*.

Our modelling work in each of the models is organised according to the views of the (Zachman 1987) framework, namely *Why*, *Who, What*, *Where and When,* remaining at the Enterprise Model layer. Hence, each viewpoint (i.e. model) comprises of a set of views.

- The *Why* view contains models of the concepts and relationships related to the reason, the intention and the motivation behind actions related to a service (e.g. a customer's decision to use a specific service).
- The *Who* view contains models of the concepts and relationships related to the agents (i.e. the actors) e.g. customer, service provider etc., that partake in activities related to a service (e.g. service provision),
- The *What* view contains models of the concepts and relationships related to the main elements that comprise a service.
- The *Where and When* view contains models of the concepts and relationships related to the spatial and temporal context in which a service is delivered; for example the location at which the service is made available/provided and the time when a service is provided. As the service context has also other dimensions, in addition to the spatial and temporal ones, we decided to include under the *When and When* view also concepts related to the social, economic and legal context of service delivery.
- The *How* view, which models behavioural aspects of customer-centric service provision has been modelled in the context of the service lifecycle presented in the previous chapter.

In our modelling work, we deliberately avoid detailing all the attributes of each of the defined classes. As this is a conceptual data model, we focus rather on identifying the classes and their replationships. Depending on the implementation formalism to be selected, e.g. RDF or XML, implementors of our service models can reuse existing classes and properties for implementing the conceptual elements of this model. For example, a customer can be modelled in RDF using properties from the ISA Core Person Vocabulary,[12] while a service provider can me modelled as a Formal Organisation from W3C's Organisation Ontology[13].

[12] http://www.w3.org/ns/person
[13] http://www.w3.org/TR/vocab-org/#org:FormalOrganisation

4.3 Core service concepts as a Unified Service Model

This section introduces a set of core service concepts and relationships, which derive from the abstraction exercise which took as input service models defined in the literature (see section 2.2 for a detailed presentation of these models). Hence the proposed Unified Service Model puts in place a common vocabulary shared between the different service models and definitions studied in Chapter 2, all of which implicitly approach the modelling of service from the provider viewpoint, i.e. the way that service providers perceive, understand and model service. Consequently, the Unified Service Model also expresses the service provider viewpoint of service. The concepts and relationships that comprise the Unified Service Model are discussed in sections 4.3.1 through 4.3.5, and are organised according to the *Why*, *Who, What*, *Where and When* views of the Zachman framework.

4.3.1 Service

In order to define what can be a minimum representation of service and consequently which service concepts are core, we approach service from a system's approach. Hence, we perceive service as a system that takes some input and transforms this into an outcome (we explain in section 4.3.4.2 that we prefer using the more generic term outcome instead of output, as often services do not have a concrete product). As discussed in Chapter 2, the nature of service systems varies from purely social constructs comprising of a set of interacting human actors, to socio-technical constructs were humans and machines collaborate in the service delivery, to fully automated technical constructs where the delivery of the service is purely carried out by a number of collaborating machines. This approach is also in line with the works of (Payne 1993), (Zeithaml and Bitner 2000), (Stanton 1981), (Grönroos 2000), (Dumas, O'Sullivan et al. 2001; Alter 2008), (Ferrario and Guarino 2009) and IBM Research (2009), who also define service as a process comprising of a set of activities that deliver outcomes and benefits to the customer, while (Mohr and Bitner 1995) say that the service process is defined as "the manner in which the outcome is transferred to the customer". In our work, the service process as a whole is considered to be identical to the notion of service.

Service is the central concept of the model and refers to the specific service being modelled. *We define service as the logical representation of business logic, encapsulated in a process that is delivered by a service provider to a customer.* A service involves the transformation of resources contributed by both the service provider and the customer, and produces an outcome that fulfils specific needs of the latter (see also section 4.3.2.1). A service entails also cognitive and emotional aspects and requires continuous interaction and communication between service provider and customer through various channels (physical or electronic ones).

Summarising related literature in the field, we select the following characteristics of service, which are of particular interest to our work:

- *Services are intangible.* Services are experiences, meaning that they cannot be seen, tasted or touched. Due to their intangibility services cannot be transported or stored. Despite being itself intangible, a service can produce tangible outcomes (see also section 4.3.4.2).
- *Services are information-driven.* Services are nowadays knowledge-intensive and capitalise heavily on the contribution of information, knowledge and skills from all participating entities (OECD 2010) (Spohrer, Demirkan et al. 2011). In section 4.3.4.1, we discuss how intangible resources, such as information and skills, are an integral part of the service, e.g. service input.
- *Services are customer-centric.* Service research, even before Service Science, perceives customers as co-producers of the service and co-creators of value. Both roles, which are synonymous, refer to the active participation of customers in service provision, e.g. by undertaking specific parts of the process and by contributing skills and knowledge. This way, customers customise/personalise available service in a way that these fulfil their needs in a unique manner and effectively influence the quality and efficiency of service provision (see also section 3.2.2). The customer-centricity of service impacts also service variability. Our work puts special focus on customer-centricity of services, which is further explored and modelled in section 4.4.
- *Services are not homogenous constructs*; on the contrary two dimensions of heterogeneity can be defined, namely *internal* and *external* heterogeneity.
    - Internal heterogeneity refers to the fact that a service, depending on its nature and complexity, comprises of different types of interacting entities. As we discuss in section 4.3.3 'Who view', services involve social actors, e.g. consumers, economic actors, e.g. organisations, businesses and governments, tangible and intangible resources, e.g. materials and skills, regulations, policies and frameworks.
    - External heterogeneity refers to the fact that services are unique, volatile and difficult to standardise. Services have a high-degree of variability. The way that a particular service is delivered to and experienced by the different customers differs depending on the profile of the customer and their context.

We perceive service heterogeneity as a key service characteristic, which impacts the overall service provision process and has an influence on the customers' experience. In fact, heterogeneity provides the flexibility to adapt services to the needs and profiles of different customers, and consequently satisfy diverse requests for service.

- *Services have become ICT-driven*, meaning that service provision relies increasingly on the use of ICT or, in other words, ICT has revolutionised service provision. However, it should not be overseen that services are not provided through pure IT-based systems, but through complex socio-techno-economic systems. Technology is an enabler and facilitator for efficient service production and delivery. Even in the case of purely technical services, such as Web services, other factors, such as legal and business requirements, also impact service delivery.
- *Services have different delivery modes*. During our analysis of the services landscape (see Chapter 2), we observed that services have different delivery modes which are determined by the use of technology and ICT. We define two main service delivery modes, namely manual and technology-enabled, which is in turn specialised into semi-automated and fully-automated service delivery.
    - In manual service delivery, all service activities are carried out by human service agents.
    - In technology-enabled service delivery, part of or all service activities are implemented through the use of technology (in particular ICT).
        - In semi-automated service delivery part of the service activities are carried out by human service agents and the rest are implemented by machines and information systems.
        - Finally, in fully-automated service delivery all service activities are carried out by machines and information systems, and there is no intervention from human service agents. Interestingly, there exist types of services that cannot be fully automated. For example, services that build upon a particular human competency, skill or talent, e.g. operating on a patient or giving a haircut, cannot be delivered electronically.

    Technology-enabled services (e.g. e-services discussed in section 2.2.4.3) are now most often realised through service oriented architectures which in turn comprise of a set of interworking technical services. As the vast majority of these systems are nowadays Web-based, they rely on Web services (see section 2.2.4).

4.3.2 Why view

The *Why view* models the reasons and the incentives that motivate the provision of a particular service. The following core concept is identified here:

- Need.

4.3.2.1 Need

The Longman dictionary defines need as "a strong feeling that you want something, want to do something, or that you must have something", which is also close to the definition of a customer's need provided by Baida et al. (2005) (i.e. "what humans need and want (to buy)").

Customers have needs, e.g. I am hungry, I want to travel or I have to submit my annual tax declaration. Customers purchase, consume and experience services in order to fulfil their needs, e.g. dine in a restaurant or book flights respectively. (Estefan, Laskey et al. 2009) emphasise also the fact that customers' needs are satisfied via services. Customer's needs actually motivate service provision, both from the service provider's and the customer's perspective. As we discuss in this section, satisfying their needs is in fact the ultimate reason why customers purchase and consume services. This creates demand for services, which in turn also ignites the supply of services.

Need was one of the core concepts that derived from our abstraction exercise, as explained in Table 8.

Table 8: The need cluster

During our review, we observed that customer's need is mentioned in service literature as one of the core elements that have an impact on service provision, cfr. (AMA 1960), (Zeithaml and Bitner 2000), (Basole and Rouse, 2008), (De Kinderen and Gordijn 2008), (Kotler and Keller 2006), (Estefan, Laskey et al. 2009), (Vargo and Lusch 2004), (Unified Service Description Language SIG 2009). Often, people used synonymous terms for need, such as want and goal. More specifically, (Stanton 1981) and (International Organisation for Standardisation 2011) use the term want, while (Grönroos 2000) does not explicitly refer to need, but says that a service brings a solution to a customer's problem; thus meaning the same thing. Other service modelling efforts, especially technology-enabled ones, use the term goal instead of need, cfr. (IBM Research, 2009), W3C Web Services Architecture Working Group (2004), (Ferrario and Guarino 2009), WSMO (Polleres, Bussler et al. 2005; Roman, Keller et al. 2005) and WSMO-Lite (Vitvar, Kopecky et al. 2008; Fensel, Fischer et al. 2010). Finally, demand is heavily discussed in literature originating in the marketing science, e.g. (Zeithaml and Bitner 2000) and (Lovelock 2001). It is also part of some technology-enabled service modelling efforts, including(Akkermans, Baida et al. 2004) and (Unified Service Description Language SIG 2009). The decision of a customer to consume a service is the turning point from need to demand.

Following the example of Baida et al. (2005) and De Kinderen and Gordijn (2008), we base ourselves on the seminal work of (Kotler and Keller 2006) to classify needs. In that work, Kotler and Keller distinguished between needs and wants.

- A need is defined as "a state of felt deprivation of some basic satisfaction".
- A want is defined as "a desire for specific satisfiers of these deeper needs".

In this work, we define three different types of need (as subconcepts) (see also Figure 18):

- *Basic need* which refers to a feeling related to the physical well-being of the customer, e.g. hunger or thirst.
- *Want* which refers to desires related to the emotional, psychological and/or social well-being of a customer, e.g. entertain oneself, travel or study.
- *Obligation* which refers to a requirement that must be fulfilled and which is imposed by a third party as a result of specific legal, professional or social conventions, e.g. paying tax. A penalty is usually associated with the non-fulfilment of an obligation.

Relationships

Two relationships are defined:

- *has need* which relates *customer* to *need*. A *customer* may have zero or more *needs*. A *need* may be shared by one or more *customers*.
- *satisfied by* which relates *need* to *service*. A *need* may be satisfied by zero or more *services*. A *service* may satisfied one or more *needs*.

Our modelling of the customer's need is summarised in the figure below.

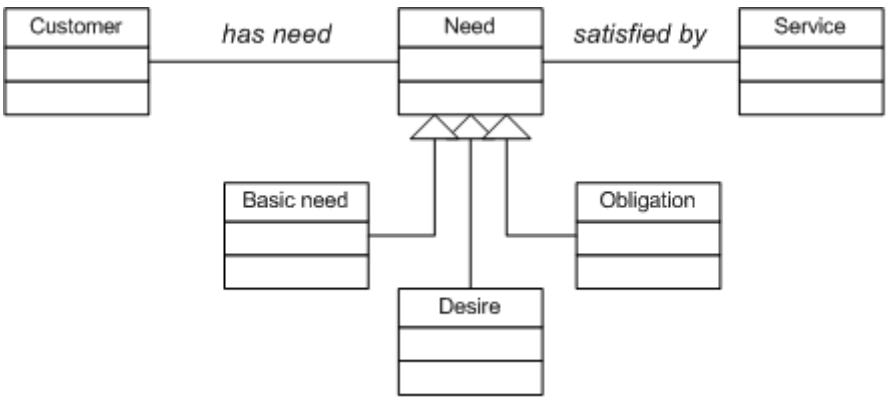

Figure 18: The customer's need concept

The needs of customers are fulfilled through the value delivered by specific services (e.g. see (Akkermans, Baida et al. 2004) (Basole and Rouse 2008) (Lusch, Vargo et al. 2010)). Service providers have the task to translate the customers' needs into services, corresponding to the 'translation of customers' needs into services' co-production interaction discussed in section 3.2.2. We remind to the reader, that as defined in section 3.2.2, co-production interactions are a specialisation of service activities in which the customer plays a protagonistic role, e.g. by driving the interaction and the communication with the service provider and/or other service stakeholders.

The 'translation of customers' needs into services' co-production interaction is led by the service provider, but the participation of the customer is of ultimate importance. The implementation of this co-production interaction requires to:

- quantify the demand for a particular service;
- understand what the customer wants/requires (see also section section 4.3.2.1);
- provide adequate information to the customer regarding the services available and understand whether the customer's need can be satisfied by an existing service or not;
- estimate how much the customer is willing to spend/sacrifice in order to satisfy her need; and
- group and categorise services (if required) in order to fulfil more complex needs; often needs are complex enough and cannot be satisfied by a single service (see also section 4.4.3.1).

4.3.3 Who view

This section models the main actors that partake in service provision and their roles. It details the *Who view* of service provision. These actors are grouped under the term service agent, which effectively refers to any physical or legal entity that may be active and participate in the delivery of a particular service.

We specify the following *types of service agents* (see Figure 19):

- *Natural persons*, i.e. individuals participating somehow in the provision of a service, e.g. as customers;
- *Organisations*, where we distinguish between:
    - *Legal entities*, i.e. private businesses of any form providing, consuming or playing any other role in service provision;
    - *Public organisations*, i.e. public administrations at any level of government (i.e. local, regional, national and trans-national) providing, consuming or playing any other role in service provision; and

- *Other types of organisations*, such as not-for-profit organisations, NGOs, charities etc., consuming or playing any other role in service provision.

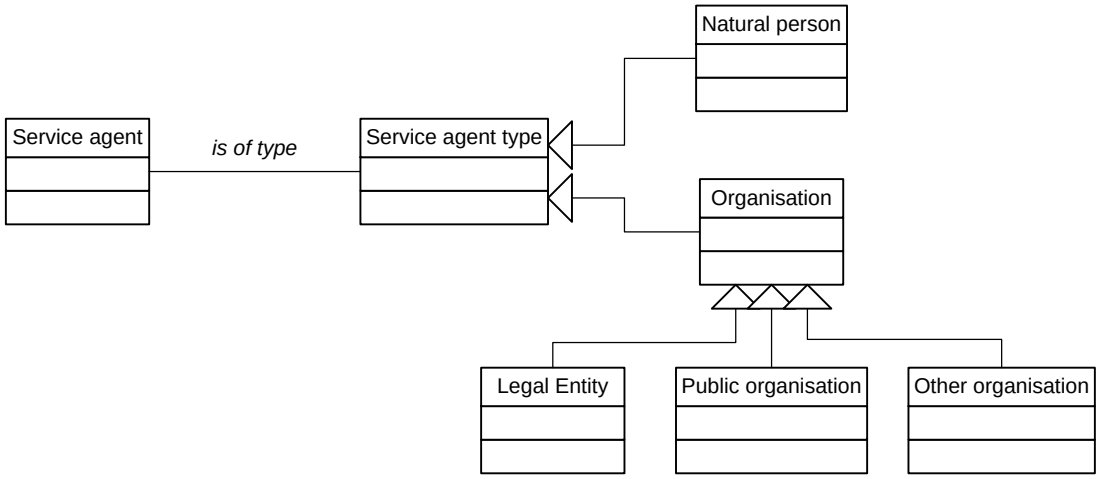

Figure 19: Service agent types

Service provision engages different service agents that *play different service roles* in the context of service activites. The two main service roles are obviously those of the service provider and the customer. In addition to those, we define in this section a set of additional service roles played by service agents, to which we refer to collectively using the term service stakeholders.

We remind to the reader that the *How* view of customer-centric service provision has been modelled and analysed in Chapter 3 in the context of the service lifecycle. There, in section 3.2.1, we defined service activity and its three main subclasses, i.e. basic activity, co-production interaction and management and governance activity. Due to the importance of co-production interactions for this work, these have been discussed separately in section 3.2.2.

Relationships

The following relationships are defined:

- *is type of* which links a class with a set of controlled values providing the possible types of the instances of this class.
- *participates in* which relates *service agent* to *service*. This is a relationship modelled as an association class, in order to express that a service agent may participate under different *service roles* in the service.

  At least two service agents, i.e. the service provider and the customer, participate in any service.

- *performs* which relates *service role* to *service activity*. A *service role* performs (on its own or by collaborating with other service roles) one or more *service activities* during the

provision of a *service*. Especially for *co-production interactions*, every co-production interaction involves the collaboration of at least one *customer* and one other service role, e.g. the *service provider* or another *service stakeholder* (e.g. a service frontstage entity or a service regulator).

In the remainder of this chapter, we will elaborate on the specific relationships between the different types of service roles and service.

Our modelling of the different types of service agents is summarised in the figure below. In our modelling of service roles we adopt the *role association class solution* of Mossé (2002), which allows dynamically specifying role relationships by using objects, hence defining the role that a service agent plays in a particular service instance.

We define in the remainder of this section a number of generic service role types played by the service agents involved in a service. A summary of those types in the form of a taxonomy is illustrated in Figure 21.

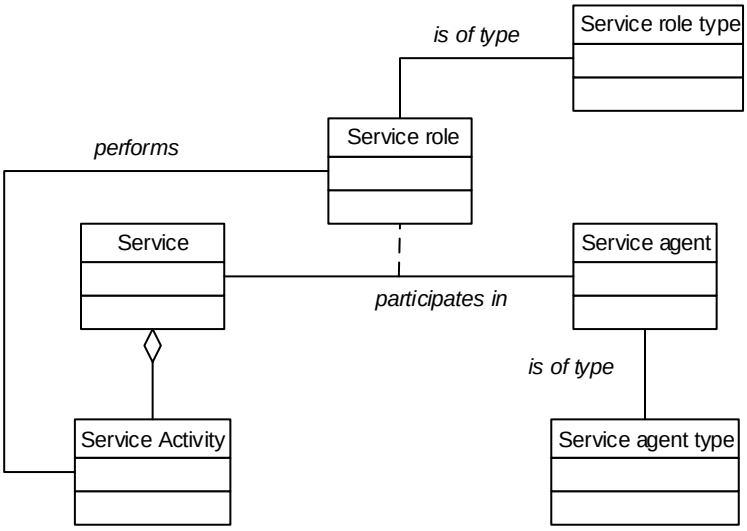

Figure 20: Participation of service agents in service provision

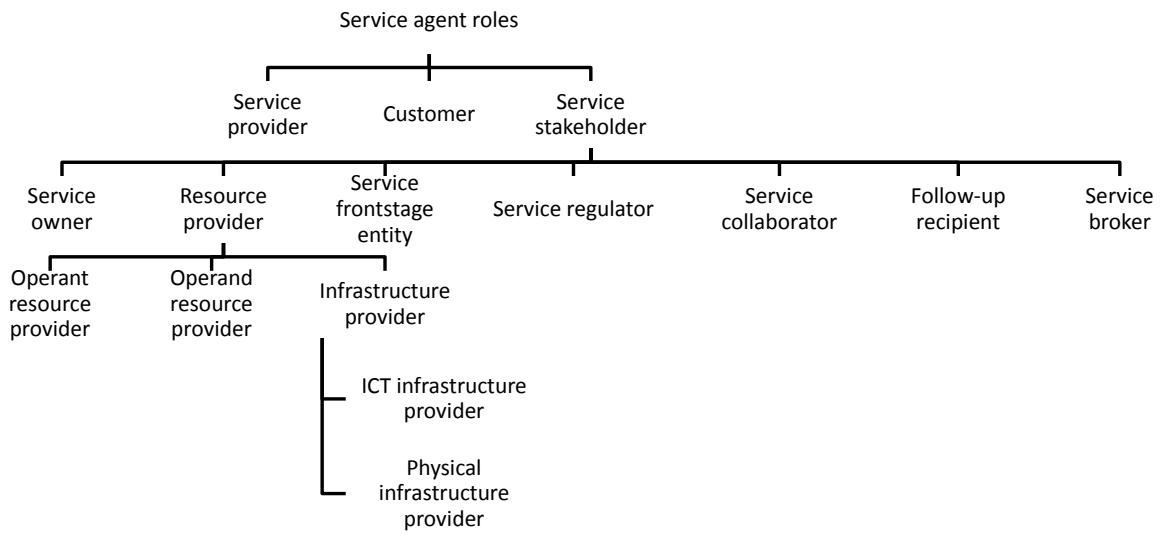

Figure 21: Types of service agent roles

4.3.3.1 Service provider

The service provider is the service role that is responsible for the coordination of the overall provision of a service, i.e. designing the service, making it available to customers, coordinating and controlling other stakeholders involved in the process, and ensuring a rich and high-quality service experience. In this sense, the service provider is also responsible for maintaining the ambience and for facilitating the customer while experiencing the service. The service provider is the primary point of contact for a service, unless a different stakeholder has been assigned the role of the service frontstage entity. A service provider may provide one or more services. A service can be made available by one or more service provider(s) through their frontstage service entities (if any).

The service provider was one of the core concepts that derived from our abstraction exercise, as explained in Table 9.

Table 9: The service provider cluster

Including the service provider as one of the roles of service agents was, as expected, an obvious decision. All service models and definitions reviewed mention the provider of the service as a discreet stakeholder in service provision. (Grönroos 2000), (Akkermans, Baida et al. 2004), (De Kinderen and Gordijn 2008) and (Ferrario and Guarino 2009) are the only ones that use a different term to refer to the provider of the service. The first two call it supplier, while the latter call it service producer.

The service provider designs the outcome of the service, ensuring that this fulfils needs of the customers (defined in section 4.3.2.1); defines the sequence and the type of activities that have to be conducted in order for the service to be delivered successfully (see sections 3.2.1 and 4.4.3.4); and plans the resources that are required, both the those that will be requested from the customer in the

form of service input and those that will be contributed internally (see section 4.3.4.3). The service provider usually sets the context of the service; let it be an office, a shop, a hospital or an online service (see section 4.3.5.1).

As explained in the previous section, the service provider may be an individual, a group of individuals, or an organisation. For example, the service provider of educational services can be a university or a private tutor, while the provider of financial services can be a bank or some other financial institution. The service provider may be commissioned/hired/paid for providing the service or may do so on a voluntary/free basis.

Our modelling of the service provider as an object of the *service role* association class defined in section 4.3.3 is summarised in the figure below.

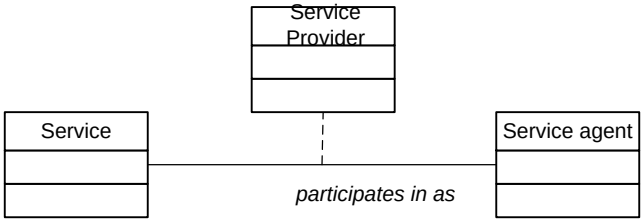

Figure 22: The service provider role

4.3.3.2 Customer

The customer is the service role that consumes/uses/experiences a service in order to satisfy a specific need, want or obligation (see also section 4.3.2.1). Interestingly, the term customer is overloaded and may refer to human consumers of a service and organisations using a service, but also to machines. In this *Thesis*, however, we understand customers being individuals (i.e. a physical entity), groups of individuals or organisations (e.g. a legal entity).

We define in this *Thesis* that the customer participates actively throughout the lifecycle of the service, from its design to its provision by contributing expectations, requirements, preferences, knowledge and skills, and feedback in the context of co-production interactions (as discussed also in section 3.2.2). The customer provides the required input (see section 4.3.4.1) to the service and receives its outcome (see section 4.3.4.2).

Customer was one of the core concepts that derived from our abstraction exercise, as explained in Table 10. As part of the Customer Service Model in section 4.4, we elaborate further on defining the different roles that customers play during the provision of a service.

Table 10: Customer cluster

The vast majority of service modelling efforts studied use the term customer to refer to the entity that is actually consuming the service. (Hill 1977) explains that a customer can be a person or an economic entity, e.g. a business or an organisation. (Alter 2008) differentiates between internal and external customers. (Spohrer, Maglio et al. 2007), IBM Research (2009), (Mora et al. 2009) , (Mora et al. 2011) and (Lau et al. 2011) use the term client instead of customer; while (De Kinderen and Gordijn 2008), (OASIS 2006), (Estefan, Laskey et al. 2009), (The Open Group 2010), (Lusch, Vargo et al. 2010) and (OMG 2009) use the term consumer. (Storbacka and Lehtinen 2001) differentiates between the payer and the consumer, while (Polter et al. 2008) , (International Organisation for Standardisation 2011) and (Lovelock et al. 2009) distinguish between the customer, the purchaser and the recipient of the service. In a similar vein, (Ferrario and Guarino 2009) explain that the customer may be different that the actual beneficiary of the service. Finally, (Blau, Kramer et al. 2009) use the term service requester instead of customer.

In order to facilitate the efficiency and efficacy of their marketing strategies, and to target the provision of their services, providers group customers in arbitrary groupings, which we call market segments. Service providers classify customers into market segments using different criteria. For example, based on a particular characteristic of their profile, e.g. the unemployed, people with children and people with high income living in Greece may be classified into different market segments. Obviously an individual person or organisation may fall in different such classifications.

In order to maximise the penetration of their services in the identified market segment, service providers need to ensure that their offering is able to satisfy customers better than the competition. For their customer targeting purposes and to raise awareness of their services to different market segments in their services, service providers communicate with third-party entities, namely service brokers (see section 4.3.3.3) such as service registries and marketplaces, marketers, yellow pages etc., and share with them a service description that can be used for advertising the service.

Relationships

The following relationships are defined:

- *provides* which relates *customer* to *service input*, thus indicating that, in order to consume the service, the *customer* has to provide the required input. This is part of the service initiation co-production interaction defined in section 3.2.2.1.
- *receives* which relates *customer* to *outcome.* After the successful execution of a service, the *customer* receives its *outcome*. This is part of the service initiation co-production interaction defined in section 3.2.2.1.

- *targets* which relates *service* to *market segment*. A service targets one or more market segments.

Our modelling of the customer is summarised in the figure below. There the customer is represented as an object of the *service role* association class defined in section 4.3.3.

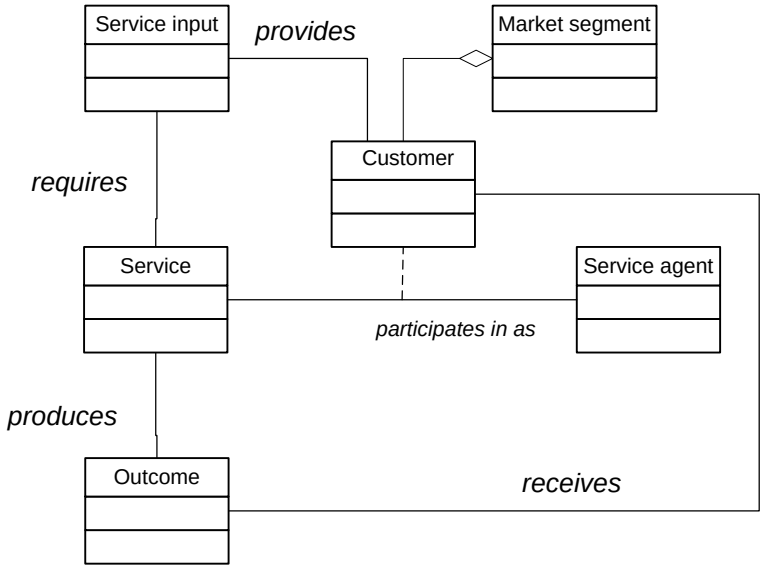

Figure 23: The customer role

4.3.3.3 Service stakeholders

The service stakeholder represent other roles of service agents that carry out (part of) a service activity (see section 3.2.1) or a co-production interaction (see section 3.2.2), and/or have an interest in the service. The outcome of the abstraction exercise for service stakeholders roles is summarised in Table 11.

Table 11: Service stakeholders cluster

Apart from the two obvious roles, that of the customer and the service provider, which are common in all modelling efforts, there are a number of other roles which appear only in few cases and are often referred to collectively as service stakeholders (e.g. (Estefan, Laskey et al. 2009) and (Spohrer, Demirkan et al. 2011)), participants (e.g. (Alter 2008) , (Bitsaki M., Danylevych O. et al. 2008), (Estefan, Laskey et al. 2009) and (OMG 2009)), actors (e.g. (Estefan, Laskey et al. 2009) and (The Open Group 2010)), service employees (Grönroos 2000) or agents (e.g. (Ferrario and Guarino 2009) (Unified Service Description Language SIG 2011). We use the term service stakeholder to refer to entities that contribute to the delivery of a particular service. Service stakeholders may assume different *service roles* in the course of service activities and/or co-production interactions.

Based on our experience we defined a number of service roles. Some of them derived as results of our abstraction exercise, while others have been introduced by us.

Service owner. (Unified Service Description Language SIG 2011) differentiates between the service provider and the business owner, which is an important differentiation in our work as well. The ITIL methodology also defines service owner as a discrete entity, different from the service provider.

Resource provider. We decided to group under this term, roles such as competence provider (Storbacka and Lehtinen 2001), host entities (Estefan, Laskey et al. 2009), supplier of resources (Lusch, Vargo et al. 2010).

Service regulator. Stakeholders that control the service process were grouped under this term, e.g. government entities defined by (Estefan, Laskey et al. 2009), authorities defined by (Spohrer, Maglio et al. 2007) and controller of quality defined by (Storbacka and Lehtinen 2001).

Service broker. Despite the importance of service brokers in today's service economy, we came across an explicit definition of this concept only in three service modelling efforts: appearing as intermediary in (Unified Service Description Language SIG 2011), as service mediator (Estefan, Laskey et al. 2009) and as service trustee in (Ferrario and Guarino 2009).

Service collaborator. We introduced this generic service role to group different roles such as enablers defined by (Basole and Rouse 2008) and service facilitator defined by (Mora et al. 2009) & (Mora et al. 2011) and co-producer of service.

In this work, we specify the following service roles that can be assumed by service stakeholders:

- Service owner,
- Resource provider,
- Frontstage entity,
- Service regulator,
- Follow-up recipient,
- Service broker, and
- Service collaborator.

Service owner. The service owner is the service role that has the primary responsibility to design and deliver a service. The service owner is also responsible for decision-making or escalation of decisions. Normally, the service provider is the same as the owner of the service. However, there are cases where the service owner may commission a third organisation to provide the service on their behalf. For example a government (i.e. service owner) may outsource the provision of healthcare services to a private organisation (i.e. service provicer). In such cases, the service owner sets out the policies and the frameworks for providing it according to pre-defined and –agreed levels of quality. The service owner is also responsible for overseeing the overall service provision. However, the actual delivery of

the service to the customers is performed by and is the responsibility of a different entity that assumes the role of the service provider.

Relationships

The following relationships is defined:

- *commissions* which relates *service owner* to *service provider*. A *service owner* may commission one or more *service providers* for making its service available to the customers.

Resource provider. A resource provider is a service role that contributes operant resources, materials and tangible goods or technical infrastructure that are required for delivering the service activities. The provision of resources to the service is part of the service initation co-production interaction defined in section 3.2.2.1. Resources, being a core concept, are modelled in section 4.3.4.3.

We define three distinct sub-types of resource provider, following the different types of resources, namely operant resource provider, operand resource provider and infrastructure provider.

- **Operant resource providers.** Operant resource providers bring knowledge, information, skills, human capital, competencies and capabilities to the service process.
- **Operand resource providers.** Operand resource providers contribute materials, tangible resources and goods that are required for the provision of a specific service.
- **Infrastructure provider.** Recent business trends (e.g. outsourcing) and technological advances (e.g. Cloud computing and in particular the Infrastructure as a Service (IaaS) paradigm) in the service world have allowed the decoupling of the service provider from the technological infrastructure required for delivering a specific service. We thus define infrastructure provider as a distinct service role. Infrastructure providers can be specialised into two distinct types: ICT infrastructure providers and physical infrastructure providers.
    - An **ICT infrastructure provider** is defined as the service stakeholder that provides ubiquitous and on-demand access to computing resources, e.g. computing power, storage and networks. For example, Amazon can be an ICT infrastructure provider if its Web Services[14] are used for deploying the service and making it available to the customers.
    - A **physical infrastructure provider** contributes buildings and equipment to the service process based on a fixed contract or on a pay-per-use base. For example, a company

[14]Amazon Web Services, http://aws.amazon.com/

renting out rooms where trainings and conferences can be held the physical infrastructure provider in the case of a particular conference or training (service).

Our modelling of the resource provider is summarised in the figure below. The resource provider is represented as an object of the *service role* association class defined in section 4.3.3The *provides* relationship has been defined in section 4.3.3.1 and is reused here. The *utilises* relationship will be defined in section 4.3.4.3 where resources are discussed.

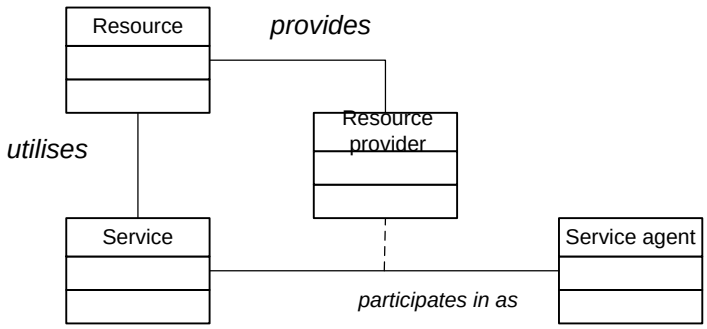

Figure 24: The resource provider concept

Frontstage entity. In many cases, the service provider does not come in direct contact with the customer during the service provision process. In these cases, the communication between service provider and service customer, e.g. the exchange of information regarding customer preferences and needs or the delivery of the outcome to the customer, goes through a third-party proxy service role termed frontstage entity. The relationship and the degree of coupling between the service provider and the frontstage entity depend on the business model followed. This means that the frontstage entity does not necessarily have to be a different legal entity; it can just be the case that the service provider has a clear distinction between client-facing service activities carried out by one department (frontstage entity) and back-office service activities carried out by another department. The frontstage entity manages the service channels which are defined in section 4.4.3.3.

Relationships

The following relationships are defined, all of which are subproperties of the *participates in* property (defined in section 4.3.3):

- *collects* which relates *frontstage entity* to *service input* thus indicating that when a fronstage entity exists it is its task to collect the service input from the customer. This is part of the service initiation co-production interaction defined in section 3.2.2.1.
- *delivers* which relates *frontstage entity* to *outcome* thus indicating that when a fronstage entity exists it is its task to deliver the outcome of the service to the customer. This is part of the service initiation co-production interaction defined in section 3.2.2.1.

Our modelling of the fronstage entity is summarised in the figure below.

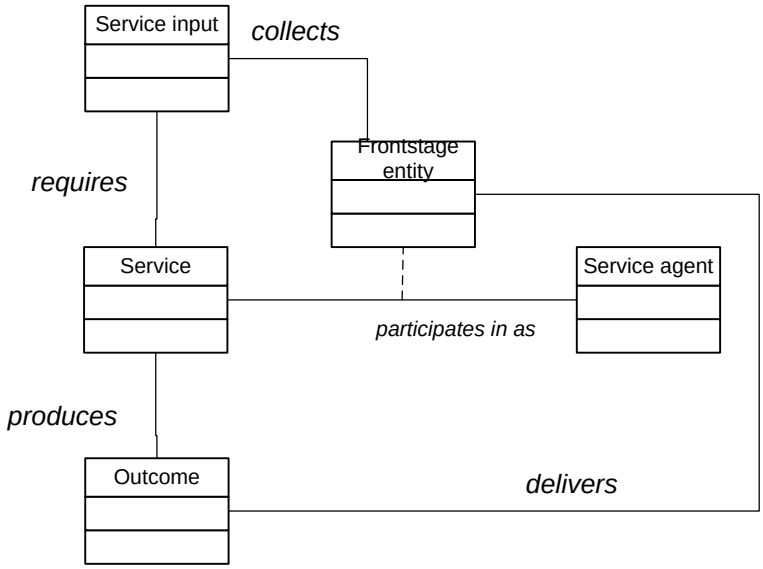

Figure 25: The frontstage entity role

Service regulator. All services, regardless of the service industry, are provided in a specific legal and political context and have to abide by certain rules (both business rules and codes of conduct, but also trans-national/national/regional/local legislation). This context is set and governed by a service regulator. The service regulator has an observer's role during the provision of a service and monitors it. Service monitoring is one of the service activities discussed in section 3.2.1. The service regulator may intervene only if required, e.g. to contribute in the resolution of a dispute. The service regulator may also have to resolve conflicts that arise during the provision of a service. This service role is usually assumed by a public administration entity or an independent auditor.

A service regulator may monitor one or more services. The same service may be monitored by different service regulators, e.g. two different public administration agencies monitoring the services provided by a provider of tourism services, one focusing on safety and the other on environmental aspects.

Relationships

The following relationship is defined:

- *governs* which relates *service regulator* to *service context* thus indicating that the legal and political dimensions of service context are set and governed by service regulators.

Service context is modelled in section 4.3.5.1 (the *delivered in* relationship is hence defined there).

Our modelling of the service regulator is summarised in the figure below.

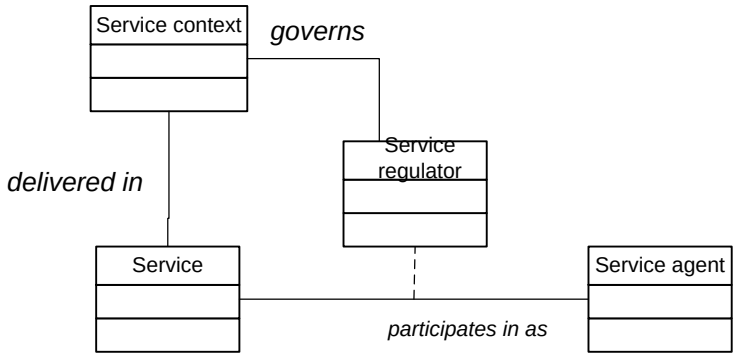

Figure 26: The service regulator role

Follow-up recipient. Follow-up recipients are involved in the service only after the service execution is completed. Follow-up recipients are notified with regards to the outcome of the service and may have to act upon it. Follow-up actions may then be performed, e.g. contacting the customer to find out whether she was satisfied with the service experience. For example, after staying in a hotel, a market research company or an internal department of the service provider dealing with contact relations may contact the customer to get feedback about their experience when staying in their hotel.

Similar to the previous service roles, the follow-up recipient is modelled as an object of the *service role* association class defined in section 4.3.3.

Service broker. The service broker is an independent mediator that facilitates the contact and the transactions between a service provider and a customer, e.g. a yellow page service, a service marketplace, a travel agent in the case of tourism services, financial and stock brokers in financial services or service registries in the case of SOA. A service broker facilitates access to one or more services. A service may be accessible via zero or more service brokers.

The service broker may advertise, promote and sell the services of a specific provider to customers. The service broker may be paid by the service provider, by the customer or by both, e.g. by getting a commission, or may not require a fee. The service broker is not responsible for the execution of the services accessible through it; this responsibility remains with the service provider.

The activities of the service broker are facilitated by the availability and publication of service descriptions. In order to promote the services accessible via it, help customers find them and enhance their understanding of these services, service brokers publish the descriptions of these services. A service description may be published on zero or more service brokers. Service descriptions are discussed in detail in section 4.4.3.10.

The availability of high-quality service descriptions is a key enabler for the service search and the service personalisation co-production interactions discussed in section 3.2.2.1.

Similar to the previous service roles, the service broker is modelled as an object of the *service role* association class defined in section 4.3.3.

Service collaborator. From our discussion so far, it is evident that the design, provision and maintenance of a specific service require the collaboration of several service agents with distinct yet complementary roles. Apart from the service roles already defined, different stakeholders may partake in the service process by undertaking fully or participating in the delivery of any of the service activities, e.g. validating information, performing a specific step of the service process or providing approval. We group this type of stakeholders under the term service collaborator. The nature of the tasks and the activities performed by the service collaborators depends heavily on the characteristics of the specific service and on the service industry. For example, different service collaborators will appear in services in the healthcare field than those in hospitality. Hence providing an exhaustive list for different instantiations of service collaborators would be impossible. Each of the tasks and activities carried out by service collaborators can be a separate service per se.

4.3.4 What view

The *What* view of the model comprises of concepts and relationships that represent the main building blocks of a service. The abstraction exercise yielded the following core concepts:

- Service input;
- Service outcome;
- Resource; and
- Service quality.

4.3.4.1 Service input

We define as service input the resources that customers have to contribute/provide in order to have the service delivered to them. Service input may refer to different types of resources, e.g. a credit card number, the customer's preferences or an ID card number, and to skills and competencies, i.e. the ability of the customer to perform part of a co-production interaction. We define resources in section 4.3.4.3.

Effectively, there is a twofold relationship between service input and resource:

- Service input is a resource, but not all resources required by the service are provided as input. For example, the IT infrastructure required for providing an IT service, e.g. a Web server, is a resource but is not part of service input.
- Service input is provided by the customer either directly or indirectly, i.e. it can be acquired from other sources, e.g. a database or as the outcome of another service, while other

resources may be provided by the service provider and other stakeholders. Service input relates directly to the sacrifice (see section 4.4.3.6) that a customer has to make in order to be able to consume the service.

- Service input refers to a resource that is owned by/belongs to the customer and that is contributed by the latter to the service.

Service input was one of the concepts that derived from our abstraction exercise, as explained in Table 12.

Table 12: The service input cluster

Service input appears as a class or a property in a number of related efforts. For instance, Murdick et al. (1990), (Lovelock, Wirtz et al. 2009), (Sampson and Froehle 2006), (Spohrer, Maglio et al. 2007), (Estefan, Laskey et al. 2009) and (Blau, Kramer et al. 2009) define input as part of their service models and definitons; while (Unified Service Description Language SIG 2011) and the SOA Ontology (The Open Group 2010) use two properties, requires and has input respectively, to refer to the input required by a service. Service input appears also as a core concept in all semantic service modelling frameworks, including WSMO (Polleres, Bussler et al. 2005; Roman, Keller et al. 2005), WSMO-Lite (Vitvar, Kopecky et al. 2008; Fensel, Fischer et al. 2010) and MicroWSMO (Kopecky, Vitvar et al. 2009), OWL-S (McIlraith and Martin 2003; Martin, Burstein et al. 2004; Martin, Burstein et al. 2007), SWSF (Battle, Bernstein et al. 2005), WSDL-S (Akkiraju, Farrell et al. 2005), SA-REST (Lathem, Gomadam et al. 2007; Sheth, Gomadam et al. 2007) and the MSM (Pedrinaci and Domingue 2010).

Service input (or at least a part of it) is processed and transformed throughout the service, hence forming the service outcome (see section 4.3.4.2).

For example, for receiving a loan from a bank, the customer has to provide information about her income and a justification for requesting the loan. The customer can provide the justification in person, but the bank can collect information about her income directly from the local Tax Office, given that the customer provides her authorisation. The income of the customer is very likely to impact the amount (service outcome) to be finally lent to her.

Service input is required for:

- invoking the service, i.e. the service usually cannot be initiated unless all required input is available;

- validating the rules that govern the service (see sections 4.4.3.4), for example in order to decide whether a customer is eligible for a service, e.g. if the customer has no income then she is not eligible for a loan; and
- personalising/configuring the service and its outcome (see section 3.2.3.3), for example if the customer's annual income is less than 10k Euros, her loan cannot be more than 3k Euro.

Relationships

The following relationships is defined:

- *requires* which relates *service* to *service input*. A *service* requires one or more pieces of *input* for it to be successfully executed.
- *Validated by* which relates service rule to service input. A service rule requires information in order to be validated, this information is provided via the service input.

The *provides* relationship which relates *customer* to *service input* has already been defined in section 4.3.3.2.

Our modelling of service input is summarised in the figure below.

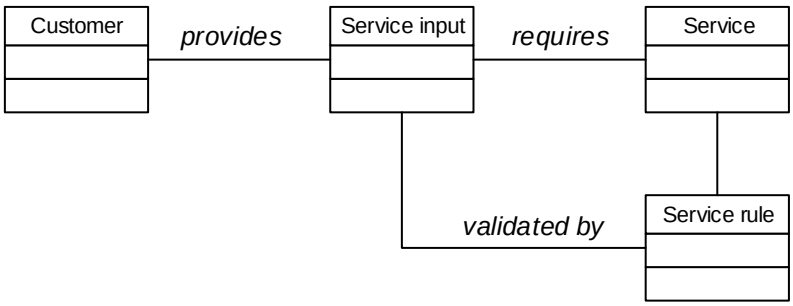

Figure 27: The service input concept

4.3.4.2 Service outcome

A service produces outcome. In other words, service outcome is what the customer receives after the successful execution of the service. No outcome is produced otherwise, i.e. if the service execution fails or if the customer chooses finally not to consume a service, e.g. because it cannot be tailored to her context and characteristics. Returning to the bank loan example of the previous section, the actual outcome of the service would be the exact amount of money given to the customer by the bank. This will happen only after the bank goes through its internal process and decides that a loan can be granted. If the customer has, for instance, no income, then the service will be terminated and no outcome will be produced.

Service outcome was one of the concepts that derived from our abstraction exercise, as explained in Table 13.

Table 13: The service outcome cluster

Many of the service modelling efforts reviewed, model service outcome, using however different terms for that. We decided to use the term service outcome as the overarching term.
(Riordan 1962), (Storbacka and Lehtinen 2001), (Blau, Kramer et al. 2009), (Unified Service Description Language SIG 2011) talk about the ***output*** of a service.
Polter et al. 2008), (International Organisation for Standardisation 2011), (Mora et al. 2009) & (Mora et al. 2011) and (The Open Group 2010) introduce the notion of service ***outcome***, while the latter also talks about the ***effect*** of a service. We discuss the effect of the service in section 4.4.3.7.
The effect of a service, which refers to the impact of a service in the real-world, is also modelled by (OMG 2009) and (Estefan, Laskey et al. 2009). We also model that separately in our work, as part of the Customer Service Model in section 4.4.3.7.
(Payne 1993), (Kotler and Keller 2006) and (Alter 2008) refer to the outcome of a service as ***product***; while (Hultgren and Eriksson 2005) and (Lovelock et al. 2009) term it as ***result***.
Service outcome, usually referred to as output, postcondition or effect appears also as a core concept in all semantic service modelling frameworks, including WSMO (Polleres, Bussler et al. 2005; Roman, Keller et al. 2005), WSMO-Lite (Vitvar, Kopecky et al. 2008; Fensel, Fischer et al. 2010) and MicroWSMO (Kopecky, Vitvar et al. 2009), OWL-S (McIlraith and Martin 2003; Martin, Burstein et al. 2004; Martin, Burstein et al. 2007), SWSF (Battle, Bernstein et al. 2005), WSDL-S (Akkiraju, Farrell et al. 2005), SA-REST (Lathem, Gomadam et al. 2007; Sheth, Gomadam et al. 2007) and the MSM (Pedrinaci and Domingue 2010).

Obtaining the service outcome, which can effectively satisfy a specific need of the customer (see section 4.3.2.1), is the main reason why a customer decides or has to consume a service.

As discussed also in the previous section, the outcome of a service can be used as input to another. For example, the customer that wants to apply for a bank loan should first contact the Tax Office where she is registered and apply for an income certificate, which actually is produced as the outcome of a public service for issuing this type of certificates.

Service outcomes may be of different nature. We distinguish between tangible outcomes, e.g. a document, a product or a good, and intangible ones, e.g. a skill or a competency acquainted while the customer was consuming the service, information or knowledge, authorisation/permission to do something etc. Service outcomes can be sensed, felt, put in practice and evaluated by the customer.

The type of the outcome may be further detailed depending on the service domain. For example, the tangible outcomes of public services may be certificates, permissions or authorisations documented in the form of administrative documents (Peristeras and Tarabanis, 2008).

Relationships

The following relationships are defined:

- *produces* which relates *service* to *service outcome*. If executed successfully, a *service* produces at lease one *outcome*.

The *receives* relationship which relates *customer* to *service outcome* has already been defined in section 4.3.3.2.

Our modelling of service outcome is summarised in the figure below.

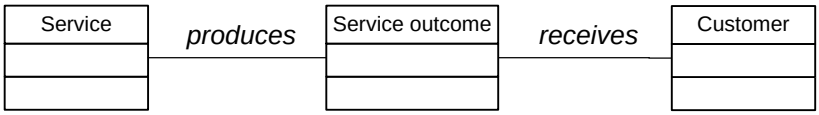

Figure 28: The service outcome concept

4.3.4.3 Resource

A service requires/consumes/uses/transforms resources in order to be delivered. These resources are contributed during the delivery of the service by the service provider (and other service stakeholders) as well as by customers. As defined in Service Science, customers and providers contribute and exchange resources throughout the provision of a service (Spohrer et al., 2011).

A resource is defined as a tangible or intangible asset that is contributed by/exchanged between/integrated by the service agents (see section 4.3.3) during the delivery of particular service and is required for the delivery of that service.

Resource was one of the core concepts that derived from our abstraction exercise, as explained in Table 14.

Table 14: Resource cluster

The perceptions that customers contribute resource during the service provision is well-received in service literatures, see for example Murdick et al. (1990), (Kotler and Keller 2006), (Lovelock, Wirtz et al. 2009), (Ferrario and Guarino 2009) and (Vargo and Lusch 2008).

Resource, either as a tangible good or as an intangible asset, e.g. information or knowledge, has come across in many of the service modelling efforts.

(Seybold 1999), (Spohrer, Maglio et al. 2007), (Estefan, Laskey et al. 2009), (Blau, Kramer et al. 2009), (Lusch, Vargo et al. 2010) and (Unified Service Description Language SIG 2011) all refer to resources, while (Grönroos 2000) refers to physical resources.

Others, such as (Alter 2008) and (IfM and IBM 2008) differentiate between information and other types of (tangible) resources required by services.

(Kwan and Min 2008) differentiate between tangible resources, skills and competencies, while (Lovelock et al. 2009) define the following types of resources required by a service: money, physical elements (e.g. facilities, networks, and systems), goods, labour and skills.

Relationships

The following relationship is defined:

- *contributes* which relates *resource* to *service agent*. A *service agent* (i.e. the service provider, the customer or a service stakeholder) provides zero or more *resources* during the provision of a service.

The *requires* relationshis is reused here and has been defined in section 4.3.4.1.

Our modeling of resource is illustrated in the figure below.

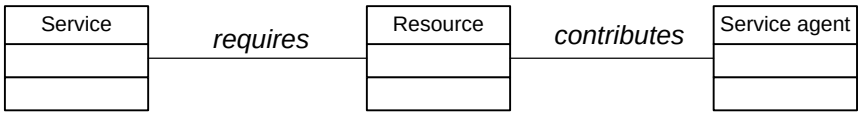

Figure 29: Resource and related concepts

We identify three types of resources: operant, operand and financial (see also Figure 30).

Operant resources act upon other resources to create benefit and value (Vargo and Lusch 2004). According to the fourth foundational principle of Service-Dominant logic, operant resources (i.e. knowledge and skills) are the fundamental source of competitive advantage. Competition is driven by the ability to integrate operant resources in different propositions to cause desired change (Vargo and Lusch 2008).

Three types of operant resources exist:

- **Information resources**, which include pieces of information and data owned by a service agent.
- **Knowledge resources** which include experiences and expertise facts.
- **Skills**, namely competences, capacities and capabilities to perform specific tasks.

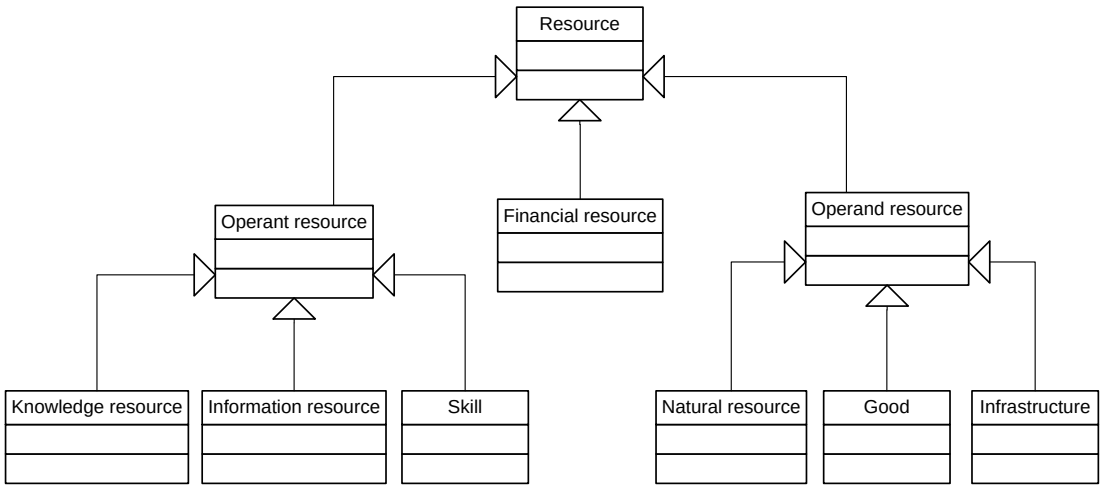

Figure 30: Types of resources

Operand resources must be acted upon to create benefit and value (Vargo and Lusch 2004), e.g. natural resources and products. Three types of operand resources are identified:

- **Natural resources**, namely natural materials used in a specific interaction, e.g. water.
- **Goods**, namely tangible commodities and products.
- **Technical infrastructure**, which may include machinery as well as ICT.

Financial resources act as facilitators for the provision of a specific service, e.g. a bank loan or own funding.

4.3.4.4 Service quality

Every service, as well as its outcome, is made available at a pre-determined level of service quality (defined by the service provider and/or the service owner), i.e. how good or bad a service is provided benchmarked against a number of determinants, but also as evaluated by the customer. The overall quality of a service depends on how well several elements of the service are configured, implemented and delivered, including the service activities, context, and the service agents involved in the provision of that service.

Table 15: The service quality cluster

Although quality as a class or property is usually not included in service models and definitions, the different determinants of quality appear in the different service modelling efforts, especially in the form of non-functional properties of services or in the context of service level agreements. We therefore decided to include service quality as a core concept. Service quality determinants can also be found in the non-functional descriptions of semantic service modelling frameworks, they are however rarely set. Service quality is

considered as a core service concept, which drives the bottom-up description of services by customers, in all efforts that tried out the social descriptions of services, discussed in section 2.3.3.

Service quality is explicitly refered in the works of (Storbacka and Lehtinen 2001), (Akkermans, Baida et al. 2004), (Basole and Rouse, 2008) and (Polter, Verheijen et al. 2008). USDL also comprises a Service Level (SLA) Module which defines different determinants of quality, including service availability, security and performance (Unified Service Description Language SIG 2009). A similar approach is also followed in the SOA Ontology and SoaML, where ServiceContract is defined as a container of SLA-related properties, while the reference model for SOA of OASIS uses the class Performance Metrics to measure the speed and quality of realizing the real world effects produced using the SOA service.

Our modelling of service quality capitalises heavily on the seminal works of (Parasuraraman, Zeithaml et al. 1985; Zeithaml, Parasuraraman et al. 1990). We thus adopt and adapt in our context some of their determinants of service quality, namely:

- *Reliability*, i.e. the fact that the service provider performs the service right and delivers it according to the pre-determined level of service quality. Ideally, during the provision of a specific service, the service quality experienced by the customers is up to the standards of the pre-determined level set by the service provider. Here we should clarify that by service reliability we do not necessarily refer to network reliability (for e-services). Service reliability means in our understanding that the delivery of the service is uninterrupted and that the service and its outcome meet the customer's expectations.
- *Responsiveness*, i.e. the fact that the service is readily available and is delivered in a timely manner.
- *Access*, i.e. the fact that the service and/or information about the service can be accessed in an easy, convenient and unobscured manner whenever the customer wants to use it.
- *Communication and understanding*, i.e. providing to the customers information about the service in a simple, understandable and personalised manner, and being able to identify the needs of a particular customer and then to adapt and personalise the service accordingly.
- *Security*, i.e. the delivery of service is risk- and danger-free for the customers and service stakeholders – not only in terms of physical safety, but also in terms of financial security and data privacy and confidentiality.
- *Courtesy*, i.e. politeness, consideration and friendliness of the service provider (and other service agents) both in face-to-face and electronic interactions with the customers.
- *Trust and credibility*, i.e. trustworthiness of the service provider, e.g. ensuring that the service provider and the service stakeholders have the required knowledge and skills in order to deliver the service successfully.

- *Tangibles*, e.g. quality, ambience and aesthetics of the location (physical or electronic) where the service is provided.

We include one additional determinant, namely *ease of use and usability*, i.e. ensuring that the customers can learn how to use the service easily, with minimum effort (cognitive or labour) and in minimum time.

Relationships

The following relationships are defined:

- *delivered at* which relates *service* to *service quality*. A *service* is delivered at a pre-defined level of *service quality*.
- *is set by* which relates *service quality* to *determinant*. The quality of a service is set by a number of determinants, e.g. reliability, trust, usability and others discussed previously.
- *defines* which relates *service provider* to *determinant*. A service provider defines one or more determinants that will set the quality of a particular service. These determinants and the performance indicators for measuring them can be part of a formal Service Level Agreement.

The concepts discussed in this subsection and their relationships are summarised in Figure 31.

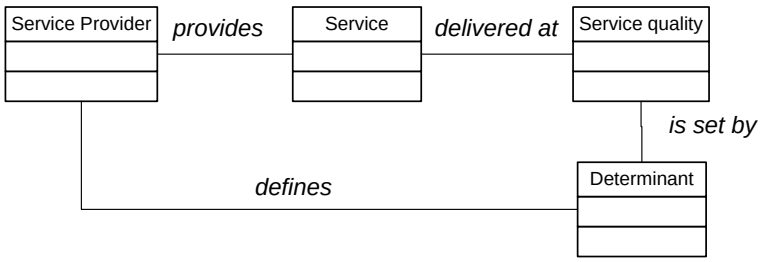

Figure 31: Service quality

4.3.5 Where and When view

The *Where* and *When* view refers to the context of service provision, i.e. the wider social, economic, legal etc. environment and the circumstance in which a service is provided. A service experience (also referred to as service instance) is a momentary construction that is developed in a certain context.

4.3.5.1 Service context

Our detailed review of the service literature revealed that a service is designed and provided in a wider environment that is influenced and formed by several factors, e.g. business, political and spatio-temporal. Modelling and understanding the context of the service helps to understand better the service itself and what customers expect from it. Although context as a class is usually not included in

service models and definitions, the different dimensions of context appear in the different service modelling efforts. We therefore decided to include service context as a core concept. However, detailed modelling of service context is out of scope of our work.

As a result of our abstraction exercise, we define the following dimensions of service context (see also Figure 32):

- *Business dimension.* The business dimension of service context models the business and organisational environment of service provision. It covers the motivation and the business case for delivering a particular service and defines the main roles and responsibilities. This is usually encapsulated in a business policy. According to the (Object-Management-Group 2008), a business policy includes a set of guidance statements and recommendations that express "the guiding procedure, philosophy or course of action for an enterprise or company" in the context of service provision.
- *Social dimension.* The social dimension of service context models the cultural and societal environment that the service operates in, e.g. moral values and attitudes, political beliefs of citizens/customers, and underlying social structures. We assume that demographics are included in the social dimension as well.
- *Economic dimension.* The economic dimension of service context models the set of economic factors, benchmarks and indices that influence the service, e.g. income, inflation, interest rates, productivity, and wealth of the (target) customers. The economic dimension of context may influence (or even define) among others the price (or the sacrifice) for using a service, i.e. how much the customer can or is willing to pay for it (see section 4.4.3.6), and the total cost of service provision. Every service is provided in a particular economic environment.
- *Political and legal dimension.* The political and legal dimension of service context models the system of government, the national and international laws, government regulations, directives and policies that govern the delivery of a service. The service agents and the service activities must conform to these laws and regulations. As we discussed in section 4.3.3.3, a number of service modelling efforts, including (Estefan, Laskey et al. 2009), (Spohrer, Maglio et al. 2007) and (Storbacka and Lehtinen 2001), foresee a separate role, that of the service regulator, who sets, governs and monitors the political and legal dimension of a service's context.
- *Spatio-temporal dimension.* A service is delivered at a specific place on a specific date and at a specific point in time. The date and time of service delivery is agreed upon between service provider and customer. Additionally, a service may also be available for a specific period, i.e. between a start and an end date and time. The temporal aspect of service provision relates to

the time-perishability characteristic of services emphasised by Murdick et al. (1990) and (Fitzsimmons and Fitzsimmons 2006).

Relationships

The following relationship is defined:

- *delivered in* which relates *service* to *service context*. A *service* is delivered in particular *service context* which comprises (some or all of) the dimensions discussed above.

The concepts discussed in this subsection and their relationships are summarised in Figure 32.

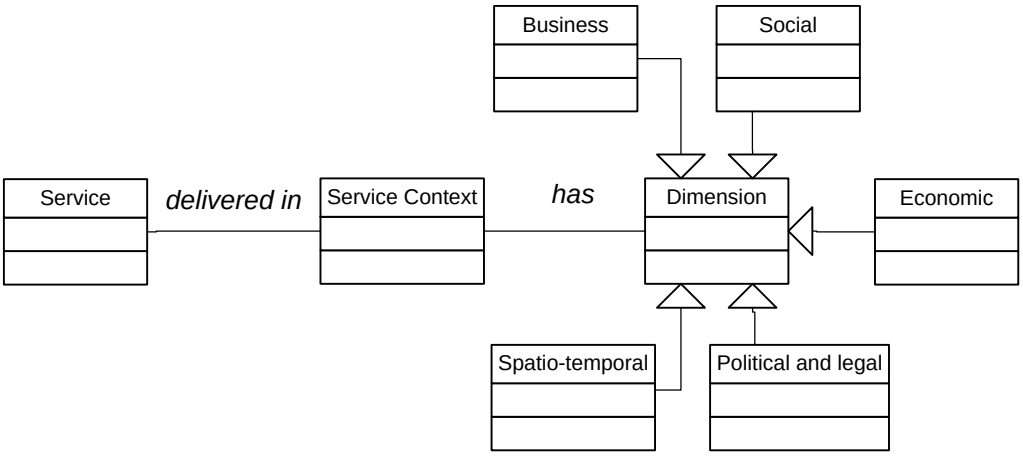

Figure 32: Service context and related concepts

4.3.6 Overview

An overview of the core service concepts defined in the previous sections is presented in the figure below in the form of a Unified Service Model. The Unified Service Model provides the basis for developing the Customer Service Model, discussed in the next section.

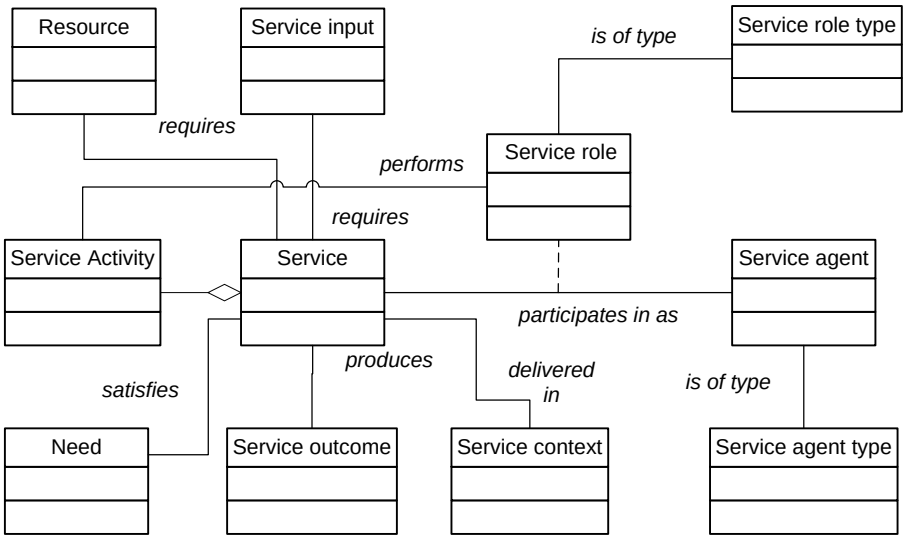

Figure 33: The Unified Service Model

4.4 Customer Service Model

In order to address the research objectives driving this *Thesis*, we develop the Customer Service Model, which provides the modelling elements for representing how service is perceived from the perspective of the customer, hence modelling the customer viewpoint. To achieve this, we review and extend the Unified Service Model in order to accommodate concepts and relationships that express the customer viewpoint. Hence, in addition to the concepts and relationships modelled in section 4.3, we introduce a number of concepts, such as *expectation*, *perceived value* and service *feedback* and the different *roles of customers*, and their relationships.

The Customer Service Model (as well as the pilot implementations and uses of this model presented in Chapter 5) can serve the following three principles which can effectively contribute to achieving the main objective of this *Thesis*, i.e. to study and conceptualise service, encompassing both the service provider's and the customer viewpoints:

- The active participation of the customer throughout the lifecycle of the service should be encouraged and facilitated.
- The collective intelligence created by the customer throughout the service lifecycle, if harnessed, can add value to the services, and foster service innovation and evolution.
- A rich service experience can be offered when emphasising on customised service search, recommendation of related services and service personalisation.

Following the same pattern as for the Unified Service Model, we organise the concepts and relationships of the Customer Service Model according to the following views: *Who*, *Why*, *What*, *Where & When*.

The *How* view, which models behavioural aspects of customer-centric service provision has been modelled in the context of the service lifecycle presented in the previous chapter.

The remainder of this section, i.e. subsections 4.4.1 through 4.4.4, defines the concepts and relationships comprising the Customer Service Model.

4.4.1 Why view

The *Why view* models the needs and goals that the customer wants to fulfil through the consumption of a (set of) service(s). In addition to the core concepts and relationships defined in section 4.3.2, the *Why view* also includes the following concepts:

- Perceived value; and
- Demand.

4.4.1.1 Perceived value

Customer expectations of service, with regards to the expected outcome and the expected quality of service, determine the perception of value that a customer will receive (see also section 4.4.3.8) by consuming that particular service. *Perceived value* refers to the way that a customer understands and feels (experiences) the outcome delivered by a service that she just consumed, how she benefited from it. We define benefit as the advantage, the improvement, or the positive change in the customer context (see section 4.4.4.1) that is caused by a service.

Customers are usually not interested in the service per se; they are rather interested in the value created (i.e. the customer's perception of how she can benefit from that service) as an effect of a specific service as conveniently and cost-effectively as possible and within a desired level of quality. For example, the customer's need/want is to get married or be healthy. Issuing a marriage certificate or receiving treatment in a hospital are outcomes of the respective services, which allow the customer to satisfy her specific need/want.

According to the tenth foundational principle of Service-Dominant Logic, value is always uniquely and phenomenologically determined by the customer (Vargo and Lusch 2008). Hence, we argue that perceived value is subjective –pertinent to the individual - and depends on the expectations (defined later in section 4.4.3.8) and the context of the service consumer (defined later in section 4.4.4.1). It is also particular to a specific service instantiation and is influenced by the quality of the particular

instantiation of the service. Hence, the perceived value of different customers for the same service will be different. Likewise the perceived value of the same customer may differ between different instantiations of the same service. This practically means that if the same customer uses on two occasions the same e-service for planning a holiday, the perceived value between each use of the service may differ; for example because the expectations of the customer with regards to the price of the holiday package that she wanted to book or the usability of the service were met in the first time and not in the second one. The high subjectivity of perceived value makes it also quite volatile over time. As peoples' minds change, perceived value may change too.

(Vargo and Lusch 2008) argue that "there is no value until an offering is used" (value-in-use) and confirm that customer experience and perception of service are essential to value determination, i.e. what the customer expects the service to deliver. In this vein, the value that a customer receives from a service is tied to:

- the appropriateness of the service outcome (i.e. how well did the outcome of the service satisfy her initial need). We remind to the reader that we defined service outcome in section 4.3.4.2 as what the customer receives after the successful execution of the service; and
- the evaluation of the overall service provision (e.g. if the service experience was a pleasant one, and if the needs and the expectations of the customer were met).

Perceived value is also influenced by the *sacrifice* that the service consumer had to assume for using the service, i.e. the cost in terms of effort, time and/or resources. These may be monetary and/or non-monetary (e.g. contribution of personal time or effort) contributions and sacrifices.

In order to evaluate perceived value, service providers should collect, study and analyse the gap between customer expectations and feedback.

Relationships

The following relationships are defined:

- *feels* which relates a customer to the perceived value of a particular service. In the end, perceived value is a feeling, something that the customer can sense and experience. It is worth reminding here that perceived value is tied to an individual service instantiation. If the customer consumes the same service for a second time, it is possibly that different perceived value will be formulated and felt.
- *delivers* which relates *service instance* to *perceived value,* indicating that perceived value is created and felt by the customers during the consumption of a service.

- *determined by* which relates *perceived* value to *customer expectations* and *sacrifice*, thus expressing that perceived value is pertinent to a particular customer. After consuming the service, the customer formulates her perception of value delivered by the service taking into account how well her expectations have been met and assessing also the cost-benefit aspects.

Our modelling of perceived value is summarised in the figure below.

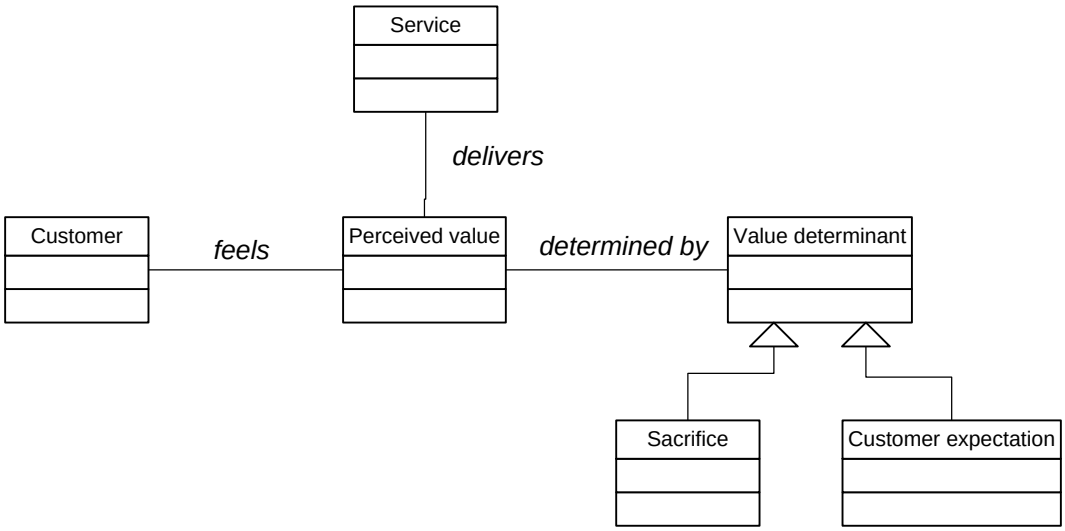

Figure 34: Perceived value and related concepts

Perceived value is usually emotional, e.g. liking something…, being satisfied with something… etc., but can also be measured in monetary units. Hence, in simple terms, *value for the customer means that after experiencing the service her emotional state has changed* – ideally it has improved - for example she now feels better, happier, healthier more satisfied, accepted, appreciated etc. than before. For instance, educational services can help people feel more confident with themselves, while receiving healthcare treatment helps someone feel healthy. Consequently, we identify two types of perceived value for the consumer of a service (Figure 35):

- *Emotional value*, where value is expressed in terms of feelings and senses, e.g. happiness, like, pleasure, satisfaction, trust, affection, comfort, ease of use etc.
- *Monetary value*, where value is measured in financial terms, e.g. through effects on revenues, cost savings or wealth gained.

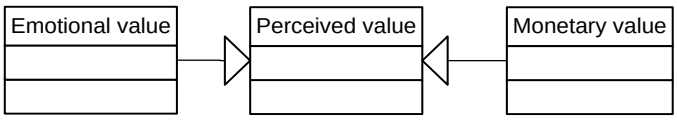

Figure 35: Types of Perceived value

4.4.1.2 Demand

The decision of a service provider to invest in the provision of a (new) service depends on a number of parameters, which have to be considered and could be part of the business plan that the service provider puts together. These (new) service propositions should come with a viable business model, which will ensure that the service will benefit the service provider as well and that it will be a means for the provider to meet their organisational/business goals and objectives. In the case of for-profit service providers, this will mean that the service generates revenues for the service provider and has positive economic externalities. In the case of not-for-profit service providers, the benefit may relate to improvements in the capacity to serve their customers or the reputation of the service provider.

The primary parameter to be considered is service demand. The demand for the service refers to the existence of a number of customers, i.e. a market segment (see section 4.3.3.2), who need the service and are willing to make the sacrifice required in order to consume it. Sacrifice entails the cost, e.g. in terms of time, effort or money, that the customer has to take on in order to use the service. We discuss sacrifice in the context of service input in section 4.4.3.6.

Building on the definition of demand given by schema.org, we define service demand as the public, not necessarily binding, not necessarily exclusive, announcement by an organisation or person to seek a certain type of services. Hence, there is a direct link between service demand and customer's need. The decision of a customer to consume a service is the turning point from need to demand.

In some cases, especially in the case of public services, the demand for a service may not come bottom-up from the customers, in this case from businesses and citizens, but top-down directly from the government themselves in order to support the customers in fulfilling a specific obligation, which we have already defined as a subconcept of need. For example governments put in place tax collection and reimbursement service in order to facilitate the obligations of citizens to pay tax on their income.

Relationships

The following relationship is defined:

- *transforms* which relates a need to demand, expressing the tight interdependency between the two concepts, which has been explained in this section.

4.4.2 Who view

In the Customer Service Model, the *Who* view models roles of the customer in the service lifecycle. In addition to the service roles defined in section 4.3.3, these also include:

- The roles that the customer assumes throughout the service lifecycle;

- The secondary beneficiaries of the service; and
- The critical audience of the service.

In section 4.3.3.2, we defined customer as the entity that consumes/uses/experiences a service in order to satisfy a specific need, want or obligation. Interestingly, the term customer is overloaded and may refer to either of humans consuming a service, to organisations using it and to machines as well.

Similar to service agent types (see section 4.3.3), customers can be of any of the following types:

- Natural persons;
- Organisations: i.e. legal entities; public organisations, or other types of organisations.

Our modelling of the different types of customer roles, which is summarised in the figure below, follows again the *role association class solution* of Mossé (2002). We define in the remainder of this section a number of generic customer role types played by the customers involved in a service. A summary of those types in the form of a taxonomy is illustrated in Figure 37.

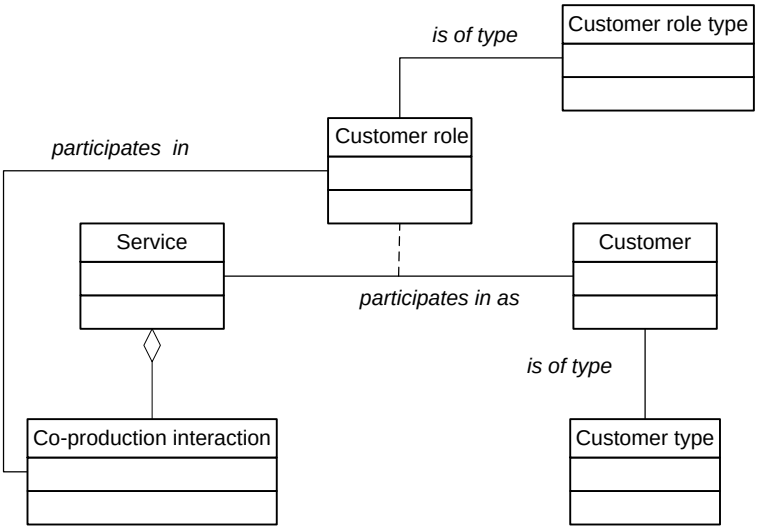

Figure 36: Participation of customer in service provision

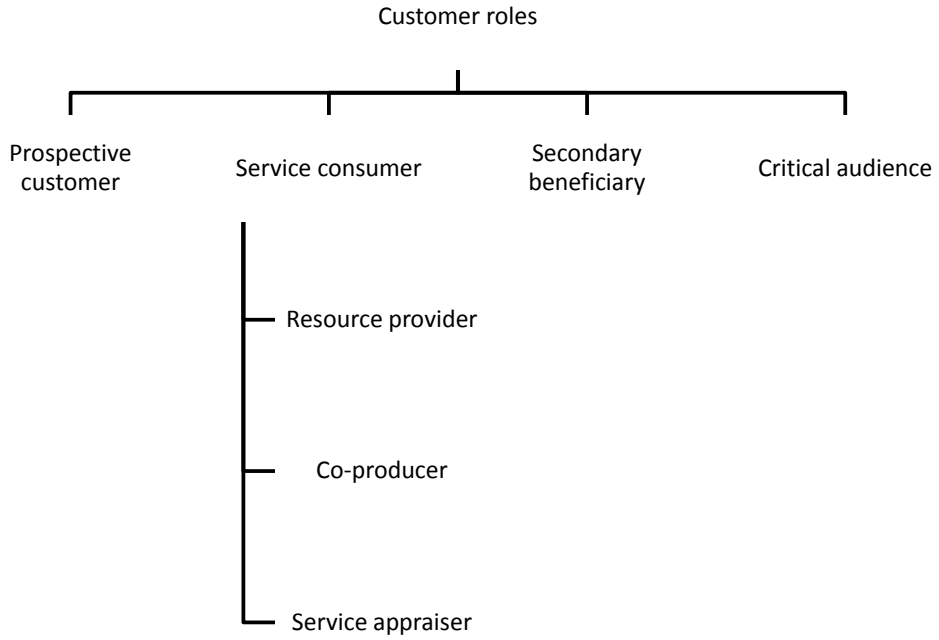

Figure 37: Types of customer roles

4.4.2.1 Prospective customer

The prospective customer refers to a role that is interested in using the service in order to receive its outcome or to integrate it with other services and/or resources. A prospective customer initially realises that she has a need/want/obligation (part of the need realisation phase discussed in section 3.2.3.1) and is then looking for the appropriate service (see also service search discussed in section 3.2.3.2) to fulfil this need. Service providers target prospective customers in the context of their marketing campaigns in order to raise awareness of their services and collect expectations and requirements.

Hence, prospective customers participate actively in the need realisation, conceptualisation and design of new services and the redesign of existing ones by contributing requirements and expectations which have to be translated by service providers into service capabilities and service quality parameters. The expectations of prospective customers may stem either from prior experience with using the service or directly from one of their needs that has to be satisfied. Customer expectations are discussed further in section 4.4.3.8.

Prospective customers are usually organised/classified by service providers into market segments (discussed in section 4.3.3.2). For example, during the redesign of a public service for setting up a new business in Greece, the government (service provider) may engage a sample of entrepreneurs and investors (prospective customers) in order to elicit their expectations, e.g. that the new service should

be efficient, the administrative burden should be minimised, and the outcome must be produced within 7 working days.

Relationships

In addition to *has need* and *satisfied* already defined in section 4.3.2.1, two relationships are defined:

- *expresses* which relates *prospective customer* to *customer expectation*. A *prospective customer* may express zero or more *expectations*. A *customer expectation* may be shared by one or more *prospective customers*;
- *concerns* to relate *customer expectation* to *service*. Before consuming the service, customers have expectations with regards to the service in terms of outcome, experience and quality. More than one *customer expectations* concern the same *service*.

Our modelling of the prospective customer as an object of the *service role* association class defined in section 4.3.3 and its relations to other concepts are depicted in the figure below.

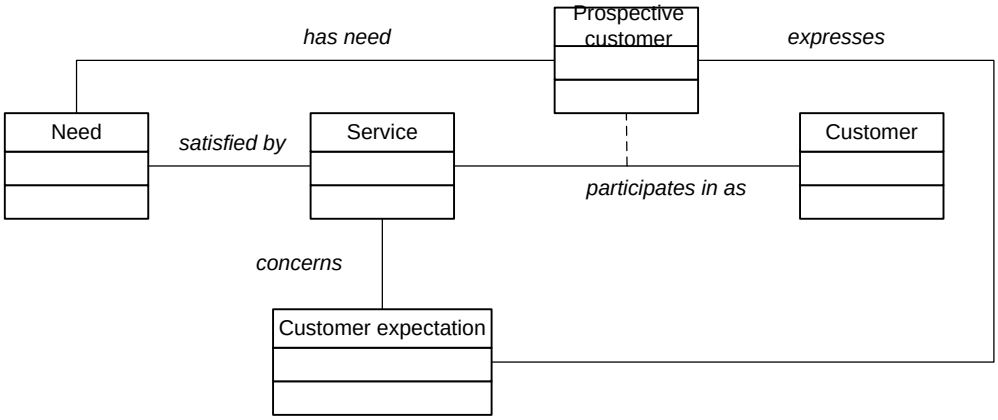

Figure 38: The prospective customer

4.4.2.2 Service consumer

We define the service consumer role, specialising the generic term customer, to refer to the customer that completed successfully the service search phase, found a service that addresses her need, purchased, initiated and experienced this service, and received its outcome in order to satisfy her needs. A service consumer consumes different services, but may also consumer different instantiations of the same service over a period of time. The service consumer is the primary beneficiary of the service.

The service consumer role is modelled in the figure below.

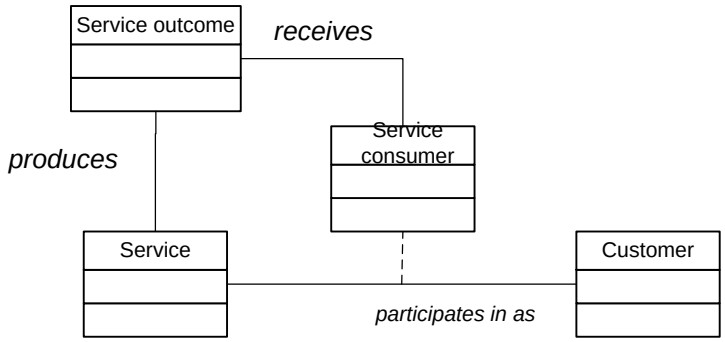

Figure 39: The service consumer role

We define three subroles of service consumer, i.e. co-producer, service appraiser and resource provider.

In Service Science, the protagonistic role of service consumers in the delivery of a service is emphasised by referring to them as co-producers of the service. This practically means that the service consumer carries out or leads activities in the service process and contributes to the creation of the service value, embedded in the outcome of the service (see also section 4.4.1.1). We refer to these activities under the term co-production interactions. We have discussed them in detail in section 3.2.2.

A typical example of customer as *co-producer* is the case of education and training services, where the customer is highly-involved in the selection and formulation of the training curriculum and in the delivery of the training service itself through his participation. The successful delivery of the training service is a shared responsibility between the customer and the service provider.

The service consumer role is modelled in the figure below.

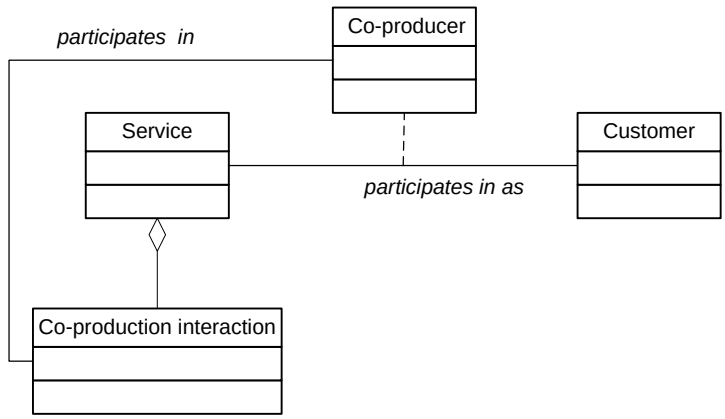

Figure 40: The co-producer role

In section 3.2.3.5, we explained the importance of service evaluation and how this runs throughout the service lifecycle. As we define in section 4.4.3, the outcome of service evaluation, which comprises customer expectations (see section 4.4.3.8) and feedback (see section 4.4.3.9) of customers forms the so-called social descriptions of services (see section 4.4.3.10). During this process, we argue that the

customer assumes the role of *service appraiser*. Hence, the service appraiser is the service consumer who evaluates the service, by sharing her expectations and feedback (modelled in sections 4.4.3.8 and 4.4.3.9 respectively). Mora et al. 2011 were the first to define that customers can act as appraisers of the service.

The service appraiser role is modelled in the figure below.

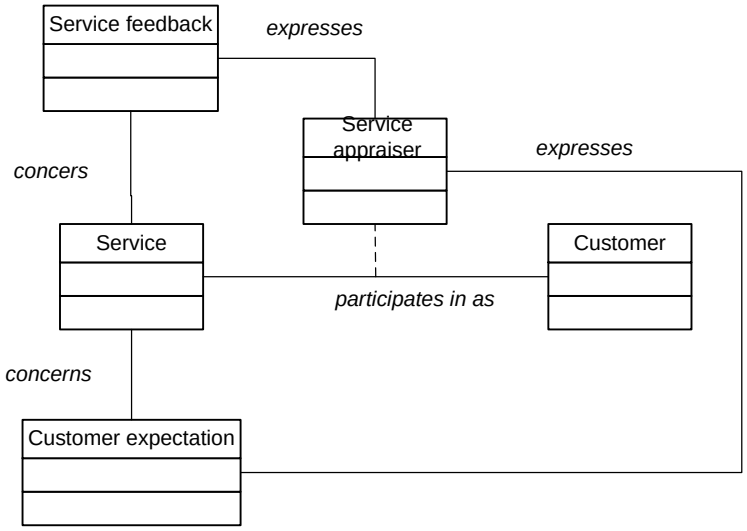

Figure 41: The service appraiser role

Finally, the service consumer may also act as resource provider (see *Who view* of the Unified Service Model in section 4.3.3), as service consumers contribute information and operant resources, such as skill and competencies, which are required for delivering the service. Resources are provided either as part of the service input (see section 4.3.4.1) or in the context of co-production interactions (see section 3.2.2).

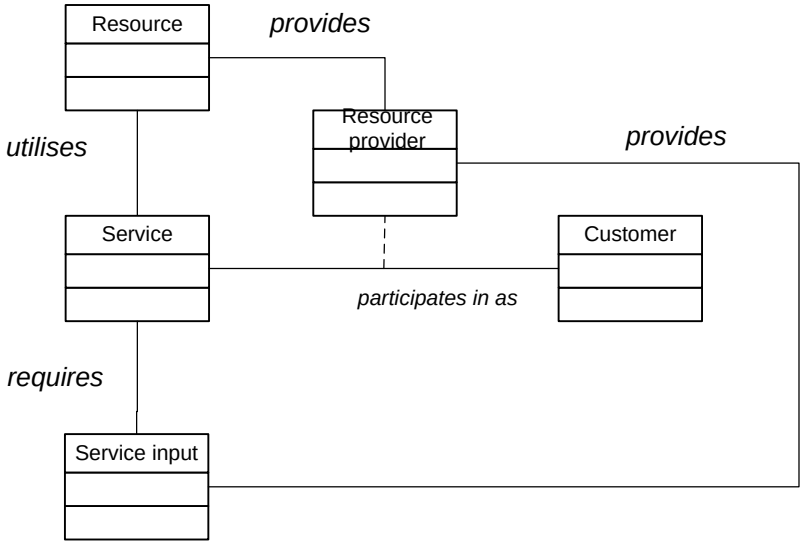

Figure 42: The resource provider role

For example, a business which is in the process of receiving a bank loan is the service consumer of the bank's lending services. During the service delivery, the representative of the business, acting as a resource provider, contributes information and knowledge about his company in order to tailor the service to its needs.

4.4.2.3 Secondary beneficiary

In some cases, other entities, apart from the service consumer, may also benefit from a service and its outcome. We use the term service beneficiary to denote this type of role. In this case, the benefit experienced and the value delivered does not relate directly to the satisfaction of a need of the secondary beneficiary, but to a positive impact of the service on her context. Secondary beneficiaries may also participate in the conceptualisation and design of services by contributing their expectations.

For example, the whole family of a patient benefits after the successful application of a medical treatment, as this contributes to the well-being, and the employees of a business who got a bank loan may also benefit from the planned growth of the business.

Our modelling of secondary beneficiary is summarised in the figure below.

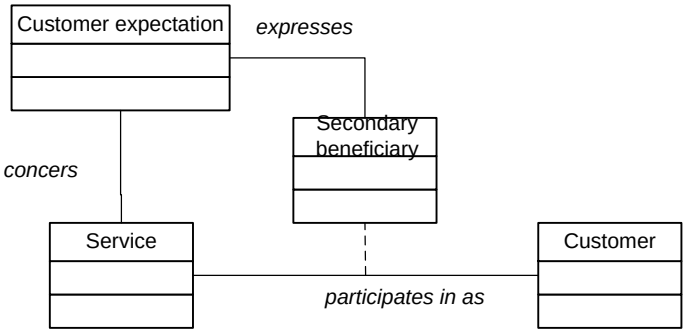

Figure 43: The secondary beneficiary

4.4.2.4 Critical audience

The critical audience refers to a customer or a group of customers that are interested in learning about the service but do not intend to or cannot use/experience it themselves. The critical audience influences the decision of the prospective customer with regards to finally consuming a particular service or not, but they are not directly involved in the service provision. Because of that, service providers include critical audience in the context of their marketing campaigns in order to raise awareness of their services and collect expectations and requirements.

For example, parents show high interest in services that will finally be consumed and experienced by their children (and they may even decide on the selection of the service that will finally be consumed), and financial brokers are interested in investment services from which their own customers could benefit.

Hence, a member of the critical audience can turn into a secondary beneficiary of the service once this is consumed by a service consumer. The critical audience of a service also forms part of the respective market segment (discussed in section 4.3.3.2).

Our modelling of critical audience is summarised in the figure below.

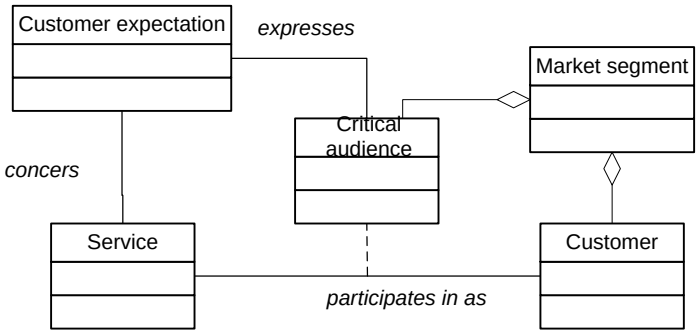

Figure 44: The critical audience

4.4.3 What view

The *What* view of the Customer Service Model extends the *What view* of the Unified Service Model in order to include concepts and relationships that impact and/or are impacted by the customer's perspective, and/or realise the customer's perspective. In addition to the core concepts and relationships defined in section 4.3.4, the following concepts are defined:

- Service and service bundle;
- Service category;
- Service rule;
- Service version;
- Service input and sacrifice;
- Service effect;
- Service channel;
- Customer expectation;
- Customer feedback; and
- Social description of service.

4.4.3.1 Service and service bundle

As discussed previously, from the customer viewpoint, a service is a means for satisfying a need and comprises of a sequence of service activities (including co-production interactions).

Often, complex customer needs cannot be addressed by a single service. In order to address such needs, a service may have to be integrated and combined with complementary and/or related services

in a *service bundle* (see also (Ferrario and Guarino 2009) and (Unified Service Description Language SIG 2011)). Although services may in the end be clustered into bundles by the service provider, it is the customers, through their service usage patterns and/or their life-events (Tambouris and Tarabanis, 2008), who form and define the service bundles that are relevant and meaningful.

Hence, a service bundle is defined as a group of complementary and/or tightly related services that fulfil a specific complex need of a customer or are targeted to a specific type of customer, e.g. the unemployed, and it is therefore recommended to be used together. A service bundle may comprise services belonging to different categories. For example, if a person wishes to go on holidays then a bundle of services would have to be executed, including booking flights and accommodation, applying for a visa (where applicable), renting a car etc. Similarly, in the context of public services, a service bundle can be used for representing a life-event, e.g. getting married or opening –up a new business. The services that comprise a service bundle may have to be executed following a specific sequence, without this however being always the case. Moreover, the execution of some of the services that comprise the bundle may be mandatory, while others may be consumed only if the customer wishes to do so (optional).

The different relationships between services that can be placed in the same bundled are defined in the next table.

Relationships

In addition to *has need* and *satisfied* already defined earlier, the following relationships are defined:

- *comprises* which relates *service bundle* to *service*. A *service bundle* comprises more than one *services*. A *service* may be part of zero or more *service bundles*.
- *consumes* which relates *customer* to *service*. A *customer* may consume zero or more *services (i.e. service instances)* in order to satisfy a *need*. The same *service* may consumed by different *customers*. However, each of them will experience the *service* differently.

We now define three recursive relationships on service to illustrate different options that drive the bundling of services.

- *relates to* to express different types of relations between services, e.g. services that are related because of: *(i)* targeting the same audience; *(ii)* targeting the same need; *(iii)* being provided by the same provider; *(iv)* being complementary – i.e. they have to/should be executed together in order to satisfy a customer's need; *(v)* being similar to other services that a customer has consumed in the past. A service may relate to zero or more other services. Effectively, different subproperties can be defined to differentiate between the different nuances of *relates to*.

- *provides input to* expresses cases when a service has to be executed prior to another one in order for the outcome of the first to be used as input for the second. For example, before receiving a bank loan, an SME needs to execute a public service provided by the Company Register to confirm that it is a registered legal entity. The outcome of this service is then provided as input to the bank loan service. *Provides input to* is a sub-property of *relates to.*
- *executed after* to be used in situations when a service has to be executed after another one. Executed after indicates a special case of complementary services where their execution sequence is well-defined. For example, after setting up a new company, the customer must also register the company in the Company Register. *Executed after* is a sub-property of *relates to.*
- *substitutes* which is used in cases when a service can be used instead of (can be replaced by) another one. A service can have zero or more substitutes, i.e. other services that can deliver the same outcome. Different substitutes may require the same or different sacrifice by the customer and may be have different quality considerations. *Substitutes* is a sub-property of *relates to.*

We also use *satisfied* to connect *need* to *service bundle* to show that a complex *need* may be satisfied by a *service bundle*.

Our modelling of service and service bundle is summarised in the figure below.

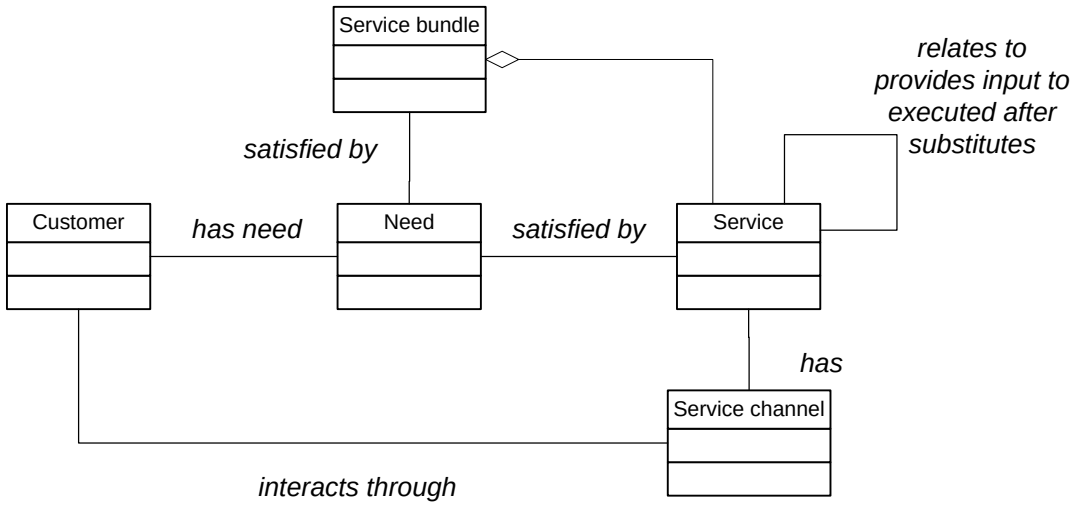

Figure 45: Service and service bundle

4.4.3.2 Service category

Services are organised/classified in service categories. Services may be placed under a specific category following different criteria. Service categories may be defined top down, reflecting the

decomposition of a business domain or a specific industry, or bottom up, reflecting the customer viewpoint. For example, services that fulfil the same need or target the same group of customers may belong to the same category. A service category may comprise more than one subcategory.

Relationships

The following relationships are defined:

- *classified into* which relates *service* to *service category*. A *service* may be classified into zero or more alternative service categories.
- *is part of* which is a reflexive relationship that indicates that a service category may be further specialised into sub-categories.

The World Trade Organisation defines a classification list of service categories[15] (referred to as service sectors and subsectors), including: Business services (e.g. legal services, R&D services and consultancy services); Communication services (e.g. postal and telecommunication services); Construction and related engineering services (e.g. installation and assembly work); Distribution services (e.g. wholesale trade and retailing services); Educational services (e.g. primary and higher education services); Environmental services (e.g. sewage and sanitation services); Financial services (e.g. insurance and banking services); Health related and social services (e.g. hospital and employment-related services); Tourism and travel related services (e.g. hotels and restaurants); Recreational, cultural and sporting services (e.g. entertainment, libraries, archives and museums); and Transport services (e.g. maritime and air transport services).

An alternative categorisation of services is that of the Statistical Classification of Economic Activities in the European Community (NACE codes)[16]. Service categories are specialised further (subcategories) when one enters a particular service domain. For example, public service types may take values from ESD Toolkit's Service List[17], INSPIRE's code list of "Utility and Governmental Services"[18] or the Classification of the Functions of Government (COFOG)[19].

Customers may also categorise services using user-defined tags, which capture their understanding of the type or the category that the service falls under. This forms part of what we define later on as social description of a service (see section 4.4.3.10).

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[15] http://www.wto.org/english/tratop_e/serv_e/mtn_gns_w_120_e.doc
[16] http://goo.gl/uGy2O
[17] http://doc.esd.org.uk/ServiceList/4.00.html
[18] http://inspire.jrc.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_US_v3.0rc2.pdf (ref. section 5.3.4.1, pages 84-8)
[19] http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=4

Our discussion in this section is summarised in Figure 46.

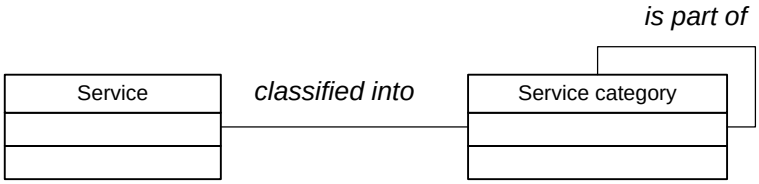

Figure 46: Service category

4.4.3.3 Service channel

A service channel is a defined a way that the customer can use for interacting with the service, providing preferences and input and/or receiving the service outcome. Service channels are under the responsibility of the service provider (and/or service owner). There are cases where the service owner and/or the service provider have assigned (or outsourced) the communication with customers to service frontstage entities (see section 4.3.3.3) or even to a service broker. In such cases, the service channel is owned and managed by the latter.

The two sets of channels, i.e. for accessing service and collecting the outcome, do not necessarily have to be the same or overlapping. This is very common in cases for example when the service is an intangible experience, like hospitality or healthcare services. In such cases, contacting the service provider to collect information about the service may be done using different channels, e.g. email or call or visiting their premises, but receiving its outcome can only be done in a specified physical location.

Based on its delivery mode, i.e. manual, semi-automated or fully-automated, a service may be available through physical and/or electronic channels.

- Physical channels are geographic locations (places) where from the service is made available and can be accessed and/or where the service outcome is delivered, such as the premises of the service provider. A physical location is identified by longitude and latitude and/or a specific postal address.
- Electronic channels may refer to any of the following:
    - A digital space on the Web from which the service is made available, e.g. an e-shop or a mobile application that provides access to a service through a mobile device.
    - A Web service which delivers the service to customers, which is available at a specific URL.
    - A telephone number that is at the disposal of the customers.

Relationships

The following relationships are defined:

- *interacts through* which relates *customer* to *service channel* to express the fact that a *customer* interacts with a service through different service channels.
- *accessed via* which relates *service* to *service channel* to represent the fact that *customers* may *access* a *service via* one or more different *service channels* (the different options are discussed above).
- *delivered through* which relates *service outcome* to *service channel* to represent the fact that *customers* may collect the *outcome* of a *service* via one or more different *service channels*.
- *responsible for* which relates a *service role* to *service channel* to model that a *service role* is responsible for the operation and maintenance of a *service channel*. A *service role* may be responsible for more than one *service channels*.

The relationship between service and service outcome has already been defined in section 4.3.4.2.

Physical and electronic channels and their relationships to other concepts of the Customer Service Model are illustrated in the figure below.

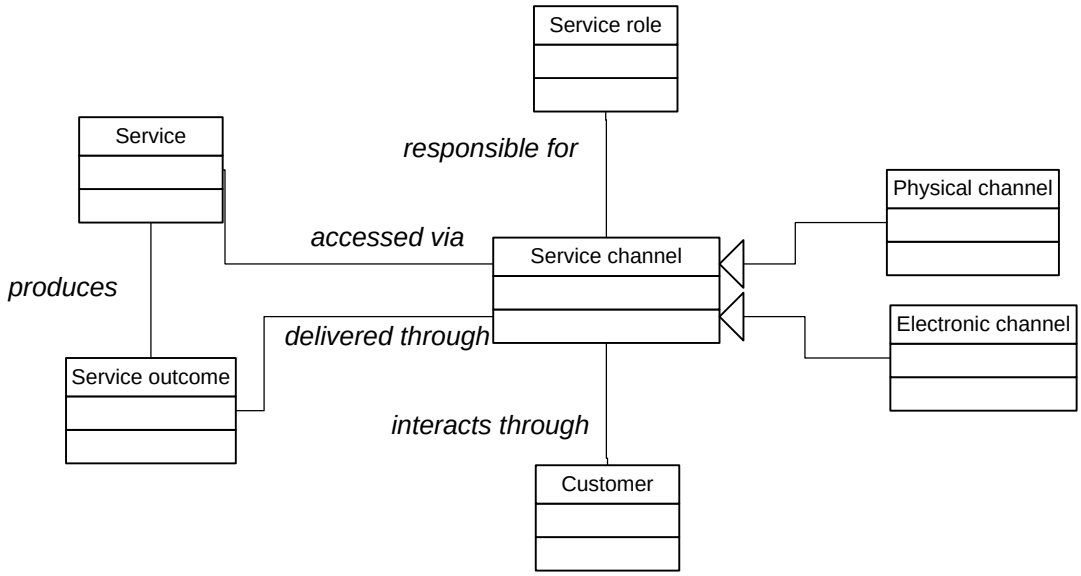

Figure 47: Electronic and physical service channels

4.4.3.4 Service rule

In section 3.2.1, we explained that the provision of a service comprises a number of service activities. We identified three types of service activities, namely basic activities, management and governance activities, and co-production interactions. We then elaborated on co-production interactions, which

are service activities where the customer has significant participation and contributions (see section 3.2.2). In this type of service activities, the customer assumes the role of co-producer defined earlier (see section 4.4.2.2).

In addition to a set of service activities, the service also includes and follows a set of business rules that answer to the following questions:

- Who is eligible to consume the service?
- Which service activities have to be executed each time depending on who is the customer?
- What is the sequence of the service activities to be executed depending on who is the customer?

In order to model service rules, we capitalise on the Semantics of Business Vocabulary and Business Rules (SBVR) standard (Object-Management-Group 2008). Among others SBVR defines the vocabulary and rules for documenting the semantics of business rules and policies.

Business rules derive from business policies and legal frameworks (see also section 4.3.5.1 where the business and legal dimensions of service context are discussed). SBVR defines *operative rules* as rules that govern the conduct of service activities, i.e. describe the way that the service is delivered.

Based on the three aforementioned questions, we define three types of *operative service rules*:

- *Eligibility rules,* which define conditions that have to be met by the customer in order for the service execution to be initiated, e.g. the customer has to be over 18 years old or she has to be physically present.
- *Service variant rules,* which are used for defining the *service version* (see also section 4.4.3.5) that best matches the profile and circumstances of a particular type of customers (e.g. customer that are below 18 years old must use the version of the service for minors).
- *Behavioural rules*, which govern the conduct, sequence and delivery of service activities, i.e. define and control the workflow of the service, e.g. the customer must express her preferences before the service provider can recommend to her the appropriate service version. Behavioural rules may be different between the different versions of the same service (see also next section).

Relationships

The following relationship is defined:

- *follows* which links *service* to the *operative service rules* that it follows. One service follows more than one operative service rules of different types, i.e. eligibility rules, behavioural rules and service variant rules.

The same rule may be common in more than one service. Because of this the modelling of atomic rules and their machine-readable implementation becomes particulary important, as it allows the ame rule to be reused in the implementation of different technology-enabled services.

Our modelling of service rule is summarised in the figure below.

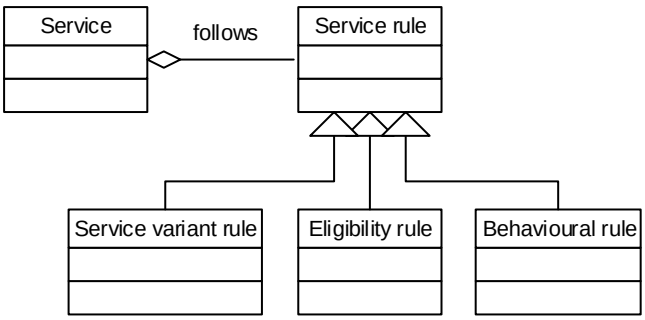

Figure 48: Service rule and related concepts

In SBVR (Object-Management-Group 2008) all types of operative rules are expressed as *logical expressions* in first-order logic[20] or in high-order logic[21] which consist of:

- The *Subject* that is the entity that is subjected to the statement of the rule, e.g. *a customer who applies for a service.* Every logical expression has exactly one subject. In the case of service personalisation the subject of the logical expression is the client of the service.
- The *Object* that is the part of the rule that describes the conditions/restrictions that are introduced by the logical expression e.g. *is an adult.* No specific syntax is used for the object.
- The *Modal* that formulates the relationship between the subject and the object. The relation can be *necessity*, *obligation*, *permission* and *possibility* (Object-Management-Group 2008). It is expressed with specific word, as indicated by the SBVR syntax: *i) it is obligatory*, *ii) it is prohibited, iii) it is necessary, iv) it is impossible, v) it is possible* and *vi) it is permitted*. Every logical expression has exactly one modal.
- The *Quantification* is a logical formulation that defines the "quantity" of the subject used at the logical expression. It is also expressed with specific words: *i)* each, *ii) at least one*, *iii) at least n*. The quantification is not obligatory to exist at a logical expression.

A detailed example can be found in section 5.4.1

[20] http://en.wikipedia.org/wiki/First-order_logic
[21] http://en.wikipedia.org/wiki/Higher-order_logic

4.4.3.5 Service version

Services have a high-degree of variability and are increasingly becoming customer-centric. Emphasing on customer-centricity increases further the variability of services, as providers are striving to adapt their offering to the needs of the individual. As discussed also in section 3.2, the increased degree of customer participation in service provision often makes the outcome of the service and the service experience particular to the individual.

Customers experience service in a unique manner, which depends on their personal preferences, peculiarities and context. Effectively, this means that the provision of the same service, as well as its outcome may actually be differentiated in order to adapt to and cover different profiles of customers who wish to use that particular service in order to satisfy a common need. For example, the same bank lending service will be adapted in the cases of a small-medium enterprise and a multinational company, or the process of a public administration service for issuing passports will be differentiate in the cases of children and adults. Additionally, as discussed in section 4.4.1.1, the same customer may experience different instantiations of the same service differently depending on her context, e.g. on emotional state and personal circumstances.

We term these variations of the same service *service versions*. Hence, service versions refer to specialisations of service that stem from and are driven by the various profiles of customers that are eligible for that particular service. Usually, depending on the profile of a customer, her context and her preferences a different service version will have to be executed, tailored to the specificities of that particular customer. Effectively, the need of a customer will be satisfied in the end through the consumption of the specific service version that fits her profile. Service versioning is a key requirement in most service industries, including public administration as outlined by Loutas et al. (2011), Peristeras & Tabaranis (2008) and Momotko et al. (2007).

Service versions can be defined using a set of *service variant rules*. In section 4.4.3.4, we defined service variant rules as a specific type of operative service rules that can be used for formally expressing (both in structured human language and in first order logic) the conditions that signal different service versions of a service, e.g. customers that are below 18 years old must use the version of the service for minors. For instance, a service variant rule could define that if the customer is under 18 years old a particular service activity has to be conducted.

The versions of the same service share common elements, e.g. all service versions share the same eligibility rules, but are different at least one in of the following service elements:

- *The types of customers (market segments)* that they are targeting at. For example, the same public service for subsidies to businesses may be delivered in different versions, depending on the size of the receiving organisation, e.g. SMEs and multinationals.
- *The service input* required by the service. For example, when applying for a job in an EU country, depending on the country of origin of the applicant (EU or non-EU citizen), and a work permit may or may not be mandatory.
- *The service outcome and consequently the effect of a service* (see section 4.4.3.7). For example, the free version of a service may expose limited functionalities as opposed to the paid one.
- *The service stakeholders* involved in the service version. For example, in many countries two versions of the same public service may engage (some) different public administrations depending on whether the prospective customers of the service are their own citizens or aliens.
- *The service activities.* Different service versions may require different service activities and co-production interactions to be realised for them to be successfully delivered. For example, the service activities involved in the registration of a Belgian citizen in a Belgian municipality are different than those required for the registration of non-Belgian citizens.
- *The service variant rules*. Different service variant rules may apply in different service versions. For example the service variant rules of the aforementioned Belgian public service will be different for the two service versions available for Belgian and non-Belgian citizens respectively. All version of the same service share all the eligibility rules.
- *The service quality*. For example, when flying business class the quality of service is expected to be higher than when flying economy.
- *The service context*. For example, different service versions of the same public service, e.g. one for adults and one for adolescents, may be governed by differentiated legislative frameworks. The location, date and time of the service delivery of different service versions may also be different. For example, a subtitled version of a movie may be played at a different time and in a different room than a dubbed version of the same movie (where watching a movie is packaged as a service).
- *The price* at which the service is available and the sacrifice that the customer is willing to make. For example, often companies offer a basic version of some service for free, but charge for a service version that offers more functionality.

This means that the different versions of the same service would require at least one different input and/or would produce a differentiated output and/or would include at least one different service activity and/or service rule.

In order to be able to use a service and maximise the value received from it, customers will have to identify the specific version of the service that matches their personal needs, characteristics, situation and context. To capture this, we defined earlier the service personalisation co-production interaction that involves a number of communications between the customer, in particular the service consumer, and the service provider during which the service provider is trying to elicit information regarding the service consumer's personal needs, characteristics, situation and context (see also section 3.2.3.3). The collected information is then used in order to individualise different parts of the service and the service experience, including the service process, the service frontstage, the service outcome etc.

Relationships

The following relationships are defined:

- *is version of* which relates *service version* to service, in order to express that a *service* is specialised into one or more *service versions*.
- *defined by* which relates *service version* to *service variant rule*. A *service version* is defined by one or more *service variant rules.* The same *service variant rule* maybe used in the definition of one or more *service versions.*
- *consumes* which relates *service consumer* to *service*. This relationship expresses the fact that what is effectively consumed *service consumers* is the *service version*. This is the executable instantiation of the service. In order to identify and consume a *service version*, the *service consumer* needs to personalise the service (see also section 3.2.3.3).
- *differentiates* which relates *service* to *service outcome*. This relationship shows that the execution of a particular service version has actually an impact on the *service outcome* produced by a *service instance*. This is effectively the essence of service personalisation, i.e. to ensure that the service outcome is adapted to the needs, context and profile of a specific customer. This differentiated (adapted) *service outcome* is produced after the execution of the appropriate *service version*.

Figure 49 summarises the concepts discussed in this subsection and their relationships.

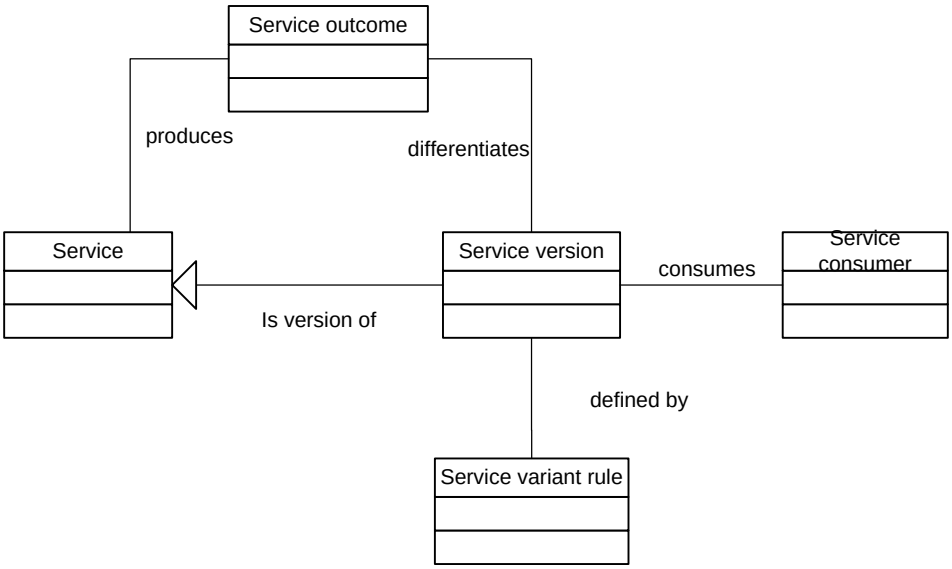

Figure 49: Service and service versions

4.4.3.6 Service input and sacrifice

In section 4.3.4.1 we defined service input as the resources that customers assuming the role of resource provider have to contribute/provide in order to have the service delivered to them. Although the definition of the input required by a service is the responsibility of the service provider, the provision of input is a responsibility of the resource provider. Therefore, in this section, we study input from the customer's perspective and investigate the types of input that the resource provider may have to provide.

The input that a service requires from its customers relates also to the sacrifice that the customer has to make in order to consume the service, i.e. to the effort that has to be put in (both as contribution to the service, but also for collecting the input itself), the cost to be paid (both for consuming the service and for collecting the input itself) and the other resources to be contributed. For example, service input that is very hard or costly to collect may eventually put the consumer of from using the service. Hence, required service input can directly impact the final decision of the service consumers as to whether they will consume the service or not.

Customers as resource providers are requested to contribute any of the following types of service input:

- *Information about their profile and preferences* required for personalising the services (see also section 3.2.3.3 – information resources);
- *Other operant resources*, e.g. specific knowledge or a skill (see section 4.3.4.3);
- *Financial resources*, i.e. the amount that has to be paid for the service consumer to be able to consume the service (see section 4.3.4.3); and

- *Self-inputs,* i.e. cases where the cooperation and the physical presence of the service consumers is required for delivering the service, e.g. health and education services (see also (Sampson and Froehle 2006)).

Relationships

In section 4.3.4.1, we defined two relationships, i.e. *requires* and *provides*, which relate *service input* with *service* and *customer* respectively (i.e. service requires service input; and customer provides service input). Here, we extend the scope of *provides* (which was originally defined to indicate that a service provider provides a service) to *resource providers* as well. Hence, a *resource provider provides input* to a service. More specifically, the *resource provider* has to provide the *service input* that corresponds to the service version that he will actually consume.

Additionally, we define the following relationships:

- *makes* to relate a *resource provider* with the *sacrifice* that he has to make, in terms of effort and cost, for consuming a *service*.
- *determines* to relate *service input* with *sacrifice*, in order to express the fact that the requested elements of *service input* play a role in determining the overall *sacrifice* that the *service consumer* (super-type of resource provider) has to make.

Our modelling of service input is summarised in the figure below.

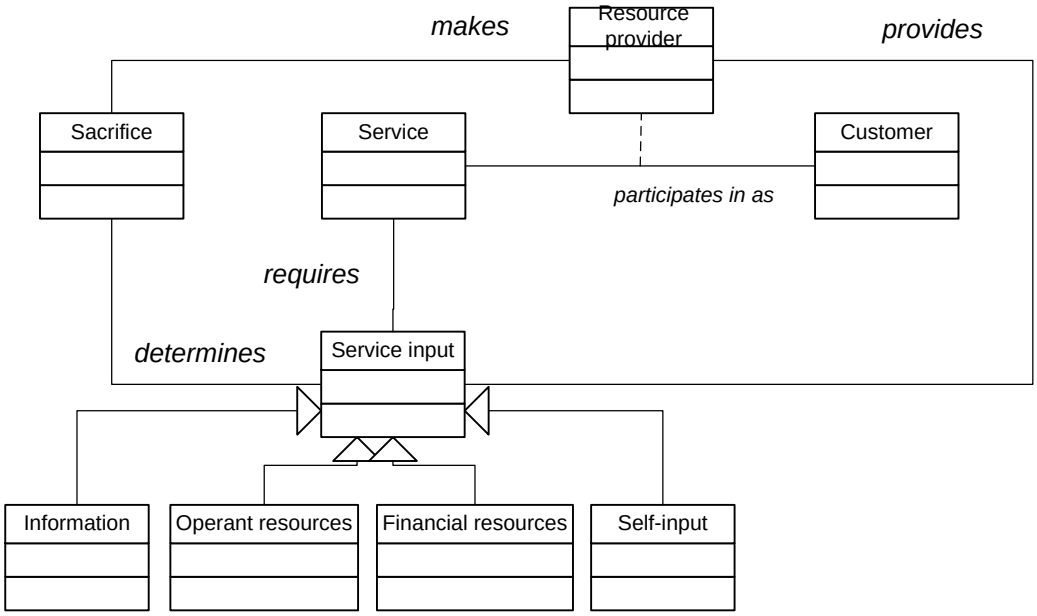

Figure 50: Service input and related concepts

4.4.3.7 Service effect

We defined in section 4.3.4.2 that a service produces outcome, which is in fact what the customer receives after the successful execution of the service. Obtaining the service outcome is the main reason why a customer decides or has to consume a service.

The acquisition of the outcome has an *effect* on the customer and/or her context, i.e. it changes/alters the current state of the customer and/or her context. In particular, the effect of a service affects service consumers and secondary beneficiaries.

The effect contributes to the determination of the overall perceived value of the service for the specific customer (particularly for service consumers and secondary beneficiaries). Practically, the service effect is what actually satisfies the initial need of the customer, i.e. the need that led her to consume the service. For example, after receiving medical treatment the health of the patient is improved (effect), and after using a service for subsidising SMEs an amount of money is deposited in the bank account of the SME (outcome) thus improving the cash flow of the SME (effect).

Interestingly, effect also appears in some semantic service frameworks, such as the WSMO family (Polleres, Bussler et al. 2005; Roman, Keller et al. 2005), OWL-S (McIlraith and Martin 2003; Martin, Burstein et al. 2004; Martin, Burstein et al. 2007), and WSDL-S (Miller, Verma et al. 2004; Akkiraju, Farrell et al. 2005; Akkiraju, Farrell et al. 2006).

Relationships

In addition to *satisfies,* which is used in this case to show that the effect of a service satisfies a customer's need, we define the following relationships:

- *has* to relate a *service* to its *effect*.
- *embeds* to relate *service outcome* to *service effect*, in order to express the fact that the acquisition of the outcome of a service brings with it an effect on the service consumer and her context.
- *affects* which relates service effect to service consumer and customer context, in order to indicate the fact that the effect of a service changes/alters the current state of the customer and/or her context.

All other relationships that appear in Figure 51 have been defined in other sections of this chapter.

The concepts discussed in this subsection and their relationships are summarised in Figure 51.

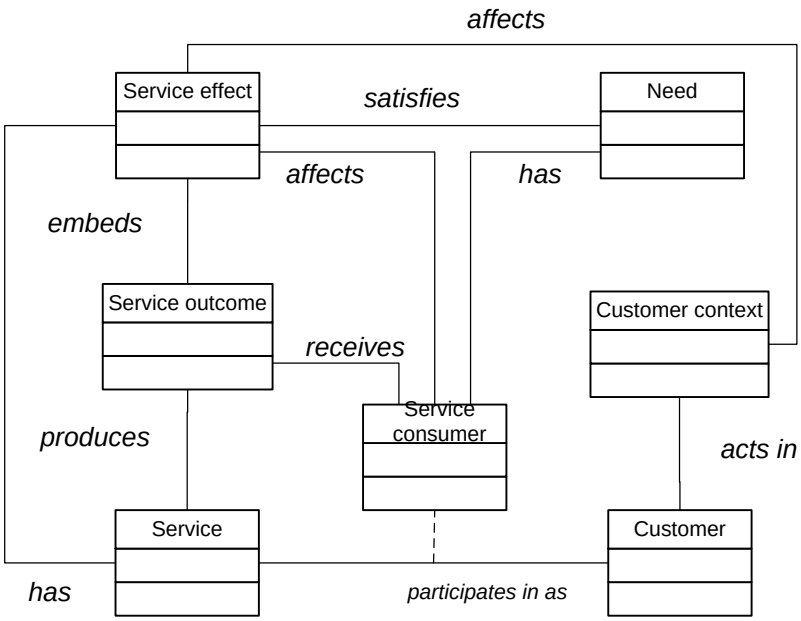

Figure 51: Service effect and related concepts

4.4.3.8 Customer expectation

Nowadays, service providers are searching for new, better and more efficient ways to create value for their customers and differentiate their services in order to attract new and keep existing customers. Thus understanding what customers need and expect, what satisfies them and what they think of existing service offerings is imperative.

Along these lines, we introduce and model the term *customer expectation* to model the customer's anticipation and requirements of the service in terms of outcome and effect, experience and quality. Customer expectations may regard the service outcome, the expected level of service quality and the overall experience of the service. By definition, customer expectations are highly subjective as they reflect personal beliefs, opinions and observations.

The following factors contribute to the formulation of expectations of customers, in particular prospective customers and the critical audience:

- *Prior consumption experience*, which indicates that the customer has used the service in the past and has concrete expectations based on her prior experience;
- *Non-experiential information* like advertising, marketing material, word of mouth, competition, rumours and opinions of others, and trust that the service provider is able to deliver quality;
- *The customer's personal situation*, namely how the customer understands the service and how she believes that it can fulfil her need(s); and

- *The pre-determined level of service quality* set and promised by the service provider (see section 4.3.4.4), e.g. as part of a service level agreement (see also the description of the service negotiation co-production interaction in section 3.2.3.3).

Understanding what a customer expects from a service is not a trivial task. Different customers may assign different, complementary, unrelated or even conflicting meanings and importance to the same service. Their expectations from that service may be the same or may differ. Additionally, the impressions and experiences created during the service consumption play a decisive role in the customer's future expectations, behaviour and loyalty, e.g. they determine whether she will use the service in the future or not. Hence, there is often a distance between what the customer believes and anticipates that a service can deliver (in terms of outcome, value and quality) and what is actually delivered, i.e. how the service is experienced (see also (Bitner, Zeithaml et al. 2010)). We term this the *customer expectations gap*.

In order to close the customer expectations gap and understand, measure and manage customer expectations, service providers need to collect information from the customers. Identifying the requirements and priorities of a customer helps the service provider scope the service and find the optimal cost-benefit relationship. For instance, customers are not always looking for the most sophisticated, highest-quality services. Understanding the expectations of customers will allow a service provider to provide a service that will increase customer satisfaction, and at the same time will guarantee their profitability.

We adopt the timeline for the service experience defined by (Heinonen, Strandvik et al. 2010) to illustrate the time when customer expectations can be expressed and collected. We believe that expectations can be expressed/given by the customers, and in turn collected by the service provider, at pre-service time, i.e. before deciding to initiate the execution of the service, and during the provision of the service. We elaborate further on this in the context of section 4.4.3.10.

Relationships

We define the following relationships:

- *expresses* to relate *customer* to *customer expectation.* A customer may express one or more expectations about a service.
- *concerns* to relate *customer expectation* to *service*, *service quality* and/or *service outcome*. Before consuming the service, customers have expectations with regards to the service in terms of outcome and overall quality.
- *impacted by* which relates *customer expectation* to *customer context*, in order to indicate the fact that the expectations of customers are formed on the basis of different inputs and

influence, coming among others from the customer context, e.g. through interactions with others who have previously consumed the service, and from the pre-determined level of service quality promised by the service provider.

All other relationships that appear in Figure 51 have been defined in other sections of this chapter.

The concepts discussed in this subsection and their relationships are summarised in the figure below.

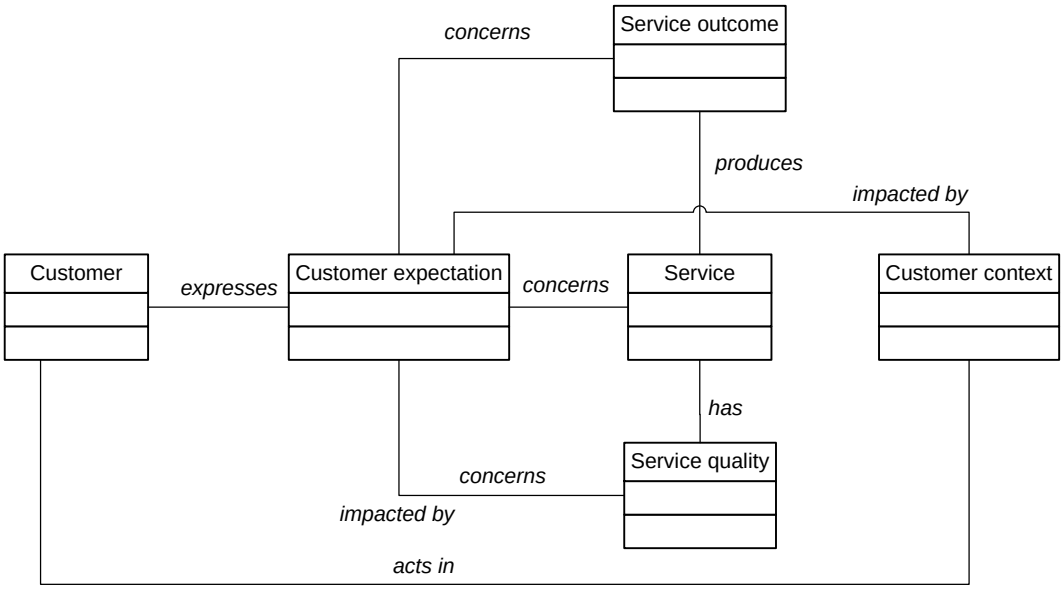

Figure 52: Customer expectation and related concepts

4.4.3.9 Service feedback

Service feedback represents evaluation, opinions and judgments of customers with regards to a service that they (recently) consumed. Service feedback is tightly linked to experiences gained during the consumption of the service; it is therefore particularly relevant to the service consumers and the secondary beneficiaries. By providing feedback, service consumers act as appraisers of the service (see also Mora et al. 2011) and controllers of service quality (see also Storbacka and Lehtinen 2001).

Adapting (Ramaprasad 1983) definition of feedback, we define service feedback as information about the customer expectation gap, i.e. the divide between customer expectations of a service and the actual service experience gained while consuming the service, which in turn – if translated into action, e.g. improvements on the service – can effectively be used for actually bridging the gap.

Service feedback involves cognitive, affective, emotional and physical responses to the service provider which encapsulate information about the service as a whole, e.g. the overall quality of the service, or about particular service elements, e.g. the outcome and/or the effect of the service. When

formalised and captured, this valuable information which reveals customers' perceptions and experiences of the service, can be utilised in order to improve existing services or to design new ones.

Similar to customer expectations, service feedback is highly subjective, based on personal judgement of a particular situation and the customer context. It is therefore pertinent to the needs, context and experience of a particular customer, more specifically those of a service consumer, in the provision of a specific service. In some cases however service feedback can be objective, e.g. when a customer reports back to the service provider a problem that occurred during the provision of the service. Unlike customer expectations, however, service feedback draws upon the actual experience that the service consumer had when using the service. As such, it is based on real facts and experiences gained during the provision of a particular service.

The following factors contribute to the formulation of service feedback:

- *Fitness-for-purpose*, i.e. the degree to which the service met the service consumer's individual needs (subjective nature – depends on how the customer feels about it);
- *Reliability*, i.e. the degree to which the experienced service quality diverted from the expected service quality promised by the service provider (subjective nature – depends on how the customer feels about it);
- *Problems and obstacles* raised during the delivery of the service, which may have impeded its successful completion or may impacted negatively the customer's experience (objective nature – is based on actual facts).

Once again, we use the timeline for the service experience defined by (Heinonen, Strandvik et al. 2010) to place the expression of service feedback on the service timeline. Service feedback is expressed by the service consumer during the provision of the service and at post-service time.

As we discuss in the following sections, service feedback, as well as customer expectations, can emerge either explicitly (see section 4.4.3.10.1) or implicitly (see section 4.4.3.10.2).

Capturing and making use of customer expectations and service feedback enables the improvement of the following co-production interactions:

- Service search (section 3.2.3.2);
- Service personalisation (section 3.2.3.3); and
- Service evaluation (section 3.2.3.5).

Relationships

We reuse the relationships already defined in the previous section, namely:

- *expresses* to relate *service appraiser* to *service feedback.* A service consumer may express feedback on one or more service. Feedback from more than one service appraiser may be collected for the same service.
- *concerns* to relate *service feedback* to *service*, *service quality* and/or *service outcome*. After consuming the service, customers can express their feedback with regards to the service in terms of outcome, overall service experience and quality.

All other relationships that appear in Figure 53 have been defined in other sections of this chapter.

Figure 53 summarises customer expectations and feedback and their relationships to other concepts of the model.

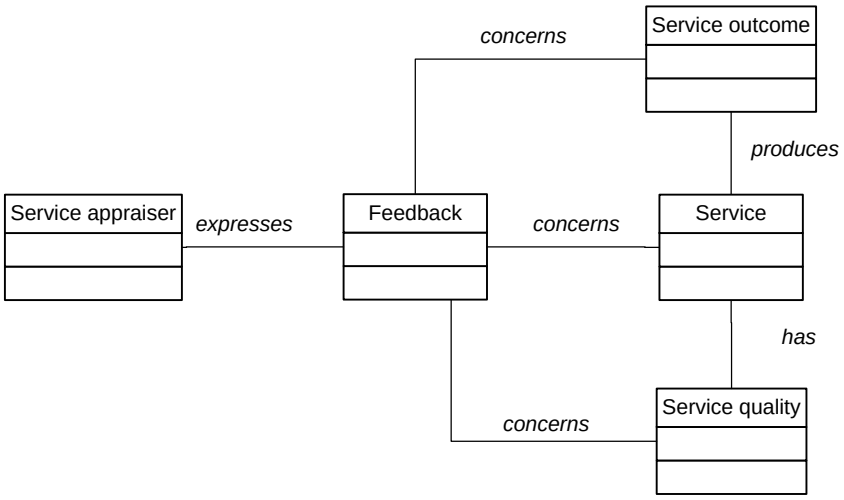

Figure 53: Customer feedback and related concepts

4.4.3.10 Social descriptions

High-quality service descriptions play an important role in service provision and lay the foundations for co-production interactions, such as service search and service personalisation. More specifically, service descriptions contribute to and leverage service search, substitution, composition and bundling, evolution and management (O'Sullivan, Edmond et al. 2002). Service descriptions improve service discovery by enabling more flexible and personalised methods. Service descriptions facilitate substitutions of alternative services as the information they include allows customers to compare similar services and select the best matching. Service descriptions make it easier for service providers and customers to compose services for developing new ones and to integrate services into service bundles. (O'Sullivan, Edmond et al. 2002) claim that service descriptions may be enriched with

information coming from the customer and the service context, thus contributing to the evolution of a specific service and potentially leading to the development of new services.

As discussed in Chapters 1 and 2, up to now, describing a service was supposed to be the task of the service provider. This has led to incomplete and/or often outdated service descriptions, which lack completely the perspective of the customer. This widens the service discovery gap, and consequently impedes basic co-production interactions such as service search and personalisation.

This *Thesis* aims to prove that high-quality service descriptions, which encompass the customer's perspective. In order to model the valuable input to the description of the service that comes from customers through the use and evaluation of the service, we introduce a service description model comprising of both provider- and customer-driven service aspects, termed the *extended service description model*. We specify that the description of a service comprises of four provider-driven service aspects, namely functional, non-functional, behavioural and technical descriptions, but also includes customer-driven service aspects, realised through social descriptions. Figure 54 provides an overview of the *extended service description model*.

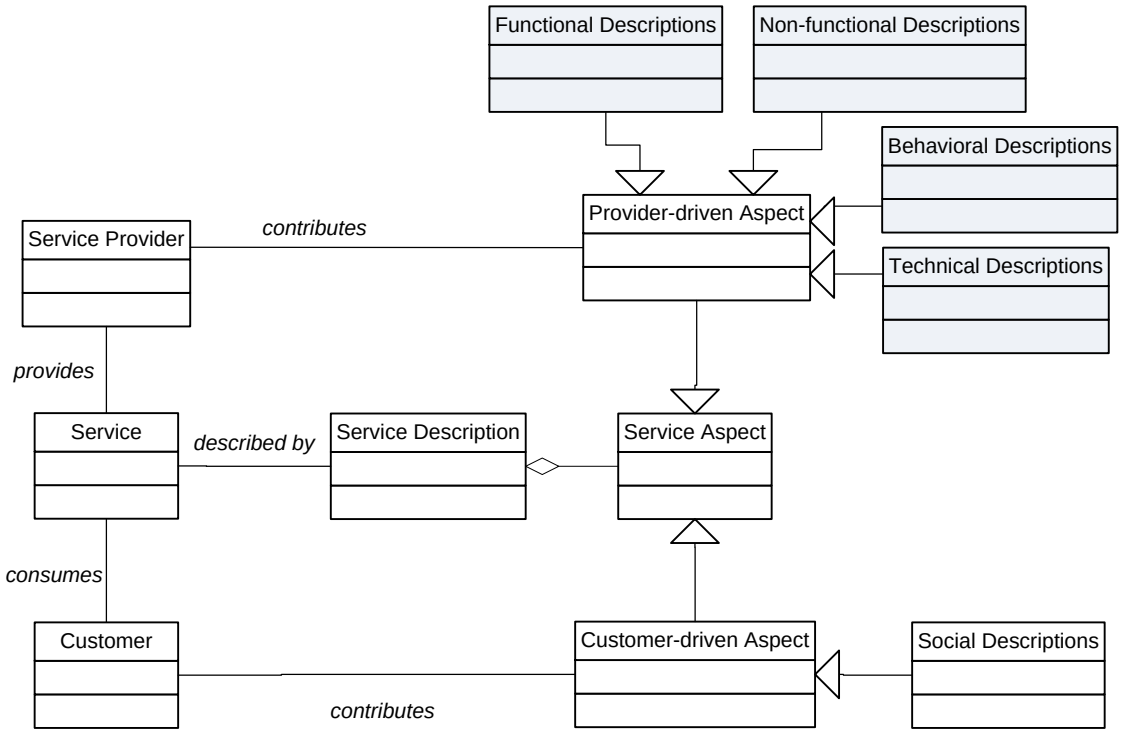

Figure 54: Extended service description model

Extending the work of (Vitvar, Kopecky et al. 2008), but using the term *service aspect* instead of *service contract* as the latter is very well defined in the SOA literature, e.g. (Papazoglou 2008), we define the provider-driven semantic service description metamodel that consists of the following *service aspects*:

- The *Functional Descriptions,* which describe the service's functionalities, namely what a service can offer to its customers if consumed and completed successfully.
- The *Non-Functional Descriptions*, which define the service quality, delivery details or the context of the service.
- The *Behavioural Descriptions*, which define the behaviour of a service, namely the service external choreography or the internal workflow of a service (what we consider as part of the *How view* of a service).
- The *Technical Descriptions,* which define details regarding the technology used by the service.

Customer-driven service aspects complement the provider-driven ones and formally model the input and contributions of customers to the description of a service (see also Figure 54).

Although the service descriptions are co-produced by service providers and customers, their maintenance remains the responsibility of the service provider. Thus, the provider of the service remains the authentic source of information for the service.

Social descriptions encompass structured information about customer expectations and feedback. They can express the customer viewpoint of a service and capture customer satisfaction. Social descriptions refer to information which includes knowledge regarding the customer expectations (subjective opinion) from the service and customer satisfaction. Social descriptions provide valuable insights on the reputation of a specific service and its service provider among the entities that comprise the target market.

Examples of social descriptions may include, among others, the reason a service consumer used a service, the occasion, e.g. to book a flight, the situational context, e.g. details about the travelling context or the nature of the trip or other useful services, evaluation of the service quality, e.g. happy with the service quality or not, and valuation of the customer's experience, e.g. enjoyed the service or feel better (or even worse) after using the service.

Relationships

We define the following relationships:

- *contributes* to relate *service provider* and *customer* to *provider-* and *customer-driven aspects* respectively, thus showing that both service agents collaborate in order to produce a complete service description.
- *described* by to associate a *service* with its *service description*. In reality, zero or more *service descriptions* may be created per *service*.

- *comprises* to indicate that a *service description* consists of *provider-driven* and *custome-driven service aspects*.

All other relationships that appear in Figure 54 have been defined in other sections of this chapter.

Social descriptions are generated explicitly (service evaluation) or implicitly (service mining) (see Figure 55). Explicit social descriptions are discussed in section 4.4.3.10.1, while implicit social descriptions are discussed in section 4.4.3.10.2.

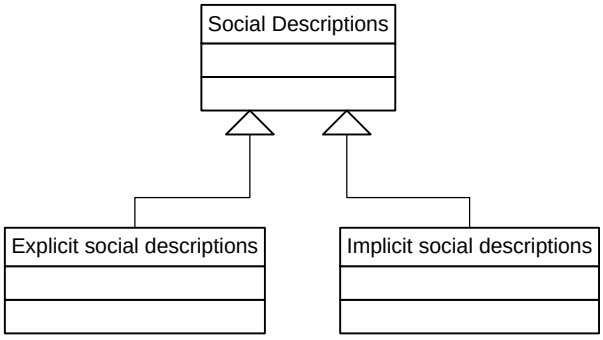

Figure 55: Explicit and implicit social descriptions

4.4.3.10.1 Explicit social descriptions

The result of service evaluation (see section 3.2.3.5) is explicit social descriptions, where customers express directly and consciously their expectations of and/or feedback on a service.

Explicit social descriptions consist of the following types of information:

- Expectations of the customers regarding service quality, trust, the need(s) that the specific service fulfils, service experience and the service outcome, contributed at pre-service time.
  For example, a prospective customer may explicitly state that she wants to learn how to drive, because she needs to go to work more conveniently or may say that she expects the driving lessons (service) to combine a high-skilled tutor with a reasonable price.
- Customers' feedback on service quality, trust, service experience and the service outcome contributed both during service execution and at post-service time.
  For example, after booking a holiday using the e-services of a travel agency, the service consumer expresses her satisfaction of the look and feel of the service and its user friendliness; or while dining in a restaurant the customer praises the chef's cooking skills.

Explicit social descriptions may be expressed using different means. We therefore identify two types of means of expression of explicit social descriptions, namely structured and unstructured ones.

Structured means of expression aim at collecting feedback on customer satisfaction, the service experience, quality and the service outcome in an organised way, thus facilitating its processing and utilisation. Structured means of expression involve the use of controlled vocabularies, e.g. taxonomies and lexicons, rating techniques that use predefined scales, e.g. likert scale or 1-5 stars scales, and closed-type questions for collecting the feedback of customers and stakeholders. Information collected this way is structured and well-formed.

Unstructured means of expression rely on the use of open-format information collection methods, such as open-type questionnaires, subjective reports, free-text comments (e.g. social media posts which are becoming increasingly popular among customers), interviews with (potential) customers and follow-up calls. Information collected this way is usually in the form of free-text.

Relationships

We define the following relationships:

- *use* to relate *means of expression* with explicit social descriptions to express the fact that customers can use different means of expression in order to contribute to explicit social descriptions.
- The aggregation relationship between feedback, customer expectation and implicit social descriptions expresses the fact that the latter comprises these types of information.

All other relationships that appear in Figure 56 have been defined in other sections of this chapter.

Figure 56 shows explicit social descriptions and their relationships to other concepts of the model. Explicit social service descriptions, using structured and unstructured means of expression, is demonstrated in the prototype implementation of section 5.3.

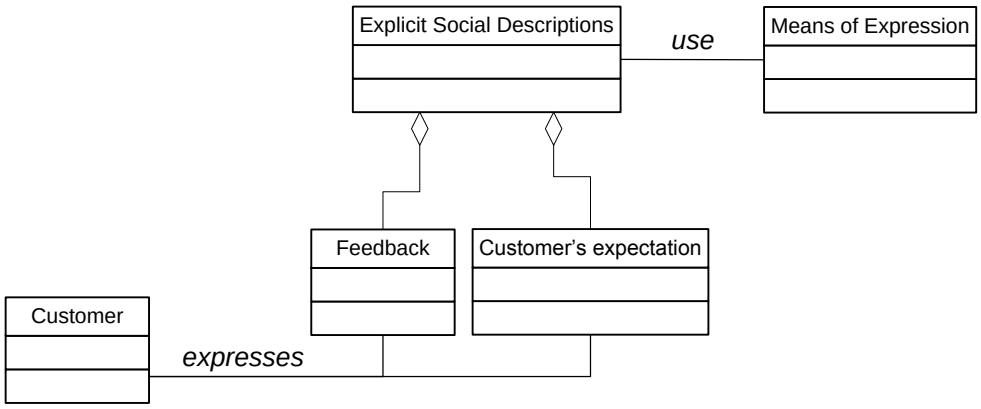

Figure 56: Explicit social descriptions and related concepts

4.4.3.10.2 Implicit social service descriptions

Implicit social descriptions consist of structured and well-formed information which is derived using methods for logging and mining the behaviour of customers throughout the service lifecycle, e.g. Web analytics in the case of e-services, and social network analysis. Hence, the implicit social descriptions comprise mainly service usage patterns and latent service relations that are inferred by collecting, logging and mining service usage data throughout the service lifecycle in the context of co-production interactions, primarily in those where customers play a leading role (see sections 3.2.1 and 3.2.2). For example, a company may log how customers move in the company's e-shop or their buying preferences in-store. Mining the collected data allows the company to discover consumption patterns, bottlenecks in the service process, related or complementary services etc. Social descriptions may also comprise information *related to the customer context* (see also section 4.4.4). For example, a company may monitor when (time/date) customers consume a specific service or on which occasion, e.g. people tend to dine out on Fridays or people living in border regions tend to use cross-border public services more often.

The ways of creating social descriptions are collectively referred to using the term *means of inference* (discussed in section 5.3.1.2).

Relationships

We define the following relationships:

- *monitor* to relate *means of inference* with *co-production interaction* and *customer context* to indicate the types of *means of inference* that are used in order to track and log a *co-production interaction* and customer context. As discussed earlier, different mining and analytical techniques may be applied per case.
- *derives* to relate *means of inference* with explicit social descriptions. Information that comprises explicit social descriptions is derived using a particular means of inference.

All other relationships that appear in Figure 57 have been defined in other sections of this chapter.

Figure 57 shows explicit social descriptions and their relationships to other concepts of the model. Implicit social service descriptions are demonstrated in the prototype implementation of section 5.3.2.

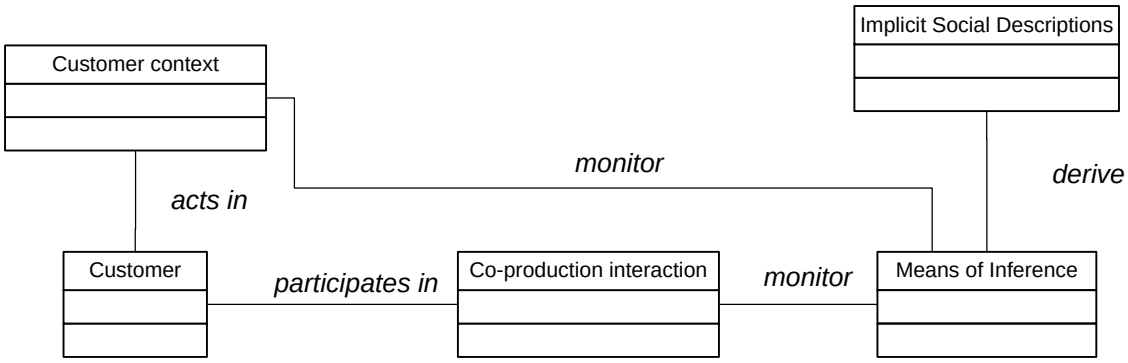

Figure 57: Implicit social descriptions and related concepts

4.4.4 Where and When view

In this case, the *Where* and *When* view refers to the context of the customer during the provision of a service instance, i.e. the wider social, emotional etc. environment and the circumstance in which the customer acts.

Context has an impact on the customer viewpoint of the service and on service feedback, e.g. whether the overall experience will be positive or negative. In fact, Service-dominant logic talks about value-in-context, which means that perceived value emerges through direct and indirect interactions between the service agents in a specific context (Lusch and Vargo 2006; Chandler and Vargo 2011).

We extend the definition of context of section 4.3.5.1. We now define two flavours of context (Figure 58):

- the service context (defined and discussed already in section 4.3.5.1); and
- the customer context (discussed in this section).

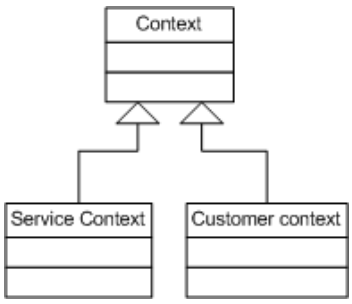

Figure 58: Context and its subconcepts

4.4.4.1 Customer context

Customers act prior to, during and after service provision in a wider environment that has several dimensions. We define the following dimensions of the customer context (Figure 59):

- *Personal dimension*. The personal dimension of customer context models the customer's unique experiences, peculiarities, habits, obligations and relationships to others, e.g. family, friends, co-workers.
- *Emotional dimension*. The emotional dimension of the customer context models the mood, disposition and motivation of the customer throughout the provision of a particular service. Emotional context is directly related to cognitive activities, such as judgements, opinions, evaluations, and thoughts.
- *Social dimension*. The social dimension of customer context models the cultural environment that the customer operates in and her interactions with other customers.
- *Spatio-temporal dimension*. The spatio-temporal dimension of customer context models the setting (i.e. location) in which the customers find themselves at a particular time, e.g. in a restaurant at dinner time.

The service context and the customer context have dimensions that overlap. This means that during the delivery of a specific service to a particular customer, the spatio-temporal dimension is identical, and the social dimension of the customer context overlaps with that of the service context.

Relationships

We define the following relationship:

- *acts in* to relate *customer* to *customer context*, thus showing that customers experience services in their own context, which comprises of different aspects as shown in Figure 59.

Our discussion in this section is summarised in Figure 59.

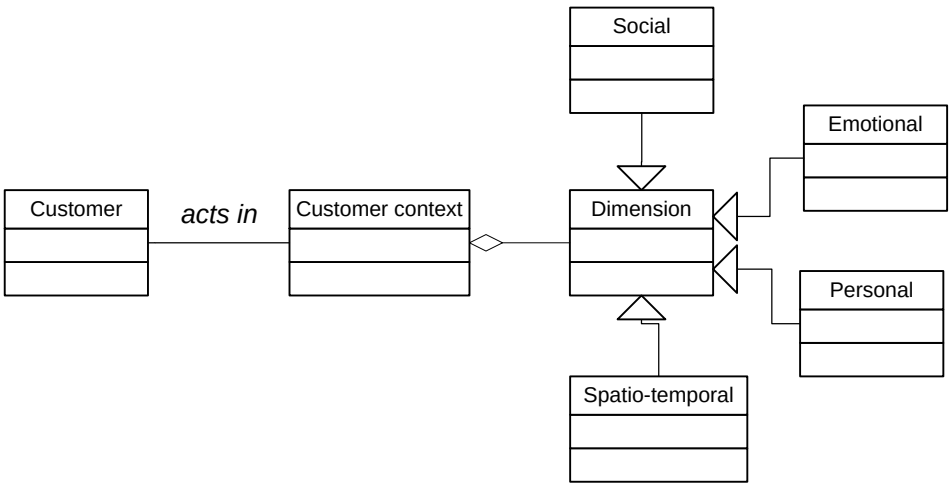

Figure 59: Customer context

4.4.5 Overview

An overview of the Customer Service Model is depicted in Figure 60. For the sake of clarity, we present here a simplified view of it.

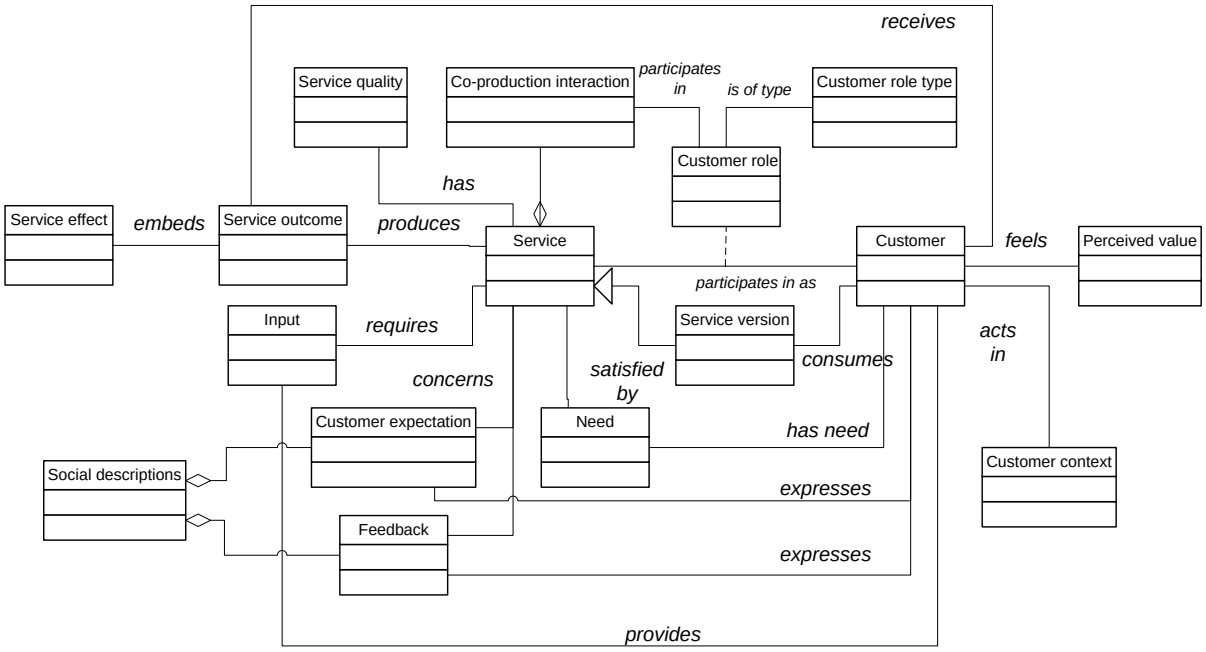

Figure 60: High-level overview of the Customer Service Model

Chapter 5
Service Model Development, Demonstration and Evaluation

Knowledge is of no value unless you put it into practice.
Anton Chekhov

5.1 Introduction

In the previous chapters, we developed a holistic representation of service which engulfs both the service provider and the customer viewpoints. Following up on this work, this chapter realises the third objective of the *Thesis*, namely to validate and evaluate the rigor, the usability and the usefulness of the models proposed in the *Thesis* by developing proof-of-concept prototypes focusing on electronic service (e-service) provision in the context of the Web of Services.

The Web of Services constitutes a large-scale, technology-enabled realisation of a service system (see section 2.2.4.2). Being a pure service-oriented environment, the Web of Services assumes that all human activity on the Web is service-driven and service-enabled. Hence, all type of activities, including economic and financial activities, social activities and interactions, production processes, leisure activities, access and management of resources, communications etc., are supported by e-services.

We selected public administration for positioning and developing the research prototypes of this *Thesis*. The reason was two-fold: on the one hand the author gained throughout his research significant experience and domain knowledge in this area, which, on the other hand, is one of the heaviest, most complex and most demanding service domains.

An interesting characteristic of public administration is that its clientele is not restricted to a certain group of people with common needs or interests. In fact, public administration tries to cover the needs of practically every citizen. To achieve this, it tries to group the diverse needs of its clientele and translate them into services.

Governmental portals constitute challenging test-beds with hundreds of services provided to millions of clients. However, traditional governmental portals and service systems lack efficient ways to facilitate the access of the users to the right service, i.e. the one that best fits their profiles, at the right time utilizing social descriptions of services and lightweight semantics. Hence, the need for

personalised service provision and adaptable service search is imperative. The possibilities for service evaluation are also quite limited on those portals.

In this vein, four research protypes have been developed, which demonstrate how the service models of Chapter 4, i.e. the Unified Service Model and its extension that is the Customer Service Model, facilitate the realisation of the following three co-production interactions in the Web of Services:

- Service search (pull and push), i.e. to search for services initiated by the customer versus service recommendation where services are proposed to the customer by a system based on the customer's preferences, profile, history, behaviour etc.;
- Service personalisation, i.e. the process of adapting a service to the context and profile of a particular customer; and
- Service evaluation, i.e. the provision of feedback on a service by the customer.

More generally, the Customer Service Model impacts the traditional service provision paradigm put forward by the SOA brokerage model in the Web of Services. In this new reality, presented in Figure 61, service providers and customers partake in the provision of services available in the Web of Services. Service providers and customers are now roles that can be acquired interchangeably by any business, organisation or individual. This reflects the fact that in the Web of Services the barriers between service providers and users are blurry; hence every business, organisation, individual or software agent is a potential service provider or user.

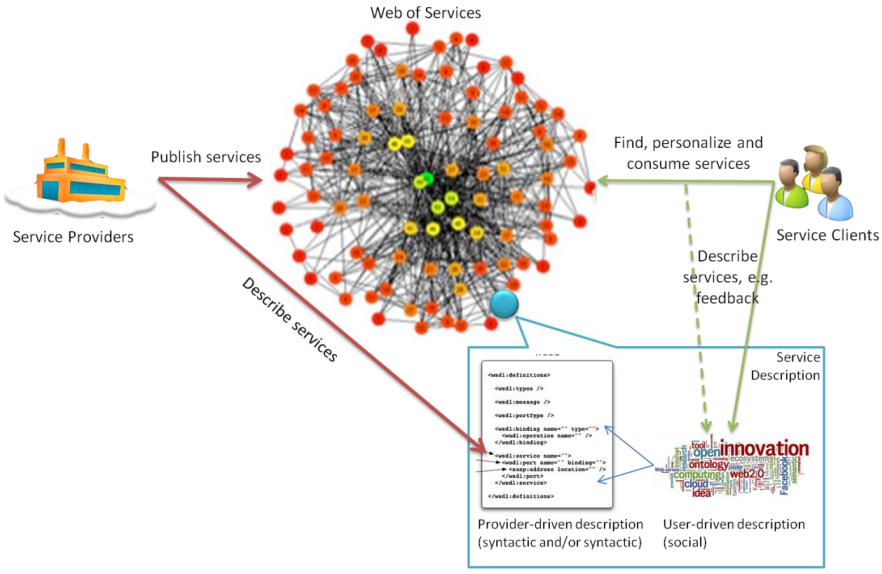

Figure 61: The Social Annotation of Services Service Description Paradigm

Consequently, the three fundamental SOA service activities, namely publishing, finding and binding, are also redefined in this new context. More specifically, publishing is not limited to the publication of a service description in a service registry. It refers to making available a service and its description at

a specific online location (i.e. at a specific URI). Finding a service is empowered through service personalisation and recommendation, and semantic search. Binding to a service remains the same as it depends mostly on the communication protocol. An additional fundamental operation is defined, that of the co-creation of the service description, through the explicit and service mining (see also section 5.3.1.1 and 5.3.1.2). In traditional SOA, this was part of the publishing. However, due to the impact of the social annotation of services paradigm, it needs to be included as a distinct operation. This new fundamental operation realises the active role of the customer in the Web of Services and highlights the great potential of customer-generated data, especially when exploited to facilitate and to improve the new generation of service finding, i.e. semantic search, service personalisation and recommendation.

The Web of Services replaces the traditional SOA Service Registry to indicate that in this new paradigm, services are provided in a decentralised manner and are published online by businesses, organisations and individuals. Similarly, service descriptions are usually not published in central service registries, but are published at the point where the service is provided from and in various formats, ranging from simple HTML pages and text-based descriptions to RDF machine-readable descriptions of services.

Summarising, the instantiation and realisation of social descriptions in the Web of Service through service evaluation and service mining empower the active participation of the customers in service provision. Moreover, enriching provider-driven service descriptions with social descriptions facilitates intelligent and highly-adaptive service search, recommendation and composition. Additionally, if harvested, the latent knowledge hidden in the social descriptions can help service providers understand better the expectations of existing customers and reach out to new ones. This will allow them to improve and enrich their services, find new purposes for their services, or design and build new services to address emerging customer needs.

Figure 62 provides insights on the contributions that this *Thesis* (both conceptual service models and research prototypes) has had in the research field of the Web of Services. The contributions of the *Thesis* are discussed in detail in Chapter 6.

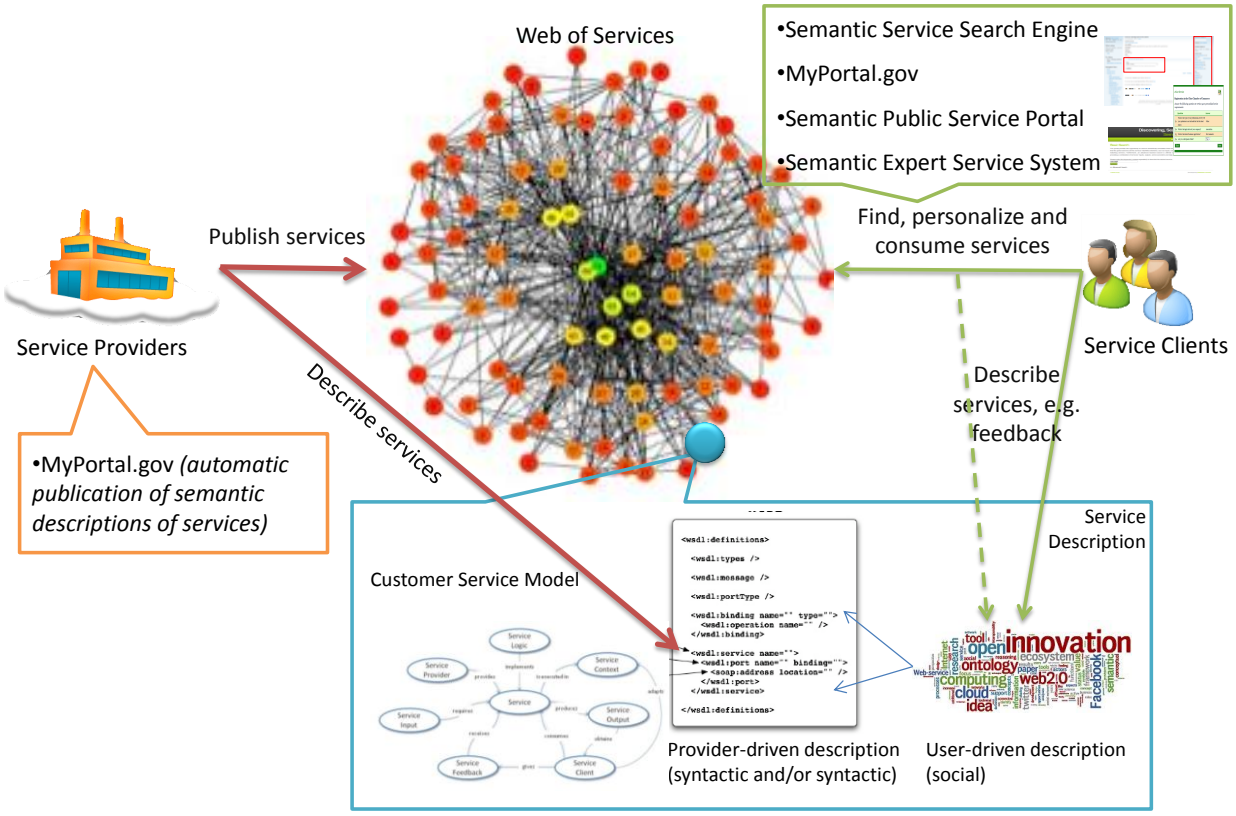

Figure 62: Research Prototypes placed in the context of the Web of Services

The remainder of this chapter is structured as follows:

We start by building the foundation of the research prototypes (section 5.2). Hence, section 5.2.1 presents the implementation of the two service models in a single linked open vocabulary, while section 5.2.2 demonstrates the implementation of service feedback in existing semantic service models, in order to bring the customer viewpoint in semantic descriptions of services.

Section 5.3 demonstrates the use of the Unified Service Model and the Customer Service Model for pull and push service search, and service evaluation. First, in section 5.3.1 we show how push and pull service search can be implemented using social descriptions of services, focusing on service feedback collected in the form of tags. Service tag clouds are formed and are combined with semantic descriptions of services, in order to compute service similarity which in turn enables pull and push service search.

Then, section 5.3.2 introduces a service portal for customer-centric service delivery, i.e. MyPortal.gov, based on the Unified Service Model and the Customer Service Model (focusing on *service input, service outcome, customer, service provider, service feedback, service effect, service rule, legal context, service stakeholder, service bundle* and *service relationships*). MyPortal.gov facilitates the creation of social descriptions of services (see section 4.4.3.10). Hence, citizens can actively participate and contribute to the description of public services using their own terms. Lightweight annotations are used to make

public service descriptions machine-readable. MyPortal.gov facilitates keyword search, tag cloud-based search and visual browsing of the underlying public service description repository. Public service recommendation mechanisms (i.e. push service search) have also been implemented.

Section 5.3.3 presents the Semantic Service Search Engine (S3E) that proposes a uniform interface for finding semantic services in the Web of Services based on service concepts from the Unified Service Model and the Customer Service Model, i.e. *service input, service outcome, service provider, service feedback, service bundle* and *service relationships* (defined in Chapter 4). S3E implements a uniform point of access over a set of heterogeneous semantic service descriptions which are homogenised using the Unified Service Model. S3E *(i)* is agnostic to the underlying semantic model used for developing the service description; *(ii)* does not require the service providers to publish their services or their descriptions in a centralised service registry; and *(iii)* exploits the semantic information that exists in semantic service descriptions in order to improve service search. S3E can be thought of as a central point of reference where descriptions about services provided by different organisations from different domains are available, whereas MyPortal.gov corresponds to the portal that a single organisation would use in order to provide information about the services they provide. Service descriptions made available by MyPortal.gov as Linked Data, are crawled by S3E's crawlers and are then discoverable in S3E.

Section 5.4 demonstrates the use of the Unified Service Model and the Customer Service Model for service personalisation based on customer dialogues. We start with defining in section 5.4.1 a customer-dialogue model and an approach for dialogue-based service personalisation.

Thereafter, section 5.4.2 presents a semantic, dialogue-based portal for public service personalisation, i.e. S-PSP, which facilitates the personalised provision of public services based on an ontology-driven dialogue that exploits detailed semantic public service descriptions. The public service descriptions of S-PSP are based the Unified Service Model and Customer Service Model, implementing mainly *customer*, *service version, service rules, service input* and *service outcome*. S-PSP *(i)* informs customers whether they are eligible for a specific public service; *(ii)* identifies the specific public service version that matches the profile of the customer; *(iii)* provides complete and well-structured information for the public service; and *(iv)* allows customers to invoke public services that are available online (if a service execution environment is in place) independent of the semantic technology and the Web service protocol used.

In a similar line of work, section 5.4.3 introduces a semantically-enhanced, dialogue-based expert system to support public service personalisation based on the Unified Service Model and the Customer Service Model, implementing mainly *customer*, *service version, service rules, service input* and *service*

outcome. Similar to the S-PSP, this research prototype aims to inform citizens whether they are eligible for a specific public service and to identify the specific public service version that matches the profile of the citizen. The main difference between this research prototype and S-PSP lies in the technologies selected for implementing the two prototypes, i.e. an OWL reasoner in the case of S-PSP, versus a hybrid approach combing semantic and expert system technolologies, i.e. ontologies and a Prolog rule engine for supporting the dialogue between the customer and the system.

The table below summarises which of the afore-mentioned co-production interactions, i.e. pull and push service search, service personalisation and evaluation, are addressed by the research prototypes.

Table 16: Research prototypes per type of type of service search

	Pull service search	Push service search	Service personalisation	Service evaluation	Elements of the service models demonstrated
MyPortal.gov	Keyword search, tag browsing, ATOM	Recommended services (based on collaborative filtering and service usage data)	Yes	Yes	service input, service outcome, customer, service provider, service feedback, service effect, service rule, legal context, service stakeholder, service bundle and service relationships
Semantic Service Search Engine	Keyword search, tag browsing	Related services, service execution sequences (based on similarity of service descriptions)	No	Yes	service input, service outcome, service provider, service feedback, service bundle and service relationships
Semantic Public Service Portal	Dialogue-based service personalisation (ontology-based)		Yes	No	customer, service version, service rules, service input and service outcome
Semantic Expert Service System	Dialogue-based service personalisation (expert-system-based)	Recommended services (based on business rules)	Yes	No	customer, service version, service rules, service input and service outcome

5.2 General development themes

The motivation of this *Thesis* (section 1.2) identified two longstanding challenges which also raise obstacles in the provision of high-quality, seamless and customer-driven services in the Web of Services. In order to effectively treat these challenges, we started by undertaking the following activities:

- Implement the the Unified Service Model and the Customer Service Model as a linked data vocabulary, thus delivering a machine-readable representation of this common view over existing service models in the Web of Services (section 5.2.1);
- Examine how service feedback can be implemented in existing semantic service frameworks, by reusing existing points of extension, i.e. properties existing already in those frameworks (section 5.2.2).

5.2.1 Implementing the conceptual service models as a linked data vocabulary

We implemented the conceptual service models of Chapter 4, i.e. the Unified Service Model and its extension that is the Customer Service Model, in RDF using the methodology defined in the Cookbook for translating relational data models to RDF schemas[22], which was co-authored by the author of this *Thesis*. The methodology comprises the following steps:

1. UML classes are encoded as RDF classes. UML properties are translated into RDF data type properties, while UML relationships are modeled in RDF as object type properties.
2. Research existing terms and their usage and maximise reuse of those terms. We have used Linked Open Vocabularies[23] as the primary service for discovering reusable RDF classes and properties.
3. Where new terms can be seen as specialisations of existing terms, create sub class and sub properties as appropriate (see Table 19 for more details).
4. Where new terms are required, create them following commonly agreed best practice in terms of naming conventions etc. We have defined the labels of all terms in camel case, and the labels of all relationships contain a verb that explains clearly the nature of the relationship;
5. Publish within a highly stable environment designed to be persistent. The RDF distribution of the service models is available under the following URI: http://islab.uom.gr/csm and is also presented in Annex I.

[22] https://joinup.ec.europa.eu/community/semic/document/cookbook-translating-data-models-rdf-schemas
[23] http://lov.okfn.org/dataset/lov/

Our implementation work is guided by the following principles – following the spirit of linked data[24]:

1. Use URIs as names for things, i.e. classes and properties;
2. Use HTTP URIs so that people can look up those names; and
3. Include links to other URIs so that they can discover more things.

Before explaining in more detail the development of the RDF Schema, we provide an introduction to RDF and RDF schema in Table 17 and explain linked data briefly in Table 18.

Table 17: The Resource Description Framework (RDF) and the RDF Schema

The Resource Description Framework (RDF) is the first specification developed for the Semantic Web (W3C RDF Working Group 2004). It was introduced in 1997 and became a W3C recommendation in 1999. RDF provides the grounds on top of which most Semantic Web models, technologies and applications are built.

RDF uses a three-partite model in order to describe data or resources in the Semantic Web. Thus, each RDF statement, called triple, comprises of:

- the subject, which denotes a resources and is therefore encoded as a URI;
- the predicate, which denotes attributes of the subject or a relationship between the subject and the object. An attribute of a formal ontology is used for encoding a predicate.
- The object, which is either another resource related to the subject or the value of one of the subject's attributes. Thus the object is encoded either as URI or as a literal.

A collection of RDF triples represents a labelled, directed graph. Imagine that we want to express the following statement in RDF: Tim Berners-Lee is the founder of the World Wide Web. The subject of the statement is *Tim Berners-Lee* (let's assume that its URI is http://example.org/TBL). The predicate of the statement is *founder of* (let's assume that the predicate is defined in a ontology that describes a person, such as FOAF (Brickley and Miller 2010), then its reference could be foaf:knows). Finally, the object of the statement is *World Wide Web* (let's assume that its URI is http://example.org/WWW).

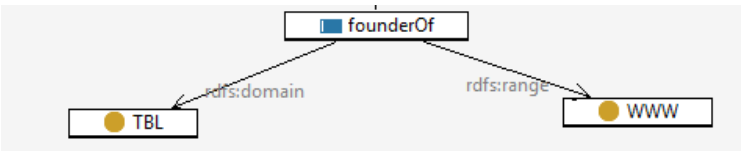

Figure 63: RDF graph of the statement

RDF Schema (RDFS) allows the creation of vocabularies used to describe resources and the (types of) relationships between resources (W3C RDF Working Group 2004). RDFS is also used in order to check the consistency of an RDF graph against the underlying RDF schemata.

RDF Schema offers the following reuse mechanisms:

- **Importing existing vocabularies**: RDFS allows reusing the class and property definitions of other vocabularies, simply by reusing their URIs. Additional usage notes could be added to clarify their meaning.
- **rdfs:subClassOf**: If we declare that one class is a sub class of another class, all instances of the former (sub) class are also instances of the latter (super) class.

[24] http://linkedservices.org/wiki/LOS_Principles

- **rdfs:subPropertyOf**: If we declare that one property is a sub property of another property, all resources that are related by the former (sub) property are also related by the latter (super) property.

Table 18: Linked Data

Linked data is a set of design principles for sharing/publishing machine-readable data on the Web ready for use by both humans and machines. *Tim Berners Lee* put forward the **four design principles** of Linked Data:

1. Use Uniform Resource Identifiers (URIs) as names for things.
2. Use HTTP URIs so that people can look up those names.
3. When someone looks up a URI, provide useful information, using the standards (RDF*, e.g. RDF, RDF-S), SPARQL).
4. Include links to other URIs so that they can discover more things.

As discussed previously, the emphasis throughout our methodology is on reusing existing terms wherever possible. Reuse of widely known terms helps to make data more reusable from a machine processing point of view and facilitates the interlinking of resources represented using the same classes and properties. Reuse makes the data part of the existing landscape and not something entirely new. In this vein, we are reusing classes and properties from a number of well-known RDF vocabularies and ontologies, as shown in Table 19 and Table 20 .

For all other classes and properties of our domain models, new RDF classes and properties are minted. The linked data vocabulary can be found in Annex I.A. As an example, Table 21 shows the RDF definitions for the following:

- Classes: customer expectation, service feedback and perceived value; and
- Properties: satisfied by (see section 4.3.2.1), feels (see section 4.4.1.1), provides input to (see section 4.4.3.1), executed after (see section 4.4.3.1) and substitutes (see section 4.4.3.1).

Table 19: Overview of reused RDF classes and properties from existing vocabularies

Unified Service Model/ Customer Service Model	Reused RDF class/property
Classes	
Service (see section 4.3.1)	It is defined as a subclass of[25] the schema:Service[26] and dctype:Service[27] generic RDF classes (see also Table 20).
Service Activity (see section 3.2.1)	It is defined as a subclass of the schema:Action and prov:Activity[28] generic RDF classes (see also Table 20).

[25] Please note that multiple inheritance is allowed in RDF.
[26] Schema.org (schema) (namespace: http://schema.org).
[27] DCMI Type Vocabulary (namespace: http://purl.org/dc/dcmitype/).
[28] The Provenance Ontology (prov) (namespace: http://www.w3.org/ns/prov#).

Service Agent (see section 4.3.3)	It is defined as a subclass of the foaf:Agent[29] and dcterms:Agent[30] generic RDF classes (see also Table 20).
Natural Person (see section 4.3.3)	It is defined as a subclass of the foaf:Person and person:Person[31] RDF classes.
Organisation (see section 4.3.3)	It is defined as a subclass of the org:Organisation[32] RDF class.
Legal Entity (see section 4.3.3)	It is defined as a subclass of the regorg:RegisteredOrganisation[33] RDF class.
Other organisation (see section 4.3.3)	It is defined as a subclass of the org:FormalOrganisation RDF class.
Resource (see section 4.3.4.3)	It is defined as a subclass of fea:Resource[34] generic RDF class.
Properties	
comprises (see section 4.4.3.1)	Implemented in RDF by reusing the dcterms:isPartOf property (as an inverse property) (see Table 20).
requires (see sections 4.3.4.1 and 4.3.4.3)	Implemented in RDF by reusing the dctemrs:requires property (see also Table 20).
receives (see section 4.3.3.2)	Implemented in RDF by reusing the cpsv:receives[35] property.
produces (see section 4.3.4.2)	Implemented in RDF by reusing the cpsv:produces property.
contributes (see section 4.4.3.10) and **expresses** (see section 4.4.3.8)	Implemented in RDF by reusing the dcterms:contributor property (see also Table 20).
delivered at (see section 4.3.4.4)	Implemented in RDF by reusing the dolce:has-quality[36] property (see also Table 20).
follows (see section 4.4.3.4)	Implemented in RDF by reusing the cpsv:follows property.
delivered through (see section 4.4.3.3)	Implemented in RDF by reusing the schema:deliveryMethod property (see also Table 20).
relates to (see section 4.4.3.1)	Implemented in RDF by reusing the dcterms:relates property.
is version of (see section 4.4.3.5)	Implemented in RDF by reusing the schema:isVariantOf property.
concerns (see section 4.4.3.8)	Implemented in RDF by reusing the schema:about property.
	dcterms:type is reused for linking in the RDF syntax of the Customer Service Model any resource, e.g. the service agent, to its type (see also Table 20).

[29] Friend of a Friend (foaf) vocabulary (namespace: http://xmlns.com/foaf/0.1/).
[30] DCMI Metadata Terms (namespace: http://purl.org/dc/terms/).
[31] Core Person Vocabulary (person) (namespace: http://www.w3.org/ns/person#).
[32] Organisation Ontology (org) (namespace: http://www.w3.org/TR/vocab-org/).
[33] Registered Organisation Vocabulary (regorg) (namespace: http://www.w3.org/TR/vocab-regorg/).
[34] Federal Enterprise Architecture ontology (fea) (namespace: http://vocab.data.gov/def/fea#).
[35] Core Public Service Vocabulary (cpsv) (namespace: http://purl.org/vocab/cpsv#).
[36] The DOLCE and DnS ontologies (dolce) (namespace: http://www.loa.istc.cnr.it/ontologies/DOLCE-Lite.owl#).

Table 20: Implementation of classes and properties in RDF through reuse

#Classes

csm:Service a rdfs:Class, owl:Class;

rdfs:label "Service"@en;

skos:broader fea:Process, msm:Service, wslt:Service;

owl:sameAs dctype:Service, schema:Service;

dcterms:isPartOf csm:ServiceBundle;

dcterms:description "A service constitutes the logical representation of business logic, encapsulated in a process that is delivered by a service provider to a customer. A service involves the transformation of resources contributed by both the service provider and the customer, and produces an outcome that fulfils specific needs of the latter."@en.

csm:ServiceActivity a rdfs:Class, owl:Class;

rdfs:label "Service Activity"@en;

rdfs:subClassOf prov:Activity, schema:Action;

dcterms:description "A service activity is an atomic step carried out as part of the service process."@en.

csm:ServiceAgent a rdfs:Class, owl:Class;

rdfs:label "Service Agent"@en;

rdfs:subClassOf foaf:Agent, dcterms:Agent;

dcterms:description "The service agent is an entity that partakes in the provision of a service under some role(s)."@en.

#Properties

dcterms:requires a rdf:Property, owl:ObjectProperty;

rdfs:label "requires"@en;

rdfs:comment "The dcterms:requires property is used for indicating the resources required by a service."@en.

rdfs:range csm:Resource.

dcterms:contributor a rdf:Property, owl:ObjectProperty;

rdfs:label "contributes"@en;

rdfs:comment "The dcterms:contributor property fully represents the different types of relations between service agents and resources and descriptions of services (including also feedback and expectations)."@en;

rdfs:domain csm:ServiceAgent.

dolce:has-quality a rdf:Property, owl:ObjectProperty;

rdfs:label "has quality"@en;

rdfs:comment "The dolce:has-quality property is used for relating a service to its predetermined level of quality."@en.

schema:deliveryMethod a rdf:Property, owl:ObjectProperty;

rdfs:label "delivered through"@en;

rdfs:comment "The schema:deliveryMethod property links service and service outcome to the different service channels through which they are accessible."@en.

dcterms:type a rdf:Property, owl:ObjectProperty;

rdfs:label "of type"@en;

rdfs:comment "The dcterms:type property is used for indicating the type/category of any resource in CSM."@en.

Table 21: Minting new classes and properties

#Classes

csm:CustomerExpectation a rdfs:Class, owl:Class;

rdfs:label "Customer Expectation"@en;

dcterms:hasPart schema:UserLikes , schema:UserComments;

dcterms:description "Customer's expectation models the customer's anticipation of the service in terms of outcome and effect, experience and quality."en.

csm:ServiceFeedback a rdfs:Class, owl:Class;

rdfs:label "Service Feedback"@en;

rdfs:subClassOf schema:Review;

dcterms:hasPart schema:UserLikes , schema:UserComments;

dcterms:description "Service feedback represents evaluation, opinions and judgements with regards to the service that a customer recently consumed. Service feedback is tightly link to experiences gained during the consumption of the service."@en.

csm:PerceivedValue a rdfs:Class, owl:Class;

rdfs:label "Perceived Value"@en;

dcterms:description "Perceived value refers to the way that a customer understands and feels the benefit delivered by a service that she just consumed."@en.

#Properties

csm:satisfiedBy a rdf:Property, owl:ObjectProperty;

rdfs:label "satisfied by"@en;

rdfs:comment "The satisfiedBy property links a need to the service(s) that fulfil it."@en;

rdfs:domain csm:Need;

rdfs:range csm:Service.

csm:feels a rdf:Property, owl:ObjectProperty;

rdfs:label "feels"@en;

```
        rdfs:comment "The feels property relates a customer to the perceived value of a particular service. In the end, perceived value is a feeling, something that the customer can sense and experience."@en;
        rdfs:domain csm:Customer;
        rdfs:range csm:PerceivedValue.

csm:providesInputTo a rdf:Property, owl:ObjectProperty;
        rdfs:label "provides input to"@en;
        rdfs:subPropertyOf dcterms:relation;
        rdfs:comment "The provides input to property expresses cases when a service has to be executed prior to another one in order for the outcome of the first to be used as input for the second."@en.

 csm:executedAfter a rdf:Property, owl:ObjectProperty;
        rdfs:label "executed after"@en;
        rdfs:subPropertyOf dcterms:relation;
        rdfs:comment "The executed after property is used in situations when a service has to be executed after another one. Executed after indicates a special case of complementary services where their execution sequence is well-defined."@en.

csm:substitutes a rdf:Property, owl:ObjectProperty;
         rdfs:label "substitutes"@en;
         rdfs:subPropertyOf dcterms:relation;
         rdfs:comment "The substitutes property in cases when a service can be used instead of another one. A service can have zero or more substitutes, i.e. other services that can deliver the same outcome. Different substitutes may require the same or different sacrifice by the customer and may be have different quality considerations."@en.
```

As part of the conceptual service models of Chapter 4 we have also defined the following six controlled vocabularies. All controlled vocabularies have been encoded it using the Simple Knowledge Organisation System (SKOS). All SKOS taxonomies can be found in Annex I.B. A brief introduction to SKOS is given in Table 22.

Table 22: Simple Knowledge Organisation System

The **Simple Knowledge Organisation System** is the recommended standard for documenting reference data, such as code lists. SKOS is a common data model for sharing controlled vocabularies such as code lists, thesauri, and taxonomies via the Web in a machine-readable format. SKOS allows representing the terms in a controlled vocabulary as instances of the class **skos:Concepts**. SKOS also defines properties for multi-lingual labels (**skos:prefLabel**), associated codes (**skos:notation**), and definitions (**skos:definition**).

The representation of controlled vocabularies in SKOS brings the following advantages:

1. **De-referencing**: the principles of Linked Data requires each term in the controlled vocabulary to be identified by a corresponding term URI based on the HTTP protocol. This means that when someone else encounters such a URI, she can look up its meaning by entering the URI in the address bar of her browser.
2. **Machine-readability**: The user can use the term URI to retrieve both a machine-readable and human-readable file containing definitions, labels, and related concepts for this term expressed in SKOS.
3. **Multilingualism**: SKOS allows to associate labels and definitions in multiple languages to any concept.

- *The roles of service agents* (defined in sections 4.3.3 and 4.4.2). Table 23 shows an example of the definition of service provider, customer and service consumer roles as SKOS concepts.

Table 23: Roles of service agents as SKOS concepts

```
<http://islab.uom.gr/csm/service-agent-roles/ServiceProvider> a skos:Concept ;
        skos:prefLabel "Service Provider" ;
        skos:definition "The service provider is the entity that is responsible for the coordination of the overall provision of a service, i.e. designing the service, making it available to clients, coordinating and controlling other stakeholders involved in the process, and ensuring a rich and high-quality service experience. " ;
        skos:inScheme "http://islab.uom.gr/csm/service-agent-roles/1.00" .

<http://islab.uom.gr/csm/service-agent-roles/Customer> a skos:Concept ;
        skos:prefLabel "Customer" ;
        skos:definition "The customer is the entity that consumes/uses/experiences a service in order to satisfy a specific need, want or obligation. " ;
        skos:inScheme "http://islab.uom.gr/csm/service-agent-roles/1.00" .

<http://islab.uom.gr/csm/service-agent-roles/ServiceConsumer> a skos:Concept ;
        skos:prefLabel "Service consumer " ;
        skos:definition "We define the term service consumer, specialising the generic term customer, to refer to the entity that successfully completed the service search phase, found a service that addresses his need, purchased, initiated and experienced this service, and received its outcome. The service user is the primary beneficiary of the service.";
                skos:broader "http://islab.uom.gr/csm/service-agent-roles/Customer" ;
                skos:inScheme "http://islab.uom.gr/csm/service-agent-roles/1.00" .
```

- *The types of service agents* (see section 4.3.3). Table 24 shows an example of the definition of natural person and legal organisation as SKOS concepts.

Table 24: Types of service agents as SKOS concepts

```
<http://islab.uom.gr/csm/service-agent-types/NaturalPerson> a skos:Concept ;
        skos:prefLabel "Natural Person" ;
        skos:exactMatch person#Person, foaf:Person ;
        skos:inScheme "http://islab.uom.gr/csm/service-agent-types/1.00" .

<http://islab.uom.gr/csm/service-agent-types/LegalEntity> a skos:Concept ;
        skos:prefLabel "Legal Entity" ;
        skos:broader "http://islab.uom.gr/csm/service-agent-types/Organisation" ;
        skos:exactMatch regorg:RegisteredOrganisation;
        skos:inScheme "http://islab.uom.gr/csm/service-agent-types/1.00" .
```

- *The types of resources* (section 4.3.4.3). Table 25 shows an example of the definition of operant resource and skill as SKOS concepts.

Table 25: Types of resources as SKOS concepts

```
<http://islab.uom.gr/csm/resource-type/OperantResource> a skos:Concept ;
        skos:prefLabel "Operant resource" ;
        skos:definition "Operant resources act upon other resources to create benefit and value (Vargo and
        Lusch 2004)" ;
        skos:inScheme "http://islab.uom.gr/csm/resource-type/1.00" .

<http://islab.uom.gr/csm/resource-type/Skill> a skos:Concept ;
        skos:prefLabel "Skill" ;
        skos:broader "http://islab.uom.gr/csm/resource-type/OperantResource" ;
        skos:inScheme "http://islab.uom.gr/csm/resource-type/1.00" .
```

- *The dimensions of service and customer context* (sections 4.3.5.1 and 4.4.4.1 respectively). Table 26 shows an example of the definition of the spatio-temporal and the emotional dimensions as SKOS concepts.

Table 26: Dimensions of contexts as SKOS concepts

```
<http://islab.uom.gr/csm/context-dimension/SpatioTemporal> a skos:Concept ;
        skos:prefLabel "Spatio-temporal dimension" ;
        skos:definition "A service is delivered at a specific place on a specific date and at a specific point in
        time. The date and time of service delivery is agreed upon between service provider and customer.
        Additionally, a service may also be available for a specific period, i.e. between a start and an end
        date and time. " ;
        skos:inScheme "http://islab.uom.gr/csm/context-dimension/1.00" .

<http://islab.uom.gr/csm/context-dimension/Emotional> a skos:Concept ;
        skos:prefLabel "Emotional dimension" ;
        skos:definition "The emotional dimension of customer context models the mood, the disposition
        and the motivation of the customer throughout the provision of a particular service. Emotional
        context directly related to cognitive activities, such as judgements, opinions, evaluations, and
        thoughts." ;
        skos:inScheme "http://islab.uom.gr/csm/context-dimension/1.00" .
```

- *The types of service rules* (section 4.4.3.4). Table 27 shows an example of the definition of eligibility rule and service variant rules as SKOS concepts.

Table 27: Types of rules as SKOS concepts

```
<http://islab.uom.gr/csm/rule-type/EligibilityRule> a skos:Concept ;
        skos:prefLabel "Eligibility rule" ;
        skos:definition "Eligibility rules define conditions that have to be met by the customer in order for
        the service execution to be initiated, e.g. she has to be over 18 years old or she has to be physically
        present. " ;
        skos:broader "http://islab.uom.gr/csm/rule-type/OperativeRule" ;
        skos:inScheme "http://islab.uom.gr/csm/rule-type/1.00" .

<http://islab.uom.gr/csm/rule-type/ServiceVariantRule> a skos:Concept ;
```

```
        skos:prefLabel "Service variant rule" ;
        skos:definition "Service variant rules are used for defining the Service Version that best matches the profile and circumstances of a particular type of customers (e.g. customer that are below 18 years old must use the version of the service for minors)." ;
        skos:broader "http://islab.uom.gr/csm/rule-type/OperativeRule" ;
        skos:inScheme "http://islab.uom.gr/csm/rule-type/1.00" .
```

- *The types of co-production interactions* (section 3.2.2). Table 28 shows an example of the definition of service evaluation and service search as SKOS concepts.

Table 28: Co-production interactions as SKOS concepts

```
<http://islab.uom.gr/csm/coproduction-interaction/ServiceEvaluation> a skos:Concept, ServiceActivity ;
        skos:prefLabel "Service evaluation" ;
        skos:broader "http://islab.uom.gr/csm/coproduction-interaction/CustomerCoprodInter" ;
        skos:inScheme "http://islab.uom.gr/csm/coproduction-interaction/1.00" .

<http://islab.uom.gr/csm/coproduction-interaction/ServiceSearch> a skos:Concept, ServiceActivity ;
        skos:prefLabel "Service search" ;
        skos:broader "http://islab.uom.gr/csm/coproduction-interaction/CustomerCoprodInter" ;
        skos:inScheme "http://islab.uom.gr/csm/coproduction-interaction/1.00" .
```

5.2.2 Implementing *service feedback* in existing semantic service models

In section 2.3, we reviewed all existing semantic service frameworks in the light of the five service aspects of the extended service description model, i.e. functional descriptions, non-functional descriptions, behavioural descriptions, technical descriptions and social descriptions. We showed that SWS frameworks and lightweight semantic service frameworks alike offer the means, i.e. modelling elements, for supporting all five service aspects. Despite not supporting social descriptions inherently (i.e. as part of their existing model), we observed that all semantic service models can be extended either by reusing existing modelling elements or by introducing new ones to support it.

More specifically, SWS frameworks provide the language for encoding the ontologies that express their Information Model, whereas lightweight semantic service frameworks do not impose such limitations. Their Information Models may comprise of a set of ontologies which are implemented using using different formalisms, i.e. OWL, RDF and WSML.

SWS frameworks support detailed, rich representations of both the Functional and the Behavioural Descriptions. Lightweight semantic service frameworks handle these types of descriptions as well, but the expressivity in this case is limited. It is thus clear that a trade-off between expressivity and complexity exists.

Regarding the Technical Descriptions both SWS frameworks and lightweight semantic service frameworks rely mainly on the WSDL specification.

Table 29: Overview of semantic service frameworks

	Semantic Web Service Frameworks	Lightweight semantic service frameworks
Information Model	Ontologies encoded mainly using the language that is defined in the context of the framework	Ontologies encoded in any language and are linked to specific attributes
Functional Descriptions	Defined in a rich expressive way in service's capability, where both the conditions and effects are encoded using an axiom language.	Preconditions and effects are not defined. Functional descriptions are derived from the definitions of operations and their inputs and outputs.
Non-Functional Descriptions	Expressed as non-functional properties or encoded in ontologies.	Mainly given by additional attributes that are provided by the mechanisms (see Table 5).
Behavioral Descriptions	Mainly defined as states and state transitions (WSMO) or as processes (OWL-S, SWSF).	No explicit means for describing behavioural characteristics. These are to some extent derived from the operations' definition.
Technical Descriptions	Mainly these are given in the non-semantic descriptions, usually encoded in WSDL documents.	SA-REST and MicroWSMO provide attributes and classes for technical descriptions, while SAWSDL capitalises on WSDL.
Social Descriptions	Expressed either by extending or reusing existing elements (see Table 30).	Expressed either by extending or reusing existing elements (see Table 30).

The customer's perspective on the service is notably absent, consequently social descriptions are currently not considered. Until now, all semantic service frameworks are based on the assumption that the service descriptions are developed in a top-down way by the service providers and that users are limited to service usage. However, as discussed in the remainder of this section, both SWS frameworks and semantic service models can be extended to support social descriptions (see Table 30).

The OWL-S Service Profile and/or the OWL-S Service Model can be extended in order to include bottom-up customer-generated data. In SWSF social descriptions can be included by extending the Service Descriptors. WSMO and WSMO-Lite can support social descriptions either by expressing it in the form of an ontology and linking it to the service or by reusing the non-functional properties of the service.

To support social descriptions in WSDL-S and SAWSDL, it has to be expressed formally (e.g in RDF) and then linked to the service by reusing the *modelReference* element. In a similar manner, SA-REST supports Social Descriptions by using the *sem-class* element and MicroWSMO by reusing the *Mref* element.

Table 30: Introducing service feedback in semantic service models

Social Descriptions	
OWL-S	Extend Service Profile or Service Model
SWSF	Extend Service Descriptors
WSMO	WSMO Ontology or Non-Functional Properties
WSMO -Lite	Ontology or Non-Functional Properties
WSDL-S	Using modelReference
SAWSDL	Using modelReference
SA-REST	Using sem-class
Micro WSMO	Using *Mref*

Finally, the service modelling efforts discussed in section 2.2.4.1 similarly do not currently support the social annotation of services, and consequently do not provide the model elements that map to service feedback. However, in the context of this *Thesis* we propose ways of extending these models to support the social annotation of services. In the SOA Reference Model's service feedback could be included as part of the Service Description. A social descriptions class (and service feedback being one of its sublcasses) could be defined in SoaML and a social description module could be defined in USDL, adopting the modelling elements of our work. In the SOA Ontology, a relationship between actor and service could be introduced to express service feedback. Finally, the OBELIX service ontology could include service feedback as one of the classes in the service value viewpoint. Table 29 summarises our discussion in this section.

In our work, we use the RDF implementations of classes from the Customer Service Model, i.e. service feedback and customer expectation, in order to store information about a service that is coming bottom-up from the customers. In the context of our pilots discussed later on in this chapter, this information comes in the form of tags and by mining the behaviour of customers when browsing services on service platforms. The service feedback property is used both in cases of services described directly with the Customer Service Model and whever there was a need to extend existing semantic service models, mainly SAWSDL and SA-REST, as indicated in Table 30. An example for SA-REST is shown in the table below.

Table 31: Extending SA-REST service descriptions with the service feedback class

```
<p>

<span class="sem-class" title=" http://195.251.218.39/gea/?q=node/13774"> This is the Greek Naturalisation public service. </span>

…
```

```
The tag cloud of the service is <span class="sem-class" title:”csm:ServiceFeedback"> child, marriage, immigrant, citizenship </span>

</p>
```

5.3 Demonstrating the Unified Service Model and the Customer Service Model for pull and push service search, and service evaluation

Being able to search for the services that may address ones needs and finding a description of those services, which will help the customer decide whether she finally wants to consume the service or not, is the beginning of the service lifecycle from the customer viewpoint (see section 3.2.3). As dicussed in the introduction of this *Thesis* (particularly in sections 1.2 and 1.4), we explained how traditional approaches to service search fail to fulfil their expectations of customers due to the service discovery gap, i.e. the different vocabulary used by customers and service providers.

In this *Thesis*, we are overcoming this problem by bringing together the vocabulary of the service provider (part of the provider-driven service description) with that of the customer (part of the social descriptions). Social descriptions enhance traditional descriptions of services by “capturing” and “attaching” data, which is related to the actual usage of the services by customers. As discussed in the previous section in the Web of Services, social descriptions can be collected bottom-up directly from the users:

- By allowing customers to describe the services they use using free text, such as tags, or predefined vocabularies;
- By harvesting social media and social networks to discover customer opinions on specific services; and
- By analysing the service usage patterns of the customers, i.e. how they interact with services, when and where they consume services, which types of services they prefer etc.

Social descriptions of services can provide valuable input to service provicers during the service design process that will eventually lead to higher quality and innovative public services that would better fit customer needs. Furthermore, public administration will be able to predict future needs of citizens, based on trends expressed through the social annotation of services, and become more agile and proactive. Customers will benefit as their feedback on (public) services will be made available to decision makers, contributing once again to public service innovation and quality.

The pilots presented in the following sections aim to allow customers to find services more easily using terms which are more familiar to them, e.g. customer-provided tags. We therefore assume that

service feedback, expectations and perceptions of customers are expressed by means of customer-provided service tags.

The remainder of this section is structured as follows: in section 5.3.1 we explain how social descriptions can be used in order to search for services. Section 5.3.2 presents a customer-centric eGovernment portal, MyPortal.gov, which allows citizens to annotate public, using tags, in order to express their feedback. These tags are used in order to provide pull service search and service recommendation functionalities. Finally, section 5.3.3 presents a search engine for services, which makes use of the semantic descriptions of services (both provider- and customer-driven ones) and uses them in order to provide pull service search and service recommendation functionalities. The service descriptions are harvested from the service platforms where they have been originally published, e.g. MyPortal.gov.

5.3.1 Pull and push service search based on *service feedback*

In section 3.2.3.2, we defined two types of search, namely pull and push service search. In the case of *pull* service search, the customer has an active role and initiates the service search interaction, while *push* service search is not directly triggered by the customer, but can be triggered automatically by a change in the customer context or by a (real-world) event, in the form of recommendations pushed to the customer.

In the remainder of this section we focus on pull service search and introduce different implementation approaches based on the combination of social descriptions of services with provider-oriented descriptions.

We focus on the the instantiation of social description of services in the form of customer-defined tags. A tag is a tag is a non-hierarchical term assigned to a service by a customer. The tags assigned to a service are organised and visualised in tag clouds. This kind of descriptive metadata for the service provides insights into how the service is perceived by the customer, hence revealing customer expectations and feedback. Tags are generally chosen freely and personally by the customers. However, in some cases, service providers provide mechanism that collect and analyse tags, and based on this analysis propose tags to the customers. This improves the quality of the tags attributed to a service as it reduces lexical and semantic heterogeneity.

5.3.1.1 Collecting *service feedback* using tagging

In the context of the Web of Services, *service evaluation* refers to the case when customers directly express their feedback on and expectation of a service by including information (e.g. in the form of terms or keywords) in its description. They could do it in a similar way to what they currently do for

products, content and multimedia in certain popular eCommerce and social platforms, e.g. Amazon, Flickr and Youtube. For example, customers would describe why they use a service, for what reason, on which occasion and/or under which circumstances.

The explicit social descriptions created as a result of this co-production interaction may be particular to some parameters of the services such as its outcome, or to the service experience as a whole. In addition, customers may also express their satisfaction or dissatisfaction with regards to quality of service, usability, user-friendliness, price, stability, availability, etc.

In the Web of Services, explicit social descriptions can be elicited using both *structured* and *unstructured* means of expression. Structured means of expression include the use of controlled vocabularies, scaled ratings and closed-type questions for providing feedback on services. Unstructured means of expression include the use of free-text terms and tags, comments on blogs and forums, and social media posts (e.g. posts on Twitter and Facebook).

Tags, either coming from controlled vocabularies or free-text ones, and tagging mechanisms can act as enablers of explicit social annotation, in particular of feedback. Tagging is easy, intuitive, highly-expressive and straightforward; moreover the majority of users are already familiar with it. Tagging mechanisms allow users to describe services either in their own words, using free-text, or being assisted by predefined vocabularies and taxonomies. Explicit social descriptions hence constitute a user-defined vocabulary based on a consensus of how the service is perceived and/or used in the world.

Rating using predefined scales, such as 1-5 stars, Facebook's like button or the likert scale, is another popular tool that may be used for allowing service clients to express their perspective on a service; in particular when it comes to the evaluation and assessment of service quality parameters.

User comments are not a new phenomenon. They have been part of the Web since the first online communities were formed and organised in online forums. However, the social Web re-invented and leveraged user comments. Nowadays, people are discussing every topic one could imagine in blogs, social media sites and social platforms. We therefore argue that user comments, e.g. blog posts and social media posts, could be effectively used as a means of expressing explicit service feedback. Hence, in the context of social service platforms, service clients could comment on the service experience, on service quality and value, as well as on different service parameters.

The prototypes presented in the remained of this section provide insights on how explicit social descriptions can be implemented and utilised in the context of a real-world, demanding service industry, that of public administration.

5.3.1.2 Collecting service feedback through service mining

In the context of the Web of Services, *service mining* refers to information about the service that can be inferred by monitoring service usage and the customers' behaviour during service provision. In this case, information that can be collected includes:

- preferences, such as the services that a customer usually uses or shows interest in;
- the services used before or after a specific service (or even the service descriptions browsed before or after a specific service/service description);
- the time/date/period/place of using a service;
- the frequency of using a service;
- the rate of errors and problems that happened as well as their types; and
- whether the customer is a recurrent one.

According to the specific service context and business environment, e.g. eGovernment or eCommerce, additional information may be required for meaningful conclusions to be derived.

As discussed in Chapter 4, implicit social descriptions, as an output of *service mining*, may be inferred using three broad types of available tools and techniques, namely Web analytics, logging service usage and social network analysis. All these assume that service provision happens on a service platform that supports the monitoring of user behaviour, taking into account personal data privacy concerns.

Logging the behaviour of customers on service platforms on the Web involves keeping track of all customer activity throughout the service lifecycle. Logging can also be extended to cover also cognitive and emotional reactions of the customer. Logging should be performed in a non-intrusive manner and ultimate attention should be paid to preserve the privacy of the customer. Logging customers' behaviour is usually facilitated by CRMs, software for developing Web applications, data warehouses to process the collected information and Web analytics tools (Eirinaki & Vazirgiannis, 2003).

Web analytics are particularly interesting in the case of e-services. Web analytics refers to the measurement, collection, analysis and reporting of Internet data for purposes of understanding and optimizing Web usage. For example, on a service platform Web analytics can provide information about the number of visitors and their origin, the number of page views and the sequence of the pages visited (Jansen, 2009; (O'Reilly & Battelle, 2009). We can assume that the description of a service corresponds to a Web page. Web analytics can be collected using cookies and by logging the behaviour of the user in the service portal. Web analytics enable the inference of tacit knowledge related to a specific service, related to their popularity, their relationships to other services (e.g. complementary or competing) and the performance of the service delivery.

Social network analysis refers to the study and the investigation of the relationships between the entities of a social network (Scott & Carrington, 2011). These relationships may be of different types, including: kinship, e.g. father of; roles, e.g. friend of, supervisor of; affective and cognitive relationships, e.g. like and perceive; actions, e.g. does, performs; flows, e.g. information exchanged between two actors; and co-occurrence, e.g. belonging to the same group or sharing a common characteristic. Analysing the social network of customers may expose rich latent knowledge with regards to: the types and the profiles of people interested in or consuming a particular service; complementary and/or competing services; the type of information exchanged between customers; the customers' view on the service and their reactions pre- and post-service consumption (O'Reilly & Battelle, 2009; Loutas, 2009).

The prototypes presented in the remained of this section provide insights on how explicit social descriptions can be implemented and utilised in the context of a real-world, demanding service industry, that of public administration.

5.3.1.3 Computing service similarity based on service tag clouds

As discussed previously in our work, in most of the cases, pull service search is supported only by provider-driven descriptions. We argue in our work that pull service search can be improved if those descriptions are augmented by social descriptions, which are closer to the way customers understand services, and thus closer also to the vocabulary that customers would use when searching for services, i.e. bridging the service discovery gap.

In this vein, the approach presented in this section allows us to incorporate tag information and formal service descriptions into a tag cloud-based service description which can facilitate pull service search. A tag cloud-based service description S_{IF} is defined as a set of pairs $<t_i,n_i>$, where t_i is a free text tag and n_i is the frequency of tag t_i in S_{IF}.

The tag cloud description metaphor may be further refined by dividing each service description according to the concepts of the Unified Service Model and the Customer Service Model. For example, instead of a single tag cloud, we can have separate tag cloud descriptions per service for inputs and outcomes, e.g. providing separate search fields for these different aspects in a tag-based service discovery engine. In that case, service similarity must combine the similarity value for each of these fields.

Such tag clouds immediately solve the service discovery gap, since there is no formal language involved, for example technical or other formal jargon that is usually used in provider-oriented service descriptions, which needs mediation. The elimination of mediation, i.e. of the translation of the provider's vocabulary to the vocabulary of the customer, is very important and has a direct positive

impact on the customer's experience during service provision, because the cost and the effort of this mediation is carried by the customer.

Now matching customer requests, which we assume in this case that are formed as a tag set which express the customer's query (i.e. a set of search keywords), to tag clouds is obvious. Assuming tag clouds exist that describe each service, then matching these to a tag set is an almost straightforward task. The matching is performed as follows: the tags included in the customer specified tag-set are used as a filter to mask each service tag cloud, dropping all tags that are not of interest. The weighted sum of this masked tag cloud denotes the degree of match between the customer-specified tag-set and the service tag cloud.

To compare tag clouds, weights are usually normalised. The normalised tag frequency r_i of tag t_i in service description S_{IF}, where k is the number of tags in S_{IF}, is defined as:

$$r_i = \frac{n_i}{\sum_k n_k}$$

Let T be a normalised tag cloud and Q a customer-specified tag-set, then the similarity between T and Q is defined as:

$$sim(T, Q) = \sum_{t_i \in T} \delta(tp_i, Q)$$

where tp_i stands for the normalised tag-pair (*<tag, weight>*), and δ is defined as the normalised tag frequency of a tag if it is included in both the customer-specified tag-set and the service tag cloud, or is zero otherwise:

$$\delta(< t_1, r_1 >, Q) = \begin{cases} r_1 & if\ t_1 \in Q \\ 0 & otherwise \end{cases}$$

This naïve approach of tag cloud matching, e.g. based on simple keyword (string) matching, can be refined by practices from the semantic service search realm. For example, the typical asymmetry in the degree of match between two tags which takes into account the subsumption relation between them, i.e. a hierarchical class-subclass relationship between them, is lost in the tag cloud, due to its unstructured nature. The same shortcoming applies also the case of synonyms. In this vein, the transformation of the unstructured tag cloud into a taxonomy (referred to often as a folksonomy) can help utilise semantic relationships between tags in pull service search.

5.3.1.4 Pull service search by browsing service tag clouds

Browsing service tag clouds is a very popular way for discovering services on service platforms. It is intuitive as it allows customers to use their own vocabulary in order to navigate through the services available on a platform and find the ones that match their needs.

Although a tag cloud describes the most frequently used terms by other customers of a service, a new customer may still have trouble formulating a tag set that would match it, particularly if the tag cloud is sparse, i.e. it contains only few tags. An alternative approach is to provide a visual browsing mechanism where the various concepts represented in the service, e.g. input, output, need etc., are described using representative tags. This will allow the customer to browse the service tag cloud more easily and complete pull service search with less effort and within less time.

To achieve this, we propose a type of folksonmy that is automatically built by matching similar tag clouds in order to allow customers to browse service descriptions at different levels of granularity. To realise this, we combine hierarchical clustering and centroid-based classification, i.e. organising a tag cloud around the most representative tags (Han and Karypis 2000).

Hierarchical clustering approaches analyse clusters in order to build hierarchies of clusters, which are represented using tree-structures (see figure below). In the context of this *Thesis*, hierarchical clustering allows us to produce a browseable interface of service descriptions at different levels of granularity using tags. Furthermore, it provides the means for implementing recommendation mechanisms: when a user finds a service, other services that belong to the same cluster can be recommended to her. Hierarchical clustering approaches fall into two broad categories:

- Bottom-up approaches (a.k.a agglomerative) where each tag is assigned is own cluster and pairs of clusters are formed as we move up the hierarchy. This is the approach followed in our work.
- Top-down approaches (a.k.a divisive) where all tags are grouped in one single cluster which is split recursively into more fine-grained ones as we move down the hierarchy.

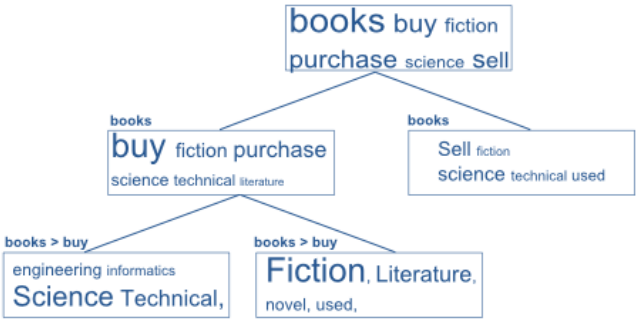

Figure 64: An example of a dendrogram induced from tag cloud data (Fernandez, Hayes et al. 2008)

We are first using constrained agglomerative clustering (Zhao, Karypis et al. 2005) to cluster the social descriptions into a concept tree. Each service is represented in terms of its tag cloud and similarity between services is calculated based on similarity between tag clouds. In general clustering is based on Van Rijsbergen's hypothesis, which proposes that similar documents are likely to be more relevant to an information requirement than less similar documents (Van Rijsbergen 1979). Hence, a tag cloud is considered to be a document and an information requirement to be the customer-defined tag-set.

Using the vector-space model, each tag cloud is represented as a vector in term space and each tag in the vector is weighted according to the standard tf-idf weighting scheme[37]. Thus each tag is assigned a weight that is:

i. highest when it occurs many times within a small number of tag clouds;
ii. lower when the tag occurs fewer times in a tag cloud, or occurs in many tag clouds (thus offering a less pronounced relevance signal);
iii. lowest when the tag occurs in virtually all tag clouds.

In the vector-space model, similarity between tag clouds (which have been represented as vectors) is calculated using the cosine measure[38], which defines that the similarity between two vectors is measured by calculating the cosine of the angle between them.

To prevent large tag clouds having undue influence during similarity matching each vector is normalised. The corpus of tag cloud vectors is then used as input to the clustering algorithm. The output of the algorithm is a dendrogram that can be browsed from its root nodes (containing all tag clouds) to its leaves, where each leaf represents a single tag cloud (and its associated service) (see Figure 64).

Each node in the hierarchical structure, i.e. a cluster, comprises a separate browsable tag cloud which derives by calculating the centroid of the cluster. The centroid contains a weighted representation of the tags which are most representative of the concept in the cluster. This concept can be one of the core concepts defined in the Unified Service Model. The centroid is produced by firstly producing a composite vector of the tag cloud vectors contained in the cluster and then normalizing each term of the composite vector by the number of tag clouds at the same cluster. For a cluster *p*, containing a set *N* of tag cloud vectors, the centroid vector Cp is defined by

[37] http://nlp.stanford.edu/IR-book/html/htmledition/tf-idf-weighting-1.html
[38] http://en.wikipedia.org/wiki/Cosine_similarity

$$C_p = \sum_{n \in N} n \Big/ |N|$$

This way a browseable dendrogram is produced, where each cluster features a tag cloud which represents a service description at different levels of granularity (from more coarse to more fine grained ones as one moves down the structure). Figure 64 illustrates an example of a dendrogram induced from tag cloud data. At each node a threshold controls how many tags are displayed. For each sub-node, the single mostly highly weighted tag in each parent node is displayed as a part of a path summary, e.g. books > buy.

5.3.1.5 Addressing the cold start problem

The cold start problem refers to the difficulty in offering a service when there is yet no user data and the difficulty in collecting user data when there is no service (Schein, Popescul et al. 2002). In the contex of our work, this means that no pull service search options can be provided until a critical mass of tags (or other form of customer-generated data) has been collected.

In order to overcome this problem in the context of the pilot implementations developed in this *Thesis*, we employ a content-based approach to the cold start problem by clustering the provider-oriented descriptions of the services (assuming that such descriptions exist). These may both consist of well-structured formal descriptions that follow one of the SWS frameworks discussed earlier.

Our approach draws upon the work of (Hayes and Avesani 2007) which uses content clustering and tags to produce interpretable tag-based summaries of data in the blog domain. The essential observation of this work is that where tag data is sparse, the underlying content data can be clustered, producing synthetic tag clouds. These tag clouds are shown to be strong indicators of the cluster semantics and coherence. Hence, provider-oriented service descriptions can provide input to a cold-start clustering process. The cluster concepts will be represented by tag clouds extracted from the service descriptions.

5.3.2 A service portal for customer-centric service delivery: MyPortal.gov

At the time of development of this *Thesis*, service platforms with social features that enabled user participation where at their infancy. The development of MyPortal.gov was driven by our intention to explore how the application of social descriptions of services could improve the provision of public services. Despite the significant investment of governments around the world on ways of facilitating the access of citizens to public services, e.g. via eGovernment portals, and the objectives set around citizen-centric service provision, most of these platforms still perceive customers, in this case citizens, as passive receivers of information and services. In many cases, the content, i.e. service descriptions,

are still provided in uni-directional way (from the service providers to the customers) and the content on the portals is often organised following the organisational structure of administration and not the way that citizens would see it fit their context. Our work came to challenge these perceptions and demonstrate that active participation of citizens in public service delivery can bring benefits to citizens and to administrations alike.

In this vein, MyPortal.gov aims at the development of a citizen-centric governmental portal, based on that satisfies the following principles:

- Encourage citizens to have an active role in public service provision by allowing them to describe public services in their own terms, i.e. by tagging service descriptions directly on the portal.
- Facilitate the citizens' access to public service information using visual, user-friendly, efficient, intuitive and easy to use mechanisms, such as service tag clouds and visual browsing of the portal's content using the ATOM Inteface (see Figure 69).
- Improve the citizens' experience in the portal by means of personalisation and public service recommendation mechanisms, i.e. by implementing push service search.
- Support the documentation of services following a standard generic service model and make available detailed, well-structured, comprehensive, high-quality public service descriptions which will be both human- and machine-understandable.

5.3.2.1 System architecture

The architecture of the portal consists of the following three layers (see also Figure 65):

- User Interface layer: The citizens interact with the portal through the user interface to use the desired functionalities. The following are the main types of users:
    - Anonymous Users. They are the citizens who visit the portal without having registered. They can only browse and read the content of the portal.
    - Registered Users. They are the citizens who have registered in the portal. Registered users can take advantage of additional functionalities, such as describing public services or getting recommendations about relevant public services.
    - Public servants play the role of the Content Manager. Content managers create and maintain public service descriptions.

- Application layer: It implements the business logic of the portal and provides its main functionalities. The main application building blocks provided by the portal (reading from left to right in Figure 65), which lead to the provision of respective functionalities, are:
    - Data entry, using a wizard that helps public servants to easily create complete

descriptions of public services;

- Pull service search using keywords;
- Pull service search using tags;
- Visual browsing of the collection using the ATOM interface (Samp et al., 2008);
- Push service search based on the analysis of user behavior logs and on similarity of services by analyzing their descriptions;
- Browsing the collection of services using tag clouds;
- Evaluation of public services through the tagging of services; and
- Publishing machine-readable descriptions of services, using annotations from the Unified Service Model and the Customer Service Model.

- Repository layer: The content of the portal, e.g. service descriptions, tags etc., is stored in the underlying repository. The logical data model of the repository follows the Unified Service Model and its extensions, i.e the Customer Service Model. More specifically, the following elements are deomonstrated: *service input, service outcome, customer, service provider, service feedback, service effect, service rule, legal context, service stakeholder, service bundle* and *service relationships*.

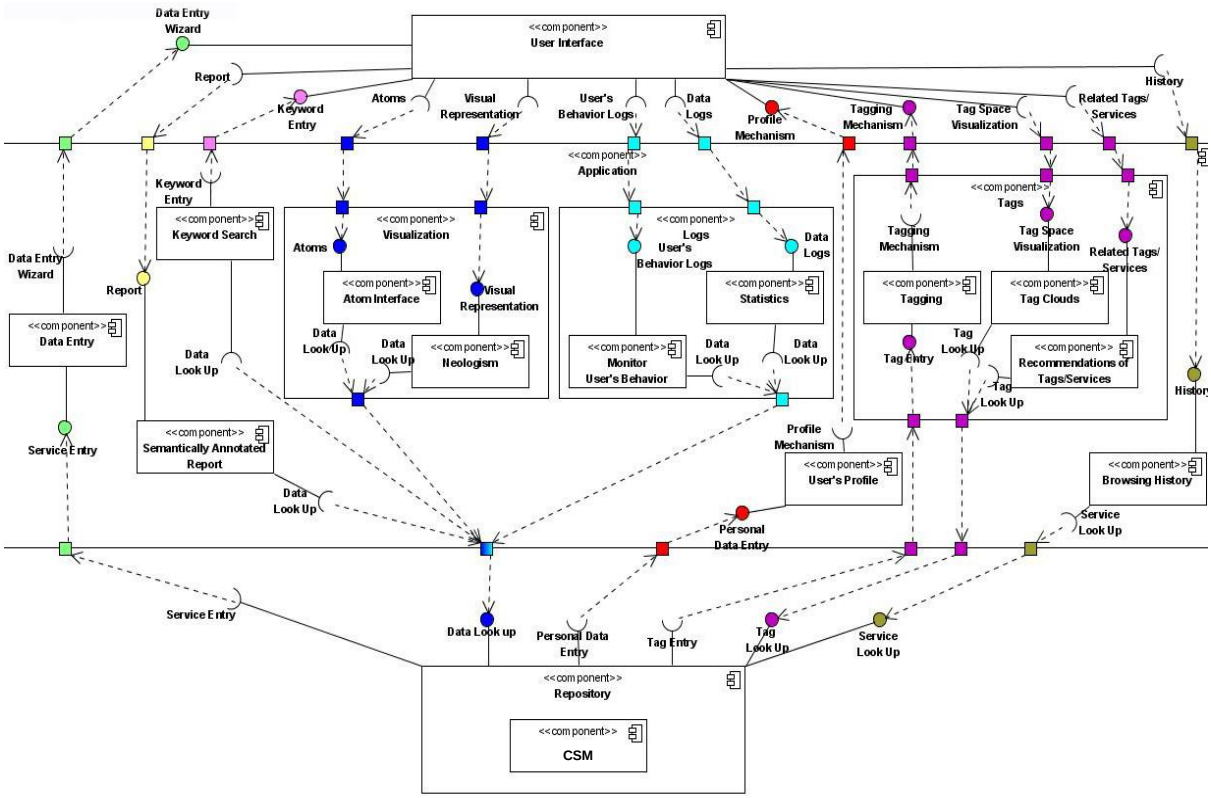

Figure 65: System architecture of MyPortal.gov

From an implementation perspective, the portal has been developed using Drupal 5, which was selected as it provides good support for Web 2.0 and semantic technologies and has a very active

developers' community. In addition to reusing existing Drupal modules, specific modules have been developed for exporting the service descriptions in machine-readable RDF formats and for allowing the inclusion of RDFa tags in Drupal 5. Therefore our work contributed with requirerments to the development of the RDF extensions[39] of Drupal, which are now part of Drupal 7.

5.3.2.2 Prototyping

This section describes the core functionalities provided by MyPortal.gov. We focus our discussion on the functionalities that contribute significantly to the fulfilment of the four principles discussed in the beginning of section 5.3.2. We thus start by explaining how registered users can view and enhance the public service descriptions offered by the portal. This means that the service descriptions provided by the portal are enhanced with additional user-defined data, which derive from the users either directly or indirectly (evaluation of services). Afterwards, we show how these extended public service descriptions are utilised in order to support service search and recommendation.

5.3.2.2.1 Evaluation of public services

This section explains how MyPortal.gov enhances traditional public service descriptions by:

- allowing citizens to annotate those using tags (i.e. allowing them to express their expectations and service feedback);
- automatically including information coming from the citizens' behaviour in the portal (i.e. implicit social descriptions); and
- automatically including lightweight annotations based on the Unified Service Model (i.e. implement provider-driven descriptions of services).

The functionalities described here explain the way of working of the respective application building blocks of Figure 65 in section 5.3.2.1.

MyPortal.gov offers fine-grained, well-structured public service descriptions based on the Unified Service Model and the Customer Service Model. They contain information regarding the service provider, the service inputs and the service effect, the cost, the waiting time, the service activities and co-production interactions (grouped under the term workflow to make it more understandable by the end-users), and the related services. Those descriptions also contain service feedback and customer expectations, which are expressed in this case in the form of tags. An example of such a description for the "Naturalisation of Adult Alien" public service, which is offered by the Greek Government to

[39] https://www.drupal.org/project/rdfx

non-Greek citizens who wish to acquire the Greek citizenship, is shown in Figure 66. A detailed description of this public service is provided in Annex II.A.

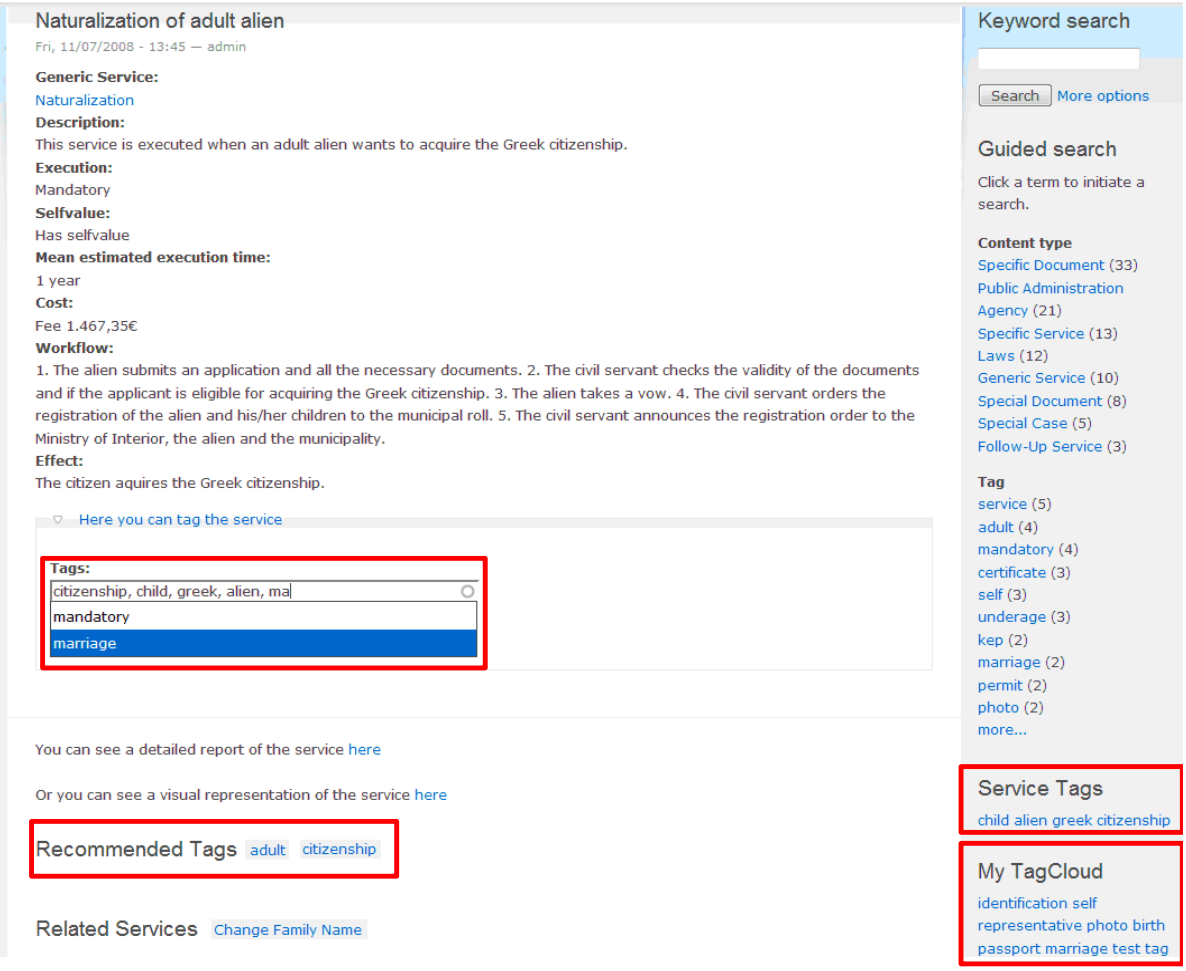

Figure 66: Service description on MyPortal.gov – social description features are highlighted

In order to facilitate the direct collection of user-defined data, a tagging mechanism has been implemented. It allows registered users to annotate any public service description using a comma-separated list of tags. It also supports tag recommendation for improving the tagging process. It suggests to the registered users tags that:

- Others already used in order to annotate a specific service. The purpose of such suggestions is to reduce lexical variations (e.g. plurals, capital letters, abbreviations etc.) and spelling errors.
- Are popular for this specific service, i.e. the tags that have the highest frequency.
- Belong to the same tag cluster with the popular ones. For example, if a cluster, defined following the approach of (Specia and Motta 2007) discussed later, contains the tags adult, marriage and birth, and marriage is among the popular tags, then adult and birth will also be suggested to the user.

We have implemented the tag recommendation approach proposed by (Specia and Motta 2007), where they try to define the semantics behind the tag space in social tagging systems, i.e. their ultimate goal is to define the nature of the semantic relationships, e.g. synonyms, hypernyms, hyponyms etc., between tags in order to turn the tag cloud into a folksonomy. Their approach consists of three steps: tag pre-processing, clustering and concept/relation identification.

In the pre-processing step, the collection of tags contributed bottom up by customers on the service portal is cleaned up by filtering out non-trivial tags, grouping together morphologically similar tags, e.g. tags with the same stem, and not taking into consideration the infrequent ones or those which stand in isolation. During clustering, statistical analysis is used so as to define groups of possibly related tags withing the cleaned-up tag cloud. The clustering methodology is based on co-occurrence and the angular separation, i.e. the cosine similarity discussed also in section 5.3.1.4, is used for clustering. The co-occurrence calculates the number of times that two tags appear together in a tag cloud. After the refinement of the generated clusters, the concept/relation identification step is performed. During this step, semantic relationships between the identified concepts within a cluster are created. They use information from Swoogle (Finin, Ding et al. 2005) and external data (e.g. from Wikipedia, DBpedia, Wordnet and/or Google) in order to specify the semantic nature of the discovered relationships.

We decided to implement this approach for a number of reasons. The co-occurrence is widely used while creating clusters of the tag space and is a measure that provides valuable input for algorithms to extract taxonomic relationships between tags (see also section 5.3.1.4). Additionally, the angular separation is believed to be more suitable when compared with other metrics such as Euclidian[40] and Manhattan[41], which are more sensitive to significant variations in a few elements than little variations in a large number of elements. Moreover, angular separation is less complex than metrics such as correlation coefficient; hence it is the measure to choose for discovering synonyms (Cattuto, Benz et al. 2008). Another strong point of this clustering technique is that it is not necessary to determine a priori the total number of the clusters, unlike k-means or other clustering algorithms. Last, we believe that this approach offers a fair trade-off between complexity and quality of results.

Hence, in our work, in order to create clusters of tags, a statistical analysis of the tag space was performed so as to determine clusters of possibly related tags. Imagine starting with the tag space of Table 32, i.e. identification, card, passport, representative, trip, police and underage. The relations between tags were detected based on their co-occurrence, i.e. how often two tags appear in the same

[40] http://en.wikipedia.org/wiki/Euclidean_distance
[41] http://en.wiktionary.org/wiki/Manhattan_distance

tag cloud. This resulted in the creation of a co-occurrence matrix (see Table 32), where every column/row is a vector which corresponds to one of the tags. We then calculated the similarity between each two of those tags using the angular separation as shown in Table 33.

Afterwards, we determined a threshold so as to filter out pairs of tags that are not highly similar to each other. We experimented with several thresholds, in the range between 0.01 and 0.5, in order to test the accuracy of the algorithm. Every pair of similar tags initiates a cluster (e.g. {identification, card} or {passport, trip}), which can be extended by a tag that is computed to be similar with the rest of the tags in the cluster. This process is repeated for all the tags of the dataset. Whenever the tag space is fully checked and the cluster cannot be further extended {e.g. identification, card, police}, a new similar pair initiates another cluster and the algorithm starts over again till all the similar pairs are used.

Two clusters may be (almost) identical although the initial similar pairs had been different. Thus, the two smoothing heuristics proposed by (Specia and Motta 2007) are used so as to minimize the number of the constructed clusters. Let two clusters *c1* and *c2,* where c1 > c2, i.e. it contains more tags:

i. If *c1* contains *c2*, i.e. if *c1* contains all the tags of *c2*, then *c2* should be removed; and
ii. If *c1* and *c2* differ within a small margin, i.e. the number of different tags in *c2* represents less than a percentage of the number of tags in *c1*+*c2*, then the distinct tags should be added to *c1* and *c2* should be removed.

In the case of our example, the following clusters were finally identified: {identification, card, police} and {passport, trip, underage, representative}. A snapshot of the tagging process and the tag cloud of the service are shown in Figure 66.

Table 32: Co-occurrence matrix for overall tag cloud of MyPortal.gov

	Identification	Card	passport	representative	trip	police	underage
identification	20	18	10	4	9	17	8
card	18	21	7	8	6	19	9
passport	10	7	30	40	20	8	25
representative	4	8	40	10	38	4	50
trip	9	6	20	38	18	10	19
police	17	19	8	4	10	18	8
underage	8	9	25	50	19	8	20

Table 33: Computing the angular separation of the tags of Table 32

	Identification	card	passport	representative	trip	police	underage
identification	-	0.9807	0.5966	0.5451	0.6009	0.9938	0.5424
card		-	0.6014	0.4853	0.6224	0.9859	0.5446
passport			-	0.8070	0.9885	0.5844	0.9807
representative				-	0.7400	0.5416	0.6926
trip					-	0.5966	0.9924
police						-	0.5378
underage							-

5.3.2.2.2 Publishing the public service descriptions as Linked Government Data

MyPortal.gov aims to fully exploit the power of the information contained in the public service descriptions. Therefore, besides publishing fine-grained, well-structured, human-understandable public service descriptions, there is also a need to publish information in a machine-readable form. To achieve this, the public service descriptions offered by MyPortal.gov are semantically annotated using properties from the RDF implementation of the Unified Service Model and the Customer Service Model which are included in the XHTML pages in the form of RDFa tags (see Table 34). This allows making the public service descriptions openly available as linked data (Berners-Lee 2006; Berners-Lee 2009; Bizer, Heath et al. 2009). The semantically annotated public service descriptions are then interoperable and can be crawled and used by Semantic Web search engines (such as S3E – see section 5.3.3). Moreover, having the public service data openly available in machine-readable format enables their easy linking and mashing with data from other sources. The functionality described here explain the way of working of the respective application building blocks of Figure 65 in section 5.3.2.1.

Table 34: Microformats and RDFa

Embedding semantic information (i.e. RDF data) directly into web pages, i.e. (X)HTML documents, was until recently an issue that concerned a big part of the Semantic Community (Benjamins, Davies et al. 2008). The microformats[42] initiative made the first step towards the solution of that problem. Microformats follow existing data models, such as hCard and hCalendar, in order to describe data in HTML documents. For example, the code snippet of Table 35 can be embedded in an HTML page in order to denote that Tim Bernes-Lee is employed by the University of Southampton. RDFa (Resource Description Framework – in – attributes) (W3C Semantic Web Deployment Working Group and W3C XHTML2 Working Group 2008), similarly to microformats, uses XHTML features but goes one step further and extends it with the following five attributes: *about*, *property*, *resource*, *datatype*, and *typeof*. This way arbitrary RDF data can be expressed within XHTML documents. Despite that, an HTML browser still perceives the document as pure XHTML, while and RDFa parser perceives it as an RDF file. Thus exporting the RDF triples from the XHTML document is a straightforward task. RDFa facilitates data and attribute reusability. (Adida 2008) proposes hGRDDL as a simple mechanism for transforming ad hoc HTML-embedded structured data, such as microformats, into RDFa.

In order to publish the descriptions of the public services as linked data a custom-made Drupal 5 module was developed, which implemented the following process. First, the public service descriptions of MyPortal.gov were published as XHMTL instread of simple HTML pages. This was required as HTML 4 did not support RDFa. Each of the services is assigned an HTTP URI following the pattern: <base URI> <collection> <service id>, where collection is a way of logically grouping services by pilot, in our case the value here is gea, and service id is a randomly generated unique identifier.

[42] http://microformats.org/

Afterwards, some core metadata about the service, i.e. service input, service outcome, service provider, service feedback (i.e. the service tag cloud), was included in machine-readable format in the service description web pages using RDFa. Thus, every XHTML public service description contained a set of RDF triples each of which has as subject the URI of the service as object either a URI or literal value, depending on the predicate. The predicates of the triples come from the Unified Service Model and the Customer Service Model.

An example of a semantically annotated service description for the Greek Naturalisation public service, party presented also shown in Figure 66, is presented in Table 35. Explanations are provided in line.

Table 35: Semantically annotated description for the Greek Naturalisation public service

```
<!-- imported namespaces-->
<div xmlns:SA-REST=http://knoesis.wright.edu/srl/SA-REST
xmlns:csm=http://islab.uom.gr/csm
xmlns:roles=http://islab.uom.gr/csm/service-agent-roles>

<!-- the service URI -->
<p>

<span class="sem-class" title=" http://195.251.218.39/gea/?q=node/13774"> Naturalisation of adult alien
</span>

…

<!-- the service provider -->
<span class="sem-class" title:”roles:ServiceProvider"> Region </span>

<!-- the service input -->
<span class="sem-class" title:”csm:ServiceInput"> Application of naturalisation </span>
<span class="sem-class" title:”csm:ServiceInput"> Statement of Naturalisation </span>
<span class="sem-class" title:”csm:ServiceInput"> Copy of Passport </span>
<span class="sem-class" title:”csm:ServiceInput"> Residence Permit </span>
<span class="sem-class" title:”csm:ServiceInput"> Birth certificate </span>
<span class="sem-class" title:”csm:ServiceInput"> Tax Statement of the last fiscal year </span>
<span class="sem-class" title:”csm:ServiceInput"> Penal Certificate for Court use </span>
<span class="sem-class" title:”csm:ServiceInput"> Certificate of non-deportation </span>

<!-- the service outcome -->
<span class="sem-class" title:”csm:ServiceOutcome"> Decision regarding the acquisition of the greek
citizenship </span>

<!-- the service effect -->
<span class="sem-class" title:”csm:ServiceEffect"> The alien acquires the Greek citizenship.</span>

</p>
 </div>
```

5.3.2.2.3 Pull service search in MyPortal.gov

This section discusses the different alternatives for finding public service information in MyPortal.gov (pull service search). The functionalities described here explain the way of working of the respective application building blocks of Figure 65 in section 5.3.2.1.

Keyword search. MyPortal.gov offers traditional keyword search functionalities as well as advanced search functionalities. Both anonymous and registered users can use multiple search criteria and combine them with logical operators such as AND, OR etc.

Guided search is also available, which is an inherent Drupal functionality tailored to our needs. In this case the search results can be stepwise refined using different attributes of the service model. Guided search can be seen as a short of facete search. As shown in Figure 67, a citizen can for example search first using some aspect of the model, e.g. by service or service outcome, and then filter the search results by other aspects, such as service provider, or service feedback (by using tags).

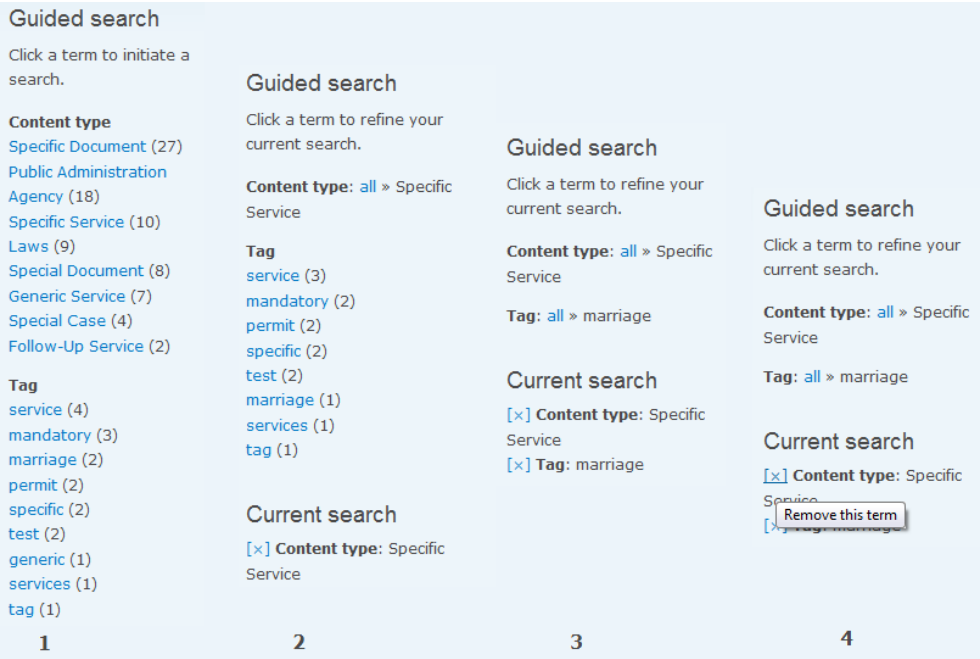

Figure 67: Guided search on MyPortal.gov

Browsing public services using tag clouds. The citizens can browse MyPortal.gov's public service description repository using tag clouds. Each time a tag selected, it acts as a filter and filters out the services that are not annotated with it. For example, if the user clicks on the tag "marriage", then all the public service descriptions tagged with this particular tag will be retrieved. The portal offers three different types of tag clouds (see also Figure 68):

- *Overall tag cloud*, which contains all the tags that have been added from every registered user to every public service. It can be used both by anonymous and registered users. The popularity

of a tag, expressed by its font size, indicates the number of services that have been annotated with this tag.

- *Service tag cloud*, which consists of all the tags that have been used by all registered users to annotate a specific public service. It appears whenever a user either anonymous or registered, accesses a public service description. Here the popularity of a tag indicates its usage frequency for the specific service.
- *Personal tag cloud*, which includes all the tags, that a registered user has selected in order to annotate the public services of his/her interest. In this case, the popularity of a tag indicates its importance for that specific user. This expresses the customer viewpoint of the services and is computed by utilising customer expectations and service feedback expressed by the users of the platform.

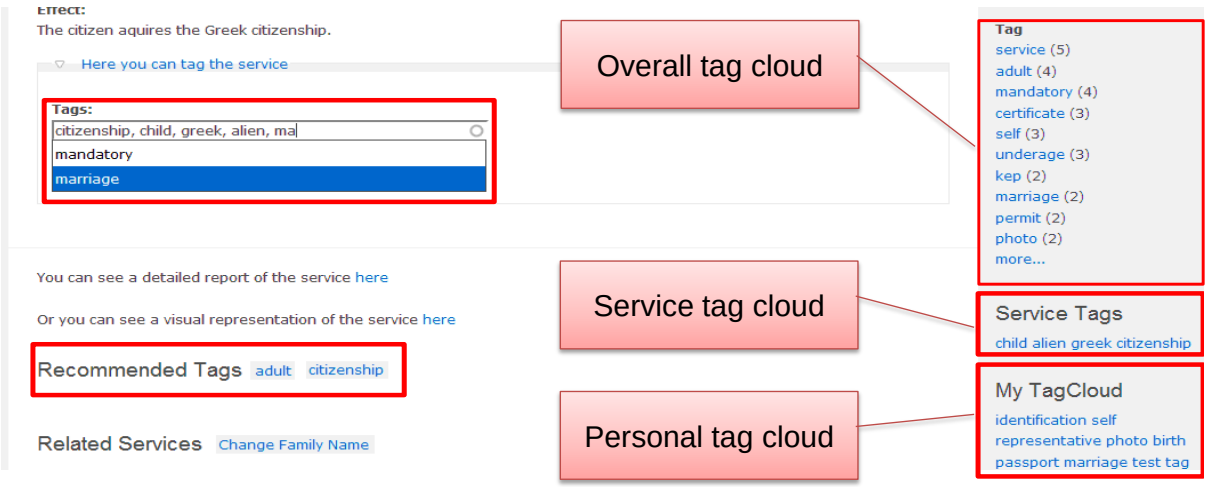

Figure 68: The three types of tag clouds on MyPortal.gov

Browsing public services using the ATOM interface. Citizens can browse MyPortal.gov's public service vice description repository using the ATOM Interface (Loutas, Samp et al., 2008). The ATOM Interface is a graphical user interface designed to interactively browse hierarchically organised information spaces such a set of services. The artefacts used by the ATOM Interface was tailored in order to address the requirements of the Unified Service Model. Thus, as depicted in the figure below, a triangle corresponds to a service provider, a circle to a service while a square to a service version. The labels on the lines information resources exchanged between service collaborators. A citizens can browse the ATOM by clicking on the triangles and the circles in order to find services offered by some service provider. Once a service (square) is found, a menu with the following four options is made available to the user:

- *Show Inputs* to view the input documents that are necessary for the execution of the selected service and the operand resource providers that provide these documents (as shown in Figure 69).
- *Show Outputs* to visualize the follow-recipients of a specific service and the information that is being communicated to them.
- *Show Follow-up* to show all the services that can be or have to be executed (optional or mandatory) after the execution of the selected service.
- *Show Details* to present the detailed description of the selected service, by linking back to a specific XHTML page on MyPortal.gov.

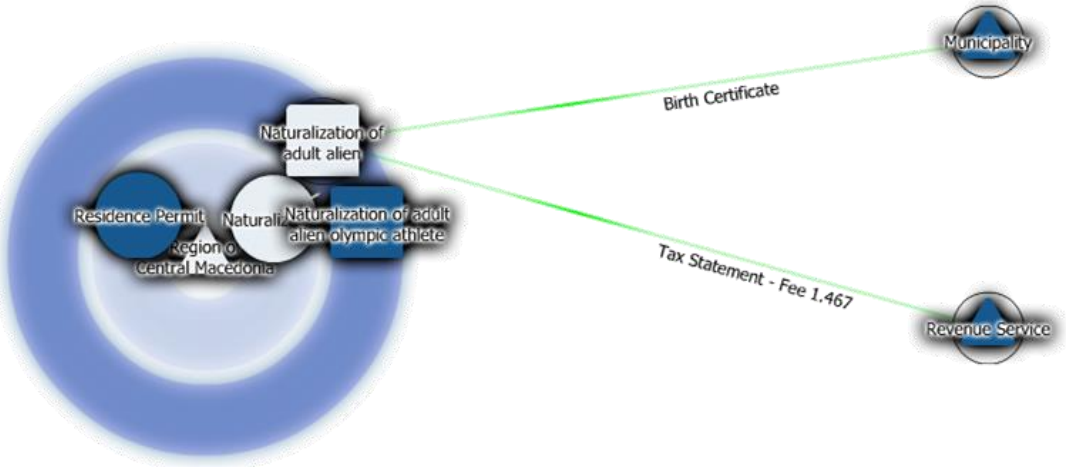

Figure 69: Implementation of the ATOM Interface in MyPortal.gov

5.3.2.2.4 Push service search in MyPortal.gov

MyPortal.gov is impelementing push service search based on service similarity and user behaviour logging. More specifically, the portal uses collaborative filtering-based recommendation mechanisms in order to suggest related public services based on the similarity of the service tag clouds. Following up on our modelling work of section 4.4.3.1, we consider two public services to be related, and hence being part of the same service bundle, when:

- they have common characteristics (i.e. input documents, service provider, tags etc) (connected with the relates to property);
- they are targeting the same audience or are addressing the same need;
- one provides input to the other (linked with the provides input to relationship);
- they are executed sequentially (one after the other) (linked with the executed after relationship).

In order to compute the similarity between services the algorithm proposed by (Specia and Motta 2007) is used again, but its outcome is reinforced also by data coming from the service description

browsing patterns calculated by the portal. The result is actually a bundle of related public services recommended to the citizen.

On the one hand, the algorithm of (Specia and Motta 2007) takes this times as input a matrix where the columns are vectors that correspond to service tag clouds. Similar to our example in the previous section, the angular separation is applied to those vectors, to compute the similarity between public services. If two vectors are similar, which means that the corresponding service tag clouds are also similar, then the services are considered to be related. The implementation of the algorithm is not explained in detail, as it follows the same steps as in the case of tag recommendation (see section 5.3.2.2.1). The only difference lies in the input, as in this case we use the service tag cloud while in the previous one we used the overall tag cloud.

On the other hand, additional related services may be identified by logging citizen's behaviour on the portal. MyPortal.gov monitors the citizen's behaviour and identifies patterns of service description browsing by computing the frequency of each pattern. For example, the description of the service "Issuing an identify card" was visited after the description of "Naturalisation of Adult Alien" or those citizens that viewed the service descriptions for "Issuance Identification Card" and "Naturalisation of Adult Alien" also viewed the description of "Issuing of a housing benefit". This metadata is also used for enhancing the public service description as they are used for defing "relates" relationships between services. In order to achieve this, during every session, the portal stores information that refers to the visited pages, the browsing order and a timestamp of each visit. Thus, information such as the date, the exact time when the citizen accessed the service description and the referrer (through which page the user accessed the current description) is kept. It should be clarified that all this information remains anonymous, thus protecting the personal data of the individual.

5.3.2.3 Evaluation

In order to evaluate MyPortal.gov, two evaluation cycles have been carried out. The main objective of the evaluation activities is to assess the overall quality of the portal's user interface and functionalities in terms of usability and usefulness.

First Evaluation Cycle. The first evaluation workshop was organised at the Ministry of Interior in Athens, Greece in mid February 2009. 20 people, both citizens and public servants, of different ages, genders and backgrounds participated in the workshop. Questionnaires were prepared and were handed out to the participants, who were encouraged to write their opinions after using the portal. The questions asked were partly based on the questionnaire proposed by (Henriksson, Yi et al. 2007). They included the following set of statements which had to be answered by assigning a weight starting from 1 (not at all) to 7 (very much):

1. I see the need and the benefits for developing of a social service platform for public administration, such as MyPortal.gov.
2. It was easy to find the needed public service.
3. I am satisfied with the keyword search of the MyPortal.gov.
4. I am satisfied with browsing public services using ATOM.
5. I am satisfied with the search via tag clouds.
6. I like the functionality of tagging public services.
7. I am satisfied with the public service recommendation mechanism of MyPortal.gov

Almost 89% of the participants liked the idea of implementing a social service platform for providing public services. More than 80% of the participants were very satisfied with the tag cloud browsing of the public service repository (Figure 70), while 60% of them liked very much browsing using ATOM. Approximately 90% of the participants found the tagging of public services very useful and seemed to comprehend its added value (Figure 71). Finally, 40% of the participants needed some help in order to use the portal and another 50% of them encountered some problems/faults while using it.

After the end of the first evaluation cycle, a list of fixes and recommendations was created, focusing mostly on improving the presentation of the service descriptions, simplifying the user interface and improving the accuracy of service recommendation and search. These were then incorporated in a new release of the portal, which was used during the second evaluation cycle.

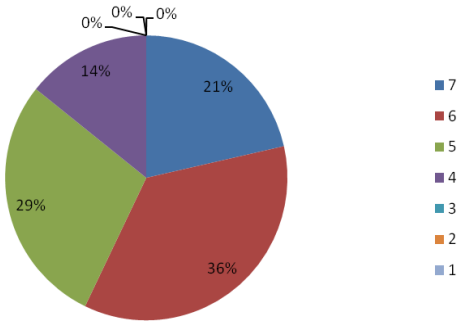

Figure 70: Distribution of answers to "I am satisfied with search via tag clouds".

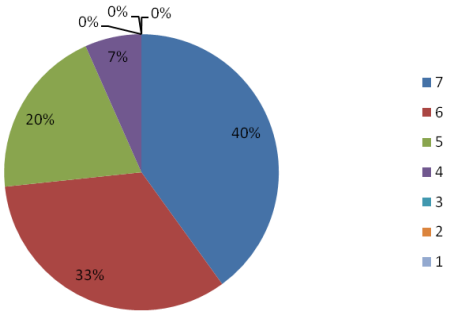

Figure 71: Distribution of answers to "I liked the functionality of tagging services".

Second Evaluation Cycle. The second evaluation cycle of the portal took place in early June 2009. It was organised by the Cypriot Ministry of Finance, where the portal was used in the context of a pilot study. 60 people participated in the evaluation. Around 69% of them already used at that time the national portal as an information channel for eGovernment, but would rather use MyPortal.gov.

This time a total of 14 questions grouped into three groups, regarding usability, usefulness and intention to use, were asked. The questions had to be answered by assigning a weight starting from 1 (not at all) to 7 (very much). We will discuss briefly the results per group of questions.

In terms of usefulness, more than 85% of the respondents agreed that the portal allows them to search for and find public service-related information faster and more efficiently through tagging and through service recommendation.

Regarding usability, approximately 75% of the respondents found it easy to use the portal without help. 59% of the respondents said that the advanced keyword search was very easy to use and a 65.6% answered that the tag cloud browsing was also very easy to use. We believe that the high adoption of the tag search is highly related to the fact that users are accustomed to similar functionalities, which are offered by all Web 2.0 platforms. Finally, the visual browsing using ATOM proved to be the less easy to use with a 36.1% (Figure 72).

In terms of intention to use the portal, the results that came out of the evaluation are very encouraging for our work. Approximately 87% of the participants replied that they would like using a Web 2.0 governmental service portal (Figure 73) and 81% said that they like being able to tag the public services that they use. They realised that this will allow them to find services more easily and that they will benefit from public service recommendation.

Approximately 82% of the public servants that participated in the evaluation, and played the role of content managers, said that they such a tool that would help them create public service description in a user-friendly way would be very useful.

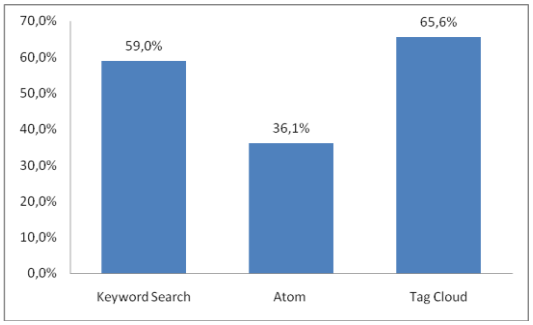

Figure 72: User satisfaction per way of public service search

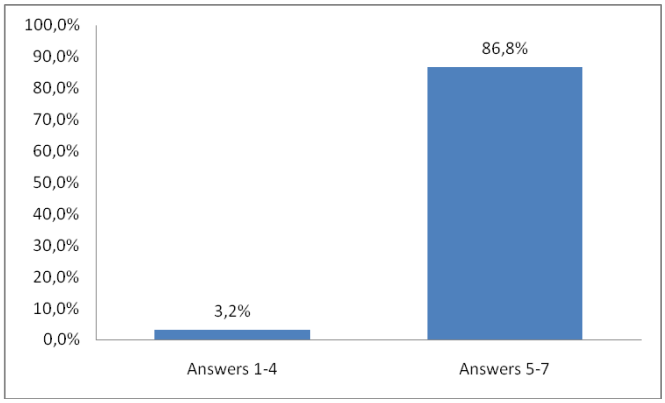

Figure 73: Distribution of answers to "Would you like using a Web 2.0 governmental portal?"

5.3.3 Semantic Service Search Engine (S3E)

Service provision on the Web follows a completely decentralised paradigm. Service providers make their services available online and advertise them on social (service) platform. MyPortal.gov presented in the previous section is such an example. Customers on the other hand browse the Web in order to find services that can address their needs. In the majority of the cases, service search is performed via traditional Web search engines, such as Google and Bing, as the use of central public registries for services has not taken up. Such Web search engines however do not utilise effectively the semantic descriptions of services. Hence, the need for service-specific search engines, which capitalise on and make use of the semantic descriptions of services in order to improve push and pull service search is evident. The architecture of such a semantic service search engine should follow the crawling approach of Web search engines.

In this vein, we developed the Semantic Service Search Engine (S3E) which proposes a uniform interface for finding semantic services on the Web based on the Unified Service Model and the Customer Service Model. More specifically S3E:

- Adopts a Web architecture and an approach that are independent of the semantic service model used. The system can crawl, identify and process all types of semantic services. It then uses the Unified Service Model to align the elements of different semantic service models in order to homogenise the collected semantic descriptions of services.
- Utilises the semantic descriptions of services to support pull service search and browsing mechanisms. More specifically, it offers advanced keyword search and service tag cloud browsing.
- Utilises the social descriptions of services to cluster and recommend related services to the users. It does so by identifying latent relationships between services based on service

similarity. It can thus recommend to the user related services or potential sequences of services, e.g. based on output-input relationships.

Figure 74 summarises the related work that is carried out in the fields of Web service and Semantic Web search engines. As shown there, there are significant efforts for searching Web services and Semantic Web content. Most of the search mechanisms that are presented by existing Web Service search engines, such as the ones organised in Figure 74, are based on matching the search keywords of users against the textual descriptions of the services without exploiting the availability of semantic annotations in the descriptions. Semantic Web search engines, such as SWSE and Sindice, make use of the semantic descriptions of content and data but leave services out of their scope. S3E bridges the gap between the two.

S3E's approach differentiates from similar approaches, e.g. (Li 2005; Klusch and Zhing 2008; Pedrinaci and Domingue 2010) which are targeting semantic services that implement a particular framework, e.g. the MSM in the case of (Pedrinaci and Domingue 2010). The S3E uses the mappings of different semantic service models to the Unified Service Model in order to support all of them as explained in section 5.2.2. In this respect, S3E is a generic and extendable solution that can provide access to effectively any sort of Web service described using any semantic service framework.

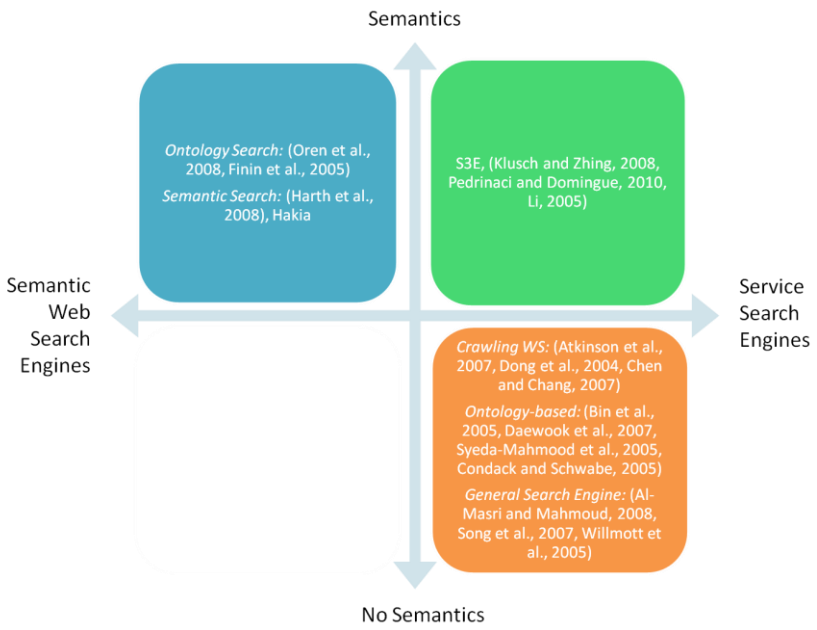

Figure 74: Overview of Service Search Engines

5.3.3.1 System architecture

S3E's approach comprises of the following three main phases:

- The crawling phase, during which semantic service descriptions that are published on the Web by service providers are retrieved by the Web crawlers of S3E and are stored locally in the system.
- The harmonisation phase when the semantics of every service description are transformed using the Unified Service Model. The harmonisation is based on pre-defined schema-level mappings between the Unified Service Model and, in the case of this pilot, SA-REST and SAWSDL.
- Finally, the search phase when the customers can query the underlying collection of harvested service descriptions, e.g. using keyword search or tag-based search, and find online services that meet their needs.

As shown in Figure 75, S3E is divided into two subsystems: the back-end subsystem and the front-end subsystem.

The back-end subsystem comprises of the Crawler and the Triple Processor. The Crawler is responsible for collecting the semantic services (e.g. SA-REST and SAWSDL) from the Web using the Fetch and Detect modules, harmonising them using the Unified Service Model as the common model using the Transform and Translation modules, and storing them in the RDF Repository using the Store Module. The Triple Processor is responsible for analysing the harvested and homogenised services and detecting similarities and latent relations between them.

The front-end subsystem offers an easy-to-use User Interface that allows submitting queries to the RDF Repository exploiting the Query evaluator, which translates the searches of the customers into SPARQL SELECT queries and then renders the results of those queries back to the User Interface, where they are displayed in HTML.

The technologies used for developing the User Interface are based on Java and Java Server Faces (JSF). Adobe Flash and Flex[43] were employed for the visualisation of the service execution sequence graph.

The RDF repository constitutes the common reference point between the back-end and the front-end subsystems. The triples that are stored in it have been extracted from the crawled service descriptions and have been mapped to the Unified Service Model and the Customer Service Model. More speficially, the following elements are demonstrated: *service input, service outcome, service provider, service feedback, service bundle* and *service relationships.* The RDF Repository has been implemented using the Apache JENA Framework[44].

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[43] http://www.adobe.com/products/flex.html
[44] https://jena.apache.org/

The following sections discuss both subsystems and their components in detail.

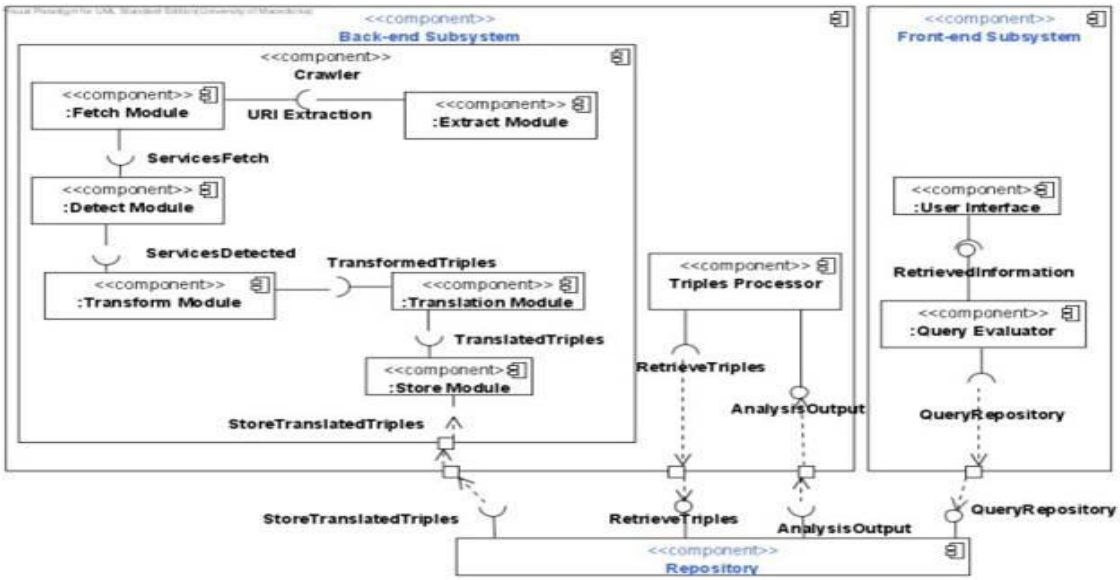


Figure 75: Architecture of S3E

5.3.3.2 S3E's Back-end subsystem

This section discusses in detail the components of the back-end subsystem and their main functionalities. The core components of the back-end are the Crawler and the Triple Processor.

5.3.3.2.1 Crawler

The crawler crawls a given set of URIs that is given as input to its Extract component. It then uses the Detect component to identify service descriptions, in our case SA-REST and SAWSDL services, within the harvested HTML pages. This is done by identifying any URIs, which can be possible URIs of semantic service descriptions, within the initial range of URIs. The Extract component can restrict the URIs by applying specific configurations, e.g. limiting search only to URIs with .gov extension.

More specifically, the crawler realises the algorithm of Table 36. The algorithm takes as input an initial set of URIs, i.e the Feed, and the number of Rounds for the crawling. The number of Rounds can be manually set, we experimented with a maximum of four rounds (see section 5.3.3.4) as our test set was known and finite. If applied on an unknown test set, the number of Rounds can be increased to ensure a more thorough exploration of the test set.

The type of search implemented by the algorithm is the Breadth First Search (BFS). This means that the algorithm begins with the Feed and then explores all the neighbouring URIs (i.e. all the URIs that can be directly reached from the initial URI). Afterwards, for each of the neighbouring URIs, it explores its unexplored neighbours, and so on until the given number of Rounds is reached. Given a branching factor β and a number of rounds ρ the time complexity of the algorithm is $|Feed| + |Feed| \cdot \beta_1 +$

$|Feed| \cdot в_2 + \ldots + |Feed| \cdot в_\rho$ that is $O(в\rho)$. This means that the time that the algorithm takes to complete is proportionate to the branching factor, as ρ is a constant.

Table 36: S3E's crawling algorithm

```
S3E Crawling (Breadth First Search)
In: Feed, Rounds //given as parameters set by the user
Out: set of URIs
URIs = Feed
toVisit= Feed
round=0
while round ≤ Rounds //until the given number of Rounds is reached
    fetchedURIs = ∅
    for each uri ∈ toVisit //for each URI that belongs to the Feed
        fetchedURIs = fetchedURIs ∪ fetchURIs(uri) //crawl the URI and add it to the
        set of fetched URIs
    end for
        toVisit = fetchedURIs //the neighbouring URIs of the fetched ones will be visited
        next
    URIs = URIs ∪ fetchedURIs
    round = round +1
end while
return URIs
```

Once the set of URIs has been collected, the crawler uses the algorithm of Table 37 for extracting the semantic information (if any) from the documents, e.g. HTML pages, identified by the URIs and stores it in the RDF Repository. Given a number of URIs υ the time complexity of the algorithm is $O(\upsilon)$, i.e. the time that the algorithms takes to complete is proportionate to the number of URIs.

Table 37: S3E triple extraction algorithm

```
S3E Tiple extraction algorithm
In: a set of URIs
Out: a collection of triples
For each uri ∈ URIs
        if uri contains semantic info //i.e. if it is an SA-REST or an SAWSDL file
                triples = extractRDF(uri) //exctract the triples from the semantic
                service descriptions
                translatedRDF = translate(triples) // harmonise the triples based on
                mappings to the Unified Service Model
                store(translatedRDF) //store the harmonised triples in the RDF
                repository
        end if
end for
```

The process of the algorithm is summarised as follows. First, the Fetch component takes as input the set of URIs. For each URI, it checks if the URI is accessible, i.e. the response is not a 404 error message, and then it fetches and stores all the information contained in the document identified by the URI. The Fetch component reused is SWSE's Fetch component (Dong, Halevy et al. 2004; Harth, Umbrich et al. 2006). If the extracted information contains any URIs, these are then fed back into the Fetch component and the same process is repeated recursively.

The Detect component is then responsible for specifying the type of the file that is going to be processed and for finding out if it corresponds to a semantic service, i.e. it is configured in order to recognise SAWSDL and SA-REST files. S3E can easily be extended to support other semantic service models as well. Consequently, the file types that the Detect component processes are (X)HTML pages and WSDL files (WSDL 2.0 descriptions are supported) corresponding to SA-REST and SAWSDL respectively (see also Table 38). The Detect component identifies the file type either from the extension of the URI or URL, e.g. .wsdl or .xhtml, or from the content type, e.g. text/html or application/wsdl+xml. After determining the file type, the Detect component explores whether the file contains semantic information. In case they do, the files are passed on to the Transform component.

Table 38: File types detected by the Detect component

File Type	Content type	File Extension
HTML	text/html	.html, .htm
XHTML	application/xhtml+xml	.xhtml
XML	Text/xml	.xml
(SA)WSDL	application/wsdl+xml	.wsdl

The Transform component extracts the semantic information, e.g. information about service input, outcome, service provider, service feedback expressed as tags, related services etc., from the semantic descriptions of services in the format of RDF triples. These triples use predicates from the semantic service model used per case (i.e. SA-REST or SAWSDL). For example, the following SA-REST definition: is transformed to the RDF triple: < http://islab.uom.gr/DrivingLicense SA-REST:hasInputMessage http://islab.uom.gr/ID> (see also Table 39).

The Translation component is responsible for converting the RDF triples created by the Transform component to triples that are aligned with the Unified Service Model, and the Customer Service Model

for service feedback. It uses adaptors which are implementing pre-defined schema-level mappings and transformations between the Unified Service Model and the Customer Service Model and, in the case of this pilot, SA-REST and SAWSDL. Note that the SA-REST service descriptions used in this pilot are actually the machine-readable semantic service descriptions published by MyPortal.gov. Based on the existing adaptors for SA-REST and SAWSDL we could develop others to support any semantic service framework, hence the genericity and the extensibility of the S3E.

The Store module is responsible for the communication with the RDF Repository where the translated, i.e. the harmonised, triples are stored.

Table 39: The translation from different semantic service models to the Unified Service Model and the Customer Service Model

Before translation phase
SA-REST
< http://islab.uom.gr/DrivingLicense **SA-REST:hasInputMessage** http://islab.uom.gr/gea.owl#BirthCertificate>
< http://islab.uom.gr/DrivingLicense **SA-REST: hasInputMessage** http://islab.uom.gr/gea.owl#License>
SAWSDL
<http://www.w3.org/2002/ws/sawsdl/spec/wsdl/order **sawsdl:input** http://www.w3.org/2002/ws/sawsdl/spec/ontology/purchaseorder#OrderRequest>
After translation phase
< http://islab.uom.gr/DrivingLicense **dcterms:requires** http://islab.uom.gr/gea.owl#BirthCertificate>
< http://islab.uom.gr/DrivingLicense **cpsv:produces** http://islab.uom.gr/gea.owl#License>
<http://www.w3.org/2002/ws/sawsdl/spec/wsdl/order **dcterms:requires** http://www.w3.org/2002/ws/sawsdl/spec/ontology/purchaseorder#OrderRequest>
NOTE: In the RDF implementation of the Customer Service Model, the dcterms:requires RDF property is reused for implementing the requires property (see section 4.3.4.1), and the cpsv:produces RDF property is reused for implementing the produces property (see section 4.3.4.2).

5.3.3.2.2 Triple Processor

As discussed in the previous section, the crawler creates a collection of semantic services which are then decomposed into a set of harmonised triples that follow the Unified Service Model and the Customer Service Model. The Triple Processor is responsible for analysing those triples and detecting relationship between them, thus resulting in the definition of service bundles. Three types of service relationships are identified:

- *relates to* which is used in this case in order to express a generic relationship between two services, which may mean that the two services: *(i)* target the same audience; *(ii)* address the

same need; *(iii)* are provided by the same provider; and *(iv)* are complementary – i.e. they have to/should be executed together in order to satisfy a customer's need.

- *provides input to* which is used to express cases when a service has to be executed prior to another one in order for the outcome of the first to be used as input for the second. For example, before receiving a bank loan, an SME needs to execute a public service provided by the Company Register to confirm that it is a registered legal entity. The outcome of this service is then provided as input to the bank loan service.
- *executed after* which is used in situations when a service has to be executed after another one. Executed after indicates a special case of complementary services where their execution sequence is well-defined. For example, after setting up a new company, the customer must also register the company in the Company Register.

Hence, we are using *relates to* to group together similar services, while *provides input to* and *executed after* are used in order to detect and model execution sequences of services. The results of both processes are stored as triples in the RDF repository and can easily be consumed by the front-end subsystem. In the remainder of this section we explain the functionalities of the Triple Processor.

The first of the functionalities offered by the Triple Processor is the detection of *service execution sequences*. A service can be part of a chain of services which models a possible sequence for executing a set of services (crf. *provides input to* and *executed after* relationships). These sequences are therefore computed by analysing the inputs and outcomes of the harvested services.

Let $S1$, $S2$ be two semantic services and $\exists\, out1 \in O1,\ in2 \in I2$ so that $out1 = in2$, then we assume that $S1$ is a *direct predecessor* of $S2$ (and consequently $S2$ is a *direct successor* of $S1$), denoted as $S1 \rightarrow S2$. In other words it holds $S1 \rightarrow S2$ if there exists at least one outcome of $S1$ that is also an input to $S2$. If a path made up of one or more successive direct predecessor/ successor relations leads from $S1$ to $S2$, then $S2$ is said to be a successor of $S1$, and $S1$ is said to be a predecessor of $S2$.

Taking into account the above definition the service sequences can be depicted in a directed graph (service execution graph). The service execution graph is a pair $G = (V,E)$ where V is a set of services and E a set of edges (i.e. direct predecessor/successor relations). This graph may contain cycles.

For example, assume four semantic services $S1$, $S2$, $S3$ and $S4$. Let the inputs and outcomes of the services be: $I1=\{a,b\}$, $O1=\{c\}$, $I2=\{c,d\}$, $O2=\{e\}$, $I3=\{c,f\}$, $O3=\{g\}$, $I4=\{g, h\}$ and $O4=\{a\}$. Then $S1$ is a direct predecessor of $S2$ and $S3$, and $S3$ is a direct predecessor of $S4$. Moreover, $S1$ is a predecessor of $S4$ but also $S1$ is a predecessor of itself (a cycle exists). The service execution graph is shown in Figure 76.

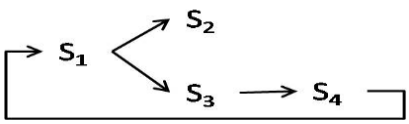


Figure 76: Example of a service execution graph

The Triple Processor realises the algorithm of Table 40. The algorithm takes as input the set of all Services (represented as nodes in the graph and comprising all harmonised triples that contain information about service inputs and outcomes). The output produced by the algorithim contains the set of all the Edges (i.e. direct predecessor/successor relations). The algorithm examines every service Si and checks if there exists a relation with another service *Sj (i≠j)*. This check is carried out through the traversal of the inputs and outcomes of both *Si* and *Sj*. Given the number of inputs $|I|$, the number of outcomes $|O|$ and the number of services $|S|$, the time complexity of the algorithm is $O(|S|^2 \cdot |I| \cdot |O|)$.

Table 40: S3E service execution sequences detection algorithm

Detect service execution sequences In: Services *(all triples containing information about inputs and outcomes)* Out:Edges *(a graph modelling the service execution sequence)*

Edges = ∅
for each S1 ∈ Services
  for each S2 ∈ Services
  if (∃ in1 ∈ I1, out2 ∈ O2 s.t. out2 = in1) *//identification of an outcome-input relationship*
  Edges = Edges ∪ (S2 → S1) *//add relationship to the service execution graph*
  end if
  if (∃ out1 ∈ O1, in2 ∈ I2 s.t. out1 = in2) *//identification of an input-outcome relationship*
  Edges = Edges ∪ (S1 → S2) *//add relationship to the service execution graph*
  end if
  end for
end for
return Edges

An important aspect of the algorithm is the determination of the equality between parameters (e.g. *out2 = in1*). The simplest solution is to use string equality. The problem with this solution is that naming is dependent on the developers' whim (i.e. synonyms, different naming rules, misspelled etc.). Another solution is to define classes of equivalence, in this case the parameters that belong to the same class are considered to be equal.

In order to define the classes of equivalence many methods can be exploited. One method is to use a lexical database (e.g. WordNet) or DBpedia to detect synonyms, hyponyms, hypernyms etc. Another solution is to use the edit distance[45] between the string representations of the parameters as equivalence metric. At this case a class will contain parameters that have an edit distance among them smaller than a threshold. (Dong, Halevy et al. 2004) propose to cluster the parameters into classes based on their co-occurrences (i.e. parameters tend to express the same concept if they occur together often). (Sánchez, Batet et al. 2010) propose a similarity method based on an ontology that can also be used to define the classes of equivalence. Finally, methods used for ontology mapping, e.g. (Kwon, Choi et al. 2006; Mocan A., Facca A. et al. 2009), can be used to define the classes of equivalence.

In our work, we experimented initially with simple string matching and then with lexical database-based methods using Wordnet and DBpedia in order to improve the accuracy of the equality between terms representing service inputs and outcomes.

The second functionality offered by the Triple Processor is the detection of *similarities among services*. This functionality supports the recommendation of related services. The related services for a specific service are computed by applying a similarity measure to service descriptions. Different approaches for calculating the similarity of two services exist. For example, in section 5.3.1, we explained how to calculate the similarity between two services, by representing them as vectors comprising a set of terms coming from their semantic descriptions and then calculating the angular separation of the terms in the vectors.

In the case of the Triples Processor, the ratio model of (Tversky 1977) has been used in order to calculate the similarity between two services. Tversky introduced two categories of similarity measures:

- namely the contrast model, where the similarity of two concepts *C* and *D* is a linear function; and
- the ratio model, where the similarity is expressed as a fraction (see Equation 1). Different values for α and β determine a different similarity measure, and similarity is in the range [0..1].

[45] The distance between two strings $x=x_1...x_n$ and $y=y_1...y_n$,(denoted as $d_{edit}(x,y)$) is defined as the minimum number of atomic edit operations (insert, delete, replace) needed to transform string *x* into string *y*.

Equation 1: Tversky's ratio model

$$sim(C,D) = \frac{f(ftrs(C) \cap ftrs(D))}{f(ftrs(C) \cap ftrs(D)) + af(ftrs(C) \setminus ftrs(D)) + b(f(ftrs(D) \setminus ftrs(C))} \quad \text{where } \alpha,\beta \geq 0$$

We use the ratio model in order to compute the similarity between two service descriptions. More specifically, we assume that *a*=*b*=0.5 there is no asymmetry in the measures that we apply. Hence, the formula of Equation 1is transformed as shown in Equation 2, where *C* and *D* represent two concepts while *ftrs(C)* is the set of features that characterise concept *C*. *f(.)* is the count of the set.

Equation 2: Tversky's ratio model where a=b=0.5

$$sim(C,D) = \frac{2 \times f(ftrs(C) \cap ftrs(D))}{f(ftrs(C)) + f(ftrs(D))}$$

Therefore, we represent each service as a collection of sets (clusters created using the approach discussed in section 5.3.1.5) organised by different elements of service. In the case of the S3E, our focus is on service provider, service input, service outcome and service feedback, hence the service is represented as follows: $\mathcal{S} = \langle S_{\mathrm{P}}, S_{\mathrm{I}}, S_{\mathrm{O}}, S_{\mathrm{F},\ldots} \rangle$. The similarity between two services can be calculated using these sets. Equation 3 shows how Equation 2 is transformed in order to calucalte the similarity between a service C and a service D.

Equation 3: Calculating the similarity of two services based on the service descriptions

$$sim(C,D)_{providers} = \frac{2 \times (f(inputs(C) \cap inputs(D)) + f(outcomes(C) \cap outcomes(D)) + f(providers(C) \cap providers(D)) + f(feedback(C) \cap feedback(D)))}{f(inputs(C)) + f(outcomes(C)) + f(providers(C)) + f(feedback(C)) + f(inputs(D)) + f(outcomes(D)) + f(providers(D)) + f(feedback(D))}$$

Where:

- f(.) is the count of the set, i.e. the number of elements in it;
- inputs(.) is the set of service input(s) required by a service;
- outcomes(.) is the set of service outcome(s) produced by a service;
- providers(.) is the set of service providers for a service; and
- feedback(.) is the set of customer-driven tags for a service.

For the computation of the set of tags, we take into account the information that concerns the frequency of the tags. For example, if a service C has been tagged with the word “marriage” 150 times, and a service D has been tagged with the same word only 2 times, then the similarity between these two services will be considered trivial.

At this point, it is important to note that the value that is the boundary in order to decide whether two services are related is computed empirically. With regards to the services that are available in our repository, the value of this boundary is approximately 0.4. This means that if the similarity measure

between two services is lower than 0.4, then the two services are considered non-related. On the contrary, if the measure's value is equal or greater than 0.4, then the two services are considered related, as shown below.

Equation 4: The boundary for deciding on the similarity of services

$$sim(C,D)\begin{cases} < 0.4, non-related \\ \geq 0.4, related \end{cases}$$

Summarising, the Triple Processor exploits the algorithm of the table below for the computation of the similarity among the services. The algorithm traverses all the services and computes the similarity among them. The time complexity of the algorithm is $O(|S|^2)$, where $|S|$ is the number of services.

Table 41: S3E service similarity algorithm

Detecting service similarity In: Services Out: similarity in SimServ (Sx)

SimServ (Sx) = ∅
For each S1 ∈ Services
  for each S2 ∈ Services
  computeSimilarity(S1, S2) *//based on Tversky's ratio model*
  SimServ (S1) = SimServ(S1) ∪ S2 *//add similar service to the set*
  end for
end for
Return SimServ(Sx)

Note that both functionalities offered by the Triple Processor are independent of the underlying semantic service model because the analysis is performed on the translated RDF triples that follow the Unified Service Model and the Customer Service Model. Thereafter, the system enables the detection of possible execution sequences and the detection of similarities among services that were initially encoded using different semantic service models.

5.3.3.3 S3E's Front-end subsystem

S3E's front-end exposes the following functionalities to the citizens:

Basic search for a service using keywords. S3E allows the search for a service given a set of keywords, i.e. the citizen can use her own search of keywords in order to query the collection of services harvestd by the S3E. The keywords may describe the service's input, outcome, service provider, need, or service feedback. This information is extracted from the information stored in the RDF repository, i.e. the harmonised collection of triples. In Figure 77 a screenshot of the search and the retrieved results are depicted. The returned result-set contains a list of services that match the search (bold letters are

used to indicate the matches). By selecting a service from the list, the user can view detailed information for the specific service.

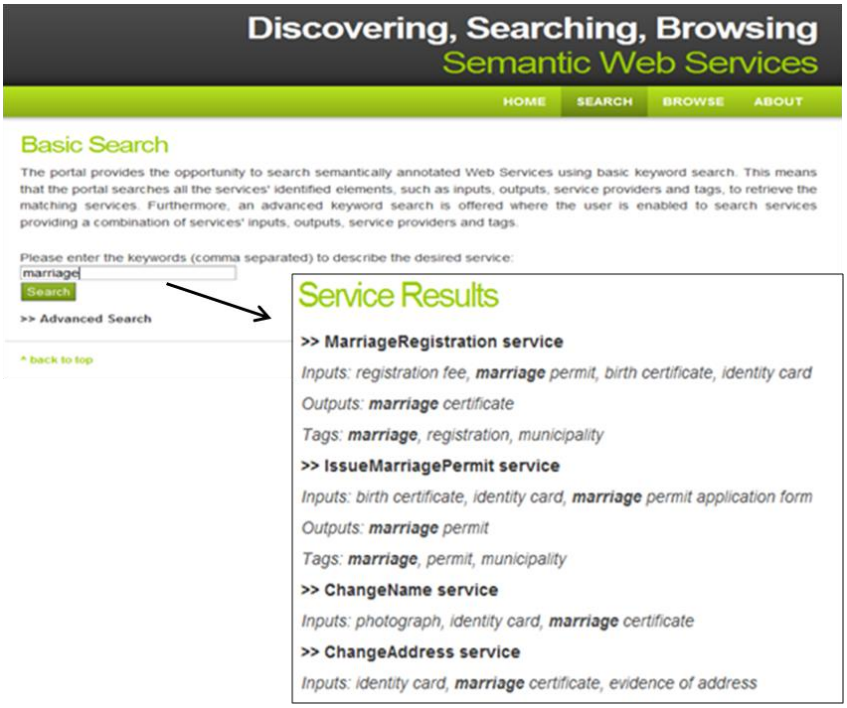


Figure 77: Basic search for services

An advanced search functionality is also available, which extends the basic search by enabling the use of complex logical expressions using AND and OR expressions operators (see Figure 78).

Figure 78: Advanced search of services

In this case, the main advantage of using the S3E is the ability to search from a single point of access for services which are physically scattered on the Web, published on the Web sites of their service providers. In addition to making service search more efficient in terms of effort and time, S3C also

reduces the service discovery gap, as citizens do not need to get accustomed to the vocabularies of different providers, but only to the one put forward by the Unified Service Model and the Customer Service Model, which is implemented on the S3E.

Browsing services using tag clouds. S3E allows citizens to search for services by browsing three different types of tag clouds (see also Figure 79):

- *Input tag cloud*, which contains all the tags that represent the inputs required by the harvested services. The tags come directly from the customers and by clustering the provider-oriented descriptions of the services (see section 5.3.1.5). The popularity of a tag, expressed by its font size, indicates the number of services that are requesting a specific input.
- *Outcome tag cloud*, which contains all the tags that represent the outcomes produced by the harvested services. The tags come directly from the customers and by clustering the provider-oriented descriptions of the services (see section 5.3.1.5). The popularity of a tag, expressed by its font size, indicates the number of services that are producing a specific outcome.
- *Provider tag cloud*, which contains all the tags that denote the service providers of the harvested services. The tags come directly from the customers and by clustering the provider-oriented descriptions of the services (see section 5.3.1.5). The popularity of a tag, expressed by its font size, indicates the number of services that a specific service provider is providing.

The information used in order to create the tag clouds is extracted from the RDF Repository. By selecting a tag in the tag clouds, the list of services that are annotated with this tag is returned.

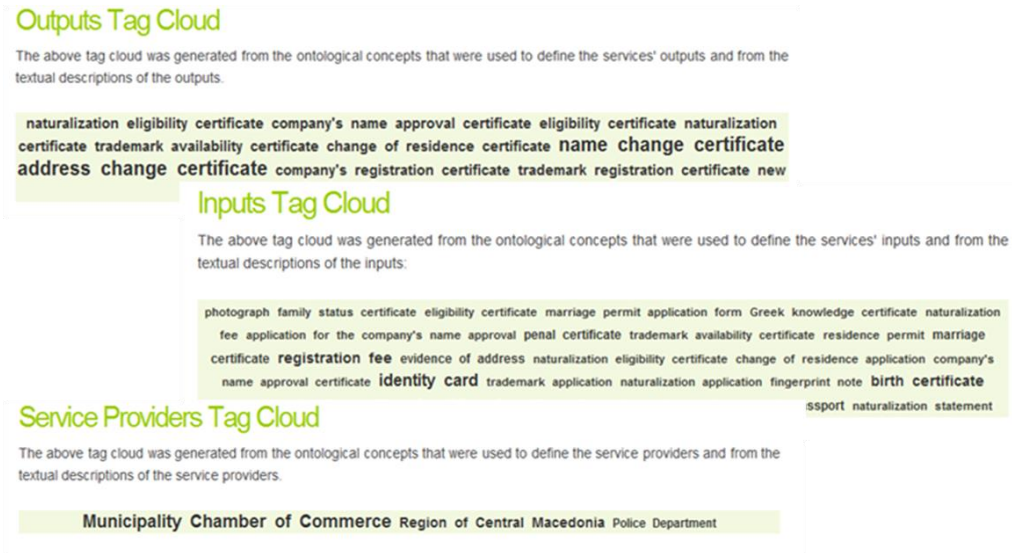


Figure 79: S3E's tag clouds

Viewing execution sequences of services. S3E's front-end visualizes the service execution sequences (i.e. the service execution graph defined in section 5.3.3.2.2). The information needed for the

visualisation is calculated by the Triple Processor using the SPARQL SELECT QUERY of Table 44 and is stored in the RDF repository. As shown in Figure 80, the *MarriageRegistration* service requires as input the marriage permit that is produced as outcome by the *IssueMarriagePermit* service. On the other hand, the services *ChangeName* and *ChangeAddress* require as input the marriage certificate that is the outcome of the service *MarriageRegistration*.

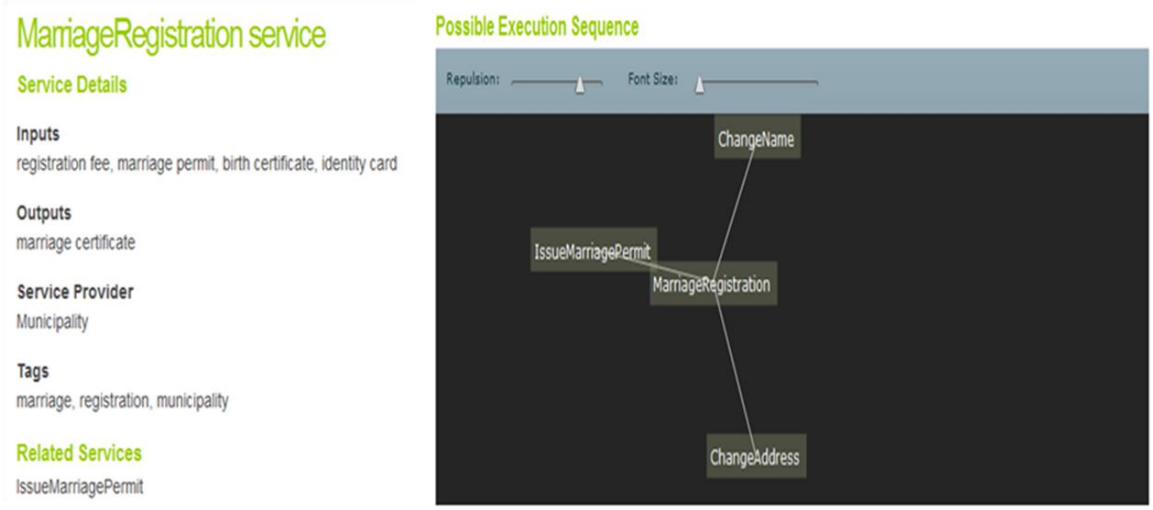


Figure 80: The MarriageRegistration service

Adobe Flash and Flex were used in order to implement the visualisation of the service execution sequences. This required to transform the RDF relationships into an XML format that could be imported and processed by these programming frameworks.

Viewing related services. Section 5.3.3.2.2 presented the way that the Triple Processor is calculating the similarity between two services using the SPARQL SELECT QUERY of Table 45. The similarity measure is utilised by the front-end subsystem to suggest services to the customer. Hence, the customer is capable of viewing in a service's report a list of related services that may be of interest. For example, the *IssueMarriagePermit* service has many common elements, e.g. common provider, addressing the same need and audience etc., with the *MarriageRegistration* service; consequently they have a high similarity. Thus, the two services are related and this information is presented in the corresponding report (see Figure 80).

The front-end subsystem provides the means for utilising the information stored and pre-processed by the back-end subsystem. The front-end subsystem comprises of the User Interface and the Query Evaluator.

5.3.3.3.1 User Inteface

The User Interface collects the user's search criteria and forwards them to the Query Evaluator which is responsible for the communication with the RDF repository. Moreover the User Interface is responsible for presenting the search results back to the user.

The User Interface realises three types of tag clouds based on service input, output and provider in order to facilitate service browsing. Thus, the User Interface communicates with the Query Evaluator in order to retrieve from the RDF Repository the information required to generate a tag cloud.

5.3.3.3.2 Query evaluator

The Query Evaluator decouples the User Interface from the tasks related with the communication with the RDF Repository. Thus, changes to the repository will not have any effect on the User Interface. The Query Evaluator is responsible for transforming the user's search criteria, e.g. keywords, into SPARQL SELECT queries, forwards these queries to the RDF Repository and returns the results back to the User Interface. The queries are formed based on pre-defined template SPARQL SELECT queries, which are populated with the search keywords entered by the users.

In the case of basic search, the keywords are checked against the values of all the properties of a services, e.g. name, descriptions, input, outcome, service provider, service feedback (i.e. tags). The SPARQL SELECT query supporting basic search is presented in Table 42.

In the case of advanced search (see Figure 78), the user has the ability to limit the search by forming complex queries using a selection service properties, e.g. name, descriptions, input, outcome, service provider, service feedback (i.e. tags), and the logical operators AND and OR. In this case, the condition of the SPARQL SELECT query created by the Query evaluator reflects the search criteria selected by the user (i.e. it would be a subset of the WHERE condition of the query shown in Table 42.

Table 42: SPARQL SELECT query for basic search

SPARQL is a query language that allows querying semantic repositories, i.e. RDF stores (W3C RDF Data Access Working Group 2013). SPARQL is a W3C recommendation. SPARQL's syntax is intuitive and quite similar to that of (SQL). However, its features are still quite limited compared to the features provided by SQL.

The code snippet below shows an example of a SPARQL SELECT query, which retrieves the URIs of the public services that correspond to the keywords provided by the user.

```
SELECT DISTINCT ?service
WHERE {
  ?service is a csm:Service.
OPTIONAL{
  ?service dcterms:title ?title.
  ?service dcterms:description ?description.
  ?service dcterms:requires ?input.
  ?service cpsv:produces ?outcome.
```

```
  ?provider csm:participatesIn ?service.
  ?provider csm:participatesInAs http://islab.uom.gr/csm/service-agent-roles/ServiceProvider.
  ?service csm:receives ?feedback.
FILTER (regex (?title, ?keyword) || regex(?description, ?keyword) || regex (?tags, ?keyword) || regex
((str(?input), ?keyword)) || regex ((str(?outcome), ?keyword)) || regex ((str(?provider), ?keyword))
}
```

The Query Evaluator is also used for the generation of the detailed service reports, i.e. retrieving all information about a service (see Table 43), the retrieval of the service execution graph (see Table 44) and the retrieval of the related services (see Table 45).

Table 43: Retrieving all triples related to a specific service from the RDF store

```
SELECT ?service ?p ?o
WHERE {
  ?service is a csm:Service.
  ?service ?p ?o.
}
```

Table 44: Retrieve the service execution graph for a service

```
SELECT ?service1 ?p ?service2
WHERE {
  ?service1 is a csm:Service.
  ?service2 is a csm:Service.
  OPTIONAL {
  ?service1 csm:providesInputTo ?service2.
  ?service2 csm:executedAfter ?service 1.
  }
}
```

Table 45: Retrieve related services

```
SELECT ?service1 ?p ?service2
WHERE {
  ?service1 is a csm:Service.
  ?service2 is a csm:Service.
  OPTIONAL {
  ?service1 csm:providesInputTo ?service2.
  ?service1 csm:executedAfter ?service2.
  ?service1 dcterms:relation ?service2.
  ?service1 csm:substitutes ?service2.
  }
}
```

5.3.3.4 Evaluation

The objectives of S3E's evaluation are to:

- Measure the number of URIs collected by the crawler.
- Evaluate the validity/correctness of the service execution sequences and the similarities calculated by the Triple Processor.

The number of SAWSDL and SA-REST services available on the Web is limited because both standards are relatively new, thus the services that are available are mainly sample services. In addition to these, we also used a test-set of 11 SA-REST-annotated eGovernment services from MyPortal.gov.

A large SAWSDL service test collection also existed, but they follow WSDL1.1, so they cannot be processed as is by S3E. We transformed the files to WSDL 2 using the Woden converter[46], but half of the files created were not valid WSDL 2 files and the others did not contain the appropriate semantics defined by the SAWSDL standard. So the test collection was finally not used.

Figure 81 shows the number of URIs collected by the crawler, starting from the initial test set, taking into account the number of rounds for the search as defined in the algorithm of Table 36. The number of URIs grows exponentially related to the number of rounds.

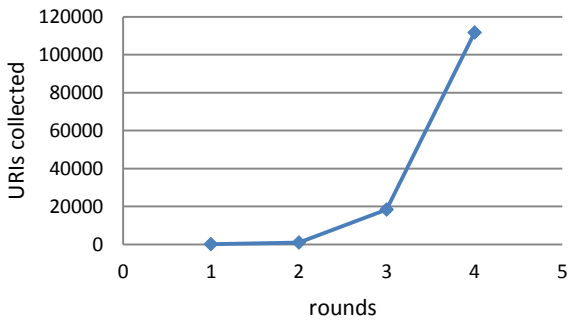


Figure 81: Number of URIs collected related to number of rounds

Finally, we conducted a quality evaluation of the system in order to examine whether the S3E Triple Processor detects successfully the service execution sequences and the similarities among the services. For the quality evaluation we used the SA-REST test set. Manually analysing the test set, we found out that it contained 3 different service execution graphs. Moreover, some of the SA-REST services share common input/output/ provider values so it is highly possible to be related with each other. The Triple Processor successfully detected all the possible service execution graphs. It also computed correctly and accurately the similarity between the services of the SA-REST test set (i.e. the RDFa annotated service descriptions from MyPortal.gov).

[46] http://ws.apache.org/woden/index.html

5.4 Demonstrating the Unified Service Model and the Customer Service Model for service personalisation

Being able to search for the services that may address ones needs and finding a description of those services, which will help the customer decide whether she finally wants to consume the service or not, is only the beginning of the service lifecycle from the customer viewpoint (see also section 3.2.3). As dicussed in section 4.4.3.5, services have high variability and the same service maybe provided in different versions in order to be adapted to the specific needs and requirements of customers with different profiles. It is therefore necessary for a customer to personalise the service and identify the specific service version, which she can eventually consume (see also section 3.2.3.3).

Service personalisation entails the matching of the profile of a customer against different service versions in order to detect the appropriate one. The customer's profile can either be stored in a knowledge-base or can be dynamically created.

The pilots presented in the following sections follow the latter approach, as we believe that pre-defining all the different parameters of profiles of potential customers is an overkill and one may never be complete. Towards this direction, we capitalize on existing work from conversational recommender systems (Mahmood and Ricci, 2009) that exploit dialogues (i.e. a sequence of questions and possible answers) to interact with the user.

Our pilots aim to guide customers through the personalisation of a desired service following a dialogue-based approach, which allows to:

- To inform a customer whether she is eligible for a specific service; and
- To identify the specific public service version that matches the profile, needs and requirements of the customer.

The remainder of this section is structured as follows: in section 5.4.1 we present the model and the approach for creating customer dialogues. We then implemented this approach following first a purely Semantic Web based implementation (see section 5.4.2) and then a hybrid approach combining expert system with Semantic Web technologies (see section 5.4.3). The main difference lies in the implementation of service rules, as in the first case, those are expressed as SPARQL SELECT queries, while in the second one as Prolog rules. Through the evaluation of both approaches, we observed that despite the different technologies, the implementation costs and the benefits delivered to the customer are in fact comparable.

5.4.1 A dialogue-based approach for service personalisation

In order to decide on the appropriate service version, information regarding the profile of the customer needs to be collected. To formulate our approach, we have been influenced by existing work on *conversational recommender systems* (Thompson, Göker et al. 2004) that exploit dialogues (i.e. a sequence of questions and possible answers) to interact with the users. In our case this happens by means of a structured dialogue between the personalisation system and customer. We are using a a *system-initiative dialogue* (James, Donna et al. 2001; Larsson 2002), where the systems prompts the customer and based on the customer's answer the next question is selected. This is done iteratively until an end state is reached. Customer-dialogues have been heaving exploited in the e-Government field, e.g. Loutas et al. (2011), Tambouris et al. (2009), Tambouris & Tarabanis (2008).

The aim of the dialogue is to assist the customer to personalise the service and identify the specific service version through a set of questions which are answered using information collected by the potential customer.

Table 46: Benefits of the dialogue-based approach

Why a dialogue-based approach?

Sonntag et al. (2002) introduce the following classification of methods for collecting the customer's characteristics (i.e. building the customer's profile) in a system:

- Dialogue methods (Larsson, 2002, James et al., 2001) explicitly ask the customer for his/her preferences. A dialogue can be system, customer or mixed initiative (Chu-Carroll, 2000), where the system, the customer or both are in control of guiding the dialog at each step.
- Collaborative Filtering methods (J. Ben Schafer, 2007, Renckes et al., 2010), where many customers rate the content and according to these ratings customers are clustered into groups with similar profiles.
- Customer behavior tracking methods (Mobasher et al., 2000), e.g. observing where does the customer click, how long does he/she remain on certain pages etc.
- Statistical Profile methods (Chen et al., 2007), where only a few general questions are presented to the customer and according to statistical profiles, the customer is placed under a certain category.

Dialogue methods are more accurate because preferences are collected directly from customers. They require however more interaction with the customer, whereas the other methods require less or no direct interaction (i.e. customer behavior tracking). In those cases though the results are less accurate, because the customers' preferences are elicited from hypothesis and customer clustering. Moreover, these methods have the "cold start" problem where the system cannot draw any inference until sufficient amount of information has been collected (see also section 5.3.1.5).

Most of existing service personalisation approaches follow dialogue methods to build the customer's profile. An important factor related to the dialogue method adopted each time is the minimisation of the customer's burden by decreasing the number of dialogue steps i.e. questions asked. Ravindran et al. (2002) propose a management framework for enabling and automating the delivery of personalised services, where a set of rules are validated against the client's profile that is built following a dialogue method. No effort is spent however on the minimisation of the dialogue's steps and the definition of a formal methodology to create the rules is out of their scope. Stollberg and Muth (2009) separate the personalisation process into three steps, the design of the service model, the definition of variable aspects of the service and the assign of values

to the variables that is conducted in an interactive fashion (i.e. dialogue). Their methodology is based on data models for each of the three steps, but they do not deal with the dialogue minimisation at all.

Yu et al. (2005) define an agent-based architecture for a personal information retrieval system based on semantic technologies. The customer defines her requirements and preferences through a dialogue and then the agent is responsible for the personalisation. This approach may suffer due to the incomplete information collected by the agent, which may lead to inaccurate conclusions or may require extra interactions with the customer.

Hybrid approaches have also been developed. Kravčík and Gašević (2006) propose an architecture for adaptive hypermedia that exploits a customer model built using a dialogue, by tracking the customer's behaviour. Chen et al. (2010) propose a framework for personalizing a portal. It collects two types of data: the customer's characteristics through a dialogue and the customer's behavior by tracking her behavior. Xuetao and Jie (2007) propose an approach for handling e-Government service recommendation using a combination of semantic similarity and collaborative filtering. Finally, Schmidt et al. (2008) propose a client-based method for personalisation based on a rule engine. The client directly executes all necessary adaptation based on a customer profile that is created by tracking the customer's interactions. All these approaches require less direct interaction with the customer compared with the dialogue method, since they collect information from the customer by tracking her behavior or by clustering the customers. Their accuracy however has proven not to be as good.

Assuming the dialogue method, the dialogue flow (i.e. the question order) can follow different strategies. The Finite-state machine (McTear, 1998) models the questions of the dialogue and the transitions between them. The sequence of the questions is explicitly predefined. The Frame-based (Bobrow, 1986) strategy is more flexible and uses the frame structure with slots for the data (e.g. an age slot). The slots can be filled in any order so there is not a predefined question order.

In our work we are following a hybrid frame-based approach. First, the customer dialogue asks all questions related to eligibilityrules and then those related to service variant rules. This decision was based on two factors: (i) this way the sequence of questions makes more sense to the customer, as one starts from generic to specific; (ii) we observed that this approach leads to shorter customer dialogues, e.g. less questions asked, particularly when the customer is not eligible for the service.

In a nutshell, the approach, which will be detailed in the remainder of this section, is summarised as follows: Service versions are modeled and encoded using eligibility and service variant rules (see section 4.4.3.4). As discussed and modelled in detail in section 5.4.1, both types of service rules are then associated with questions and are implemented in a rule engine which performs the dialogue. Information collected during the dialogue is used for validating the business rules. The ones that are finally validated point to the appropriate service version.

We propose the following steps for the acquisition of knowledge, i.e. collecting and eliciting information about service rules and formally expressing it, in order to define the eligibility and the service variant rules:

- Service analysis;
- Expression of the service rules in structured language;
- Formalisation of the service rules and visual representation of the formal expression; and

- Definition of the associated questions and answers to validate each of the service rules.

A run-through example is used in order to illustrate each step. It refers to the Naturalisation public service, which is offered by the regional authorities in Greece to all aliens that wish to acquire the Greek citizenship. Depending on the profile of the applicant, Naturalisation boils down to approximately 40 different service versions, e.g. a different version of the service is available to EU citizens compared to the one for people coming from the former USSR, and a total of 60 eligibility and service variant rules. The service versions vary in terms of profiles of prospective customers, service input and service activities. The rest of this section demonstrates how the business rules responsible for determining the eligibility of the client and for selecting the appropriate version are defined. The detailed documentation of the service following the Unified Service Model and the Customer Service Model is available in Annex II.A.

Service analysis. During the *service analysis* phase information is collected regarding the profile of customer, service input, service outcome, service activities and the service rules. This information is extracted from the documentation of the (public) service, e.g. relevant laws and directives, for the case of public services, and interviews with experts. This information has a multi-purpose use:

- To identify the different service versions and create a comprehensive and well-structured description of each one.
- To document in natural language the eligibility and service variant rules which differentiate the service versions. The rules should be atomic, i.e. not break down into simpler ones, and unambiguous.
- To identify the characteristics of the profile(s) of customer(s). For example, based on the identified service rules, the profile of alien must comprise a property for the conviction state (e.g. convicted/not convicted), one for the marital status, a property defining the citizenship of her spouse, a property defining the number of her children and a property defining the years of residence in Greece.
- Finally, the *service input* required per service version, e.g. a residence permit and/or a non-conviction certificate, is also identified in this step.

Note also that there may be dependencies between service rules. This means that the validation of one service rules may result in trigerring the validation of one or more other rules, or it may result in the elimination of one or more other service rules.

For the needs of this pilot, the legislation related with Naturalisation had to be studied and decoded. The result of the study was an exhaustive description of eligibility and service variant rules, such as:

- Eligibility rules. In order to get the Greek citizenship the applicant:

1. Must not have been convicted during the last decade before the submission of the naturalisation application for sentences as described in Par. 1β' of L. 3284/2004;
2. Must be an adult during the time of submission of the naturalisation application;
3. Must not have a pending decision of deportation; and
4. Must have adequate knowledge of the Greek language, history and civilisation.

- Service variant rules:
    1. The applicant must be a legal resident in Greece for ten years during the last twelve years before the submission of the application (excluding the time spent in the country as a diplomatic or administrative employee of a foreign country – if any).
    2. In the case of refugees (alien or without citizenship), it is required to be a Greek resident for five years in the last twelve years (except from the time spend in the country as a diplomatic or administrative employee of a foreign country).
    3. In the case of the husband/wife of Greek citizen who has a child with a Greek, it is required to be a Greek resident for three years (the time period is counted from the date of marriage).
    4. In case of aliens that were born in and are residents of Greece, there is no time requirement.
    5. In case of aliens that are Olympic Athletes, the minimum years of stay in Greece must be at least five.

Rules in structured language. Once the rules have been documented in natural language, the next step is to express the rules in structured language following the SBVR syntax. The rules of the example abover are then transformed into structured language abiding to the following syntax *<Modal> <Quantification> <Subject> <Object>* (explained in section 4.4.3.4). This is visualised in Figure 82.

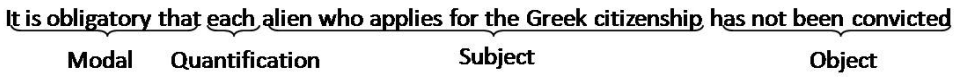


Figure 82: Examples of elibiligy rule expressed in formal English

As shown in the examples below, the main difference between eligibility and service variant rules lies in the definition of the Subject. Eligibility rules apply to all customers of a particular services, hence the Subject is generic, e.g. an alien in our example. In the case of service variant rules however, the Subject is further specialised e.g. a regugee or the spouse of a Greek citizen (i.e. aliens with some special characteristics).

We list below the eligibility rules of our walthrough example:

1. It is obligatory that each alien who applies for the Greek citizenship has not been convicted the last decade before the submission of the naturalisation application for sentences as described in Par. 1β' of L. 3284/2004.
2. It is obligatory that each alien who applies for the Greek citizenship is an adult during the time of submission of the naturalisation application.
3. It is obligatory that each alien who applies for the Greek citizenship does not have a pending decision of deportation.
4. It is obligatory that each alien who applies for the Greek citizenship has adequate knowledge of the Greek language, history and civilisation.

We list below the service variant rules of our walkthrough example:

1. It is obligatory that each alien who applies for the Greek citizenship is a legal resident in Greece for ten years during the last twelve years before the submission of the application.
2. It is obligatory that each refugee who applies for the Greek citizenship is a Greek resident for five years in the last twelve years.
3. It is obligatory that the spouse of a Greek citizen who has a child with a Greek and applies for the Greek citizenship is a legal resident for three years.
4. It is not obligatory for aliens that that were born in and are residents of Greece to be legal residents for ten years during the last twelve years before the submission of the application.
5. It is obligatory for aliens who are Olympic Athletes to be legal residents for five years before the submission of the application.

In this case, the service variant rules reveal that for receiving the same service outcome, i.e. the Greek citizenship, the customer (i.e. an alien) will have to fulfil different requirements with regards to her years of residence in Greece. Consequently, in order to fulfil those different requirements, different service input will be required per version, e.g. in the case of (2) the spouse of the Greek will have to submit a marriage certificate and one birth certificate for every child she has with a Greek.

Rules Formalisation. SBVR proposes a formal language to express the business rules. Hence in our case, every service rule expressed in structured language is also written as a formal deontil logical expression in first-order logic. According to SBVR deontic logical expressions are used in order to express obligation. They are therefore suitable for formally reprenting service rules, which by definition model conditions that have to be met for a service to be provided to a customer. Table 47 presents the mapping from structured to formal language expressions.

Table 47: SBVR structured to formal language mappings

Structured Language Expression	Formal Language Expression
Modal	
it is obligatory that p	Op
it is not obligatory that p	~Op
Quantification	
each	∀

Hence, the rules of the walkthrough example are transformed into the following logical experssions. Note that the predicate *convicted(x)* is used to declare that alien *x* has been convicted. Such predicates are be used in order to simplify the formal representation.

- Eligibility rules in first-order logic:
    1. O∀x: alien, [grant citizenship x ⊃ ~convicted(x)]
    2. O∀x: alien, [grant citizenship x ⊃ adult(x)]
    3. O∀x: alien, [grant citizenship x ⊃ ~deportation(x)]
    4. O∀x: alien, [grant citizenship x ⊃ knowledgeOfGreek (x)]
- Service variant rules in first-order logic:
    1. O∀x: alien [grant citizenship alien x ⊃ (residence(x) ≥ 10)]
    2. O∀x: spouse [grant citizenship spouse x ⊃ (residence(x) ≥ 3)]
    3. O∀x: alienBornInGR [grant citizenship alienBornInGR x ⊃ (residence(x) ≥ 0)]
    4. O∀x: alienOlympicAthlete [grant citizenship alienOlympicAthlete x ⊃ (residence(x) ≥ 5)]

As shown in the research prototypes presented later on, the implementation of the service rules in a machine-readable form depends on the technologies used for implementing the service system.

Definition of questions and answers. Once the service rules have been identified, defined and formalised, the next step is to define the associated questions and answers. In order to structure the dialogue between the customer and a service personalisation system, we model it using the Customer Dialogue Model of Figure 83.

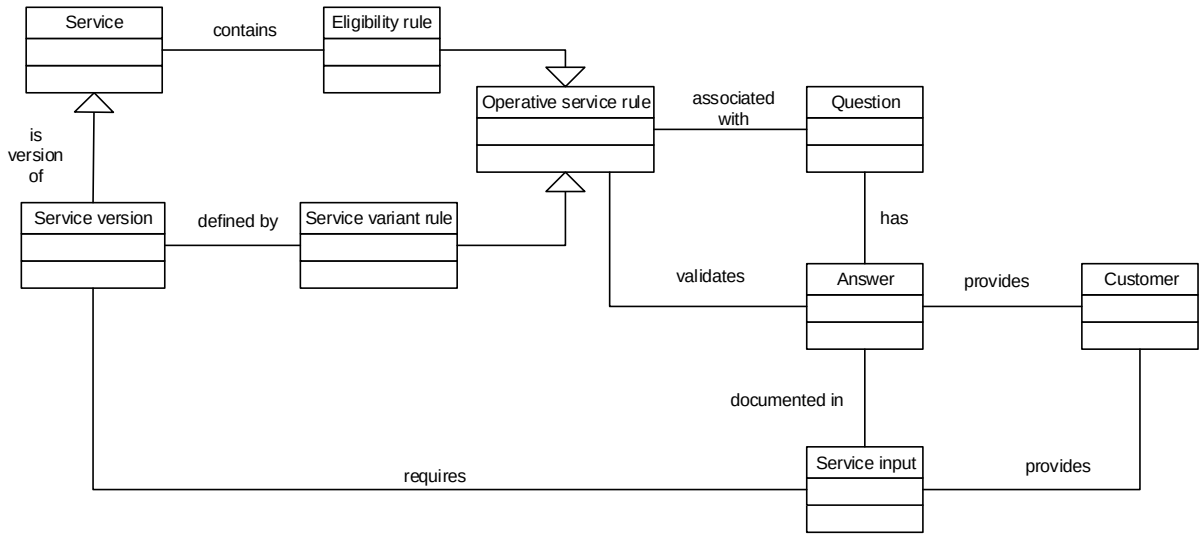


Figure 83: Customer Dialogue Model

The Customer Dialogue Model reuses concepts from the Customer Service Model, in particular customer defined and modelled in section 4.3.3.2, eligibility rule and service variant rule defined and modelled in section 4.4.3.4, service input defined and modelled in section 4.3.4.1, and adds new concepts to model questions and possible answers (see Figure 83). The questions and the answers constitute the interface between the customer and the dialogue-based personalisation system. They are in fact what the customer perceives as a dialogue.

A *Question* is defined as a request for information expressed in natural language. Each operative service rule, i.e. each eligibility rule and each service variant rule, is associated with at least one *Question*. In some cases, more than one questions may be required in order to collect all the information required for validating a service rule.

Each *Question* is associated with at least one possible *Answer,* depending on the Object of the service rule. In order to facilitate the automated validation of the service rules, answers have to be closed, either in the form of Boolean values, or values from codelists, or numbers, or defined ranges. *Answers* are provided by the customers. In order to prove the truth of the answers given by the customer, in the context of the delivery of a specific service version, the customer will be requested to submit relevant service input that documents her claims during the customer dialogue.

As discussed, we are following a hybrid frame-based approach, i.e. we assume that the *eligibility rules* are validated before the *service variant rules*. Thus no *service variant-related questions* are asked in case the customer is not eligible for the service. This saves the customer from answering to unnecessary questions and minimizes the length of the dialogue. The sequence of the questions in the dialogues will respect the dependencies between service rules. For example, if the validation of the validation of one service rules results in trigerring the validation of one or more other rules, then the

respective questions will be asked. Likewise, if the validation of one service rules results in the elimination of one or more other service rules, then the respective questions will not be asked.

In the remainder of this section, we list some questions and their associated answers (in natural language) based on some of the service rules defined previously:

- It is obligatory that each alien who applies for the Greek citizenship is an adult during the time of submission of the naturalisation application.

  Q: What is your date of birth?

  A: The alien has to provide their full date of birth, i.e. dd-mm-yyyy.

- It is obligatory that the spouse of a Greek citizen who has a child with a Greek and applies for the Greek citizenship is a legal resident for three years.

  Q1: Are you married to a Greek citizen?

  A: Yes / No

  Q2: Indicate the number of childer that you have.

  A: The alien has to provide the number of children that he has with the Greek citizen, e.g. 0, 1, …

5.4.2 A semantic, dialogue-based portal for public service personalisation (S-PSP)

In order to improve the service personalisation functionalities on governmental portals, such as MyPortal.gov, this pilot introduces a semantic dialogue-based portal for public service personalisation (S-PSP), which aims guide customers through the personalisation of a desired service. The Semantic Public Service Portal (S-PSP) provides information about available public-services, in order to:

- Inform a customer whether she is eligible for a specific service.
- Identify the specific public service version that matches the profile, needs (see section 4.3.2.1) and requirements of the customer, as well as the customer context. Two of the dimensions of customer context are of particular interest in this case: the personal dimension, i.e. her experiences, charactertics, habits and obligations, and the spatio-temporal dimension, i.e. the location where the customer will consume the service and the particular point in time that this will happen.
- Provide to the customer the personalised service input required for consuming the matching service version; and

- Allow customers to invoke public services that are available online (if a service execution environment is in place) independent of the semantic technology and the Web service protocol used.

The S-PSP implement the dialogue-based approach specified in the previous section. S-PSP was initially developed in the context of the SemanticGov project, where it played the role of the national Member State portal (Loutas, Peristeras et al. 2008). It served as an entry point for the citizens to the public services offered by the SemanticGov platform. Two prototypes of the portal were deployed at the Region of Central Macedonia in Greece and the City of Turin in Italy (Loutas, Giantsiou et al. 2010). The S-PSP is also one of the three building blocks of the Rural Inclusion[47] platform. 12 public services from 4 EU Member States, in France, Greece, Latvia and Spain, were personalised using the approach and the software of the S-PSP. A running prototype of S-PSP is available at http://vmsgov03.deri.ie:8080/rural-inc/services?pilot=gr&pageLanguage=en.

5.4.2.1 System architecture

The S-PSP follows a three-tier architecture, as shown in Figure 84, which comprises of:

- The Presentation Layer, which facilitates the interaction between the citizens and the portal, acting as an entry-point to the customer dialogue. It main component, the User Interface (UI) presents to the citizens the questions and collects their answers. The User Inteface is dynamically created based on information encoded in the Dialogue Ontologies (see section 5.4.2.2.1). This means that all forms are created on the fly. All information that is made available through those forms, i.e. questions and possible answers, comes from the underlying ontologies stored in the RDF Repository.
- The Application Layer, which consists of two components, which are discussed in detail in sections 5.4.2.2.1 and 5.4.2.2.2, as these are the core components that implement the customer dialogue :
    - the Dialogue Ontology Locator ; and
    - the Query Mechanism.
- The Data Layer, which contains the RDF Repository where all the semantic artefacts (ontologies) used by the portal are stored. In addition to the Dialogue Ontology discussed in detail in section 5.4.2.2.1 which demonstrated elements of the Unified Service Model and the Customer Service Model, such as *customer*, *service version, service rules, service input* and *service outcome*, the S-PSP also makes uses of support ontologies that model the profile of

[47] http://www.rural-inclusion.eu

different types of customers, such as businesses and citizens, who use the S-PSP in order to benefit from its public service personalisaiton features, for example by defining properties such as the legal name, the type or the legal status of a company. The RDF Repository has been implemented using Jena, an open-source RDF API provided by the Apache Foundation[48].

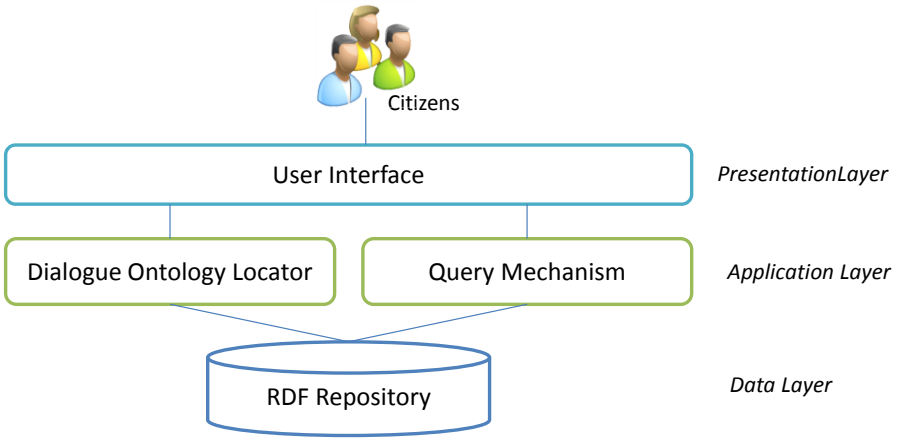


Figure 84: S-PSP Architecture

5.4.2.2 Prototyping

This section describes the technical development aspects of S-PSP and explains how the different service model elements are demonstrated.

5.4.2.2.1 Dialogue Ontology and the Dialogue Ontology Locator

The S-PSP is implementing the Customer Dialogue Model of section 5.4.1 in the form of OWL ontologies, following the OWL Lite variant. Adopting an ontology-based approach reaps the benefit of the flexibility of the RDF model. This enable direct translation of fairly complex customer dialogues into a machine-readable form, as RDF triples.

In order to facilitate the customer dialogue and respect the dependencies between the service rules, explained in section 5.4.1, the Dialogue Ontology introduces a tree-like structure. Each customer dialogue is created as an instance of the Dialogue Ontology. Hence, one instance of the Dialogue Ontology has to be created for every public service made available via the S-PSP.

We explain below the different classes in the Dialogue Ontology, their properties and their correspondence to the Customer Dialogue Model of Figure 83.

For the sake of clarity, we will use a walkthrough example, based on the Registration of a business in the Chamber of Commerce public service, provided by all Chambers of Commerce in Greece. A

[48] http://jena.apache.org/documentation/rdf/

detailed documentation of the public service following the Unified Service Model and the Customer Service Model is provided in Annex II.B.

Let the following be one of the eligibilityrules for this public service: It is obligatory that each business that wishes to register itself in the Chamber of Commerce is a legal entity.

Node. *Nodes* in the Dialogue Ontology represent different states of the customer dialogue. Each *Node* corresponds to a service rule, let it be an eligibility rule or a service variant rule. A *Node* has the following attributes:

- The *hasDescription* attribute (dcterms:description)provides a brief description of the node, i.e. it contains the expression of the service rule in natural language, e.g. it is obligatory that each business that wishes to register itself in the Chamber of Commerce is a legal entity.
- The *requires* attribute refers to the information resources, in the case of this pilot to the administrative documents, e.g. certificates, fees, and other types of service input which are required in order to validate the specific service rule represented by this node. We focus on administrative documents because this is the prevailing way of providing input to public services. A *Node* may require zero or more information resources for validating a service rule, which are all provided as input to the specific service version. In the case of our example, the administrative document for validating the eligibility rule is a Business Inception Certificate from the competent Tax Authorities.

The following three classes, i.e. *InternalNode* and *LeafNode* have been defined in the ontology as subclasses of Node. They thus inherit all its attributes.

- *InternalNode*. This class represents those nodes of the Dialogue Ontology that have descendants, i.e. other nodes following them (be reminded that the Dialogue Ontology introduces a tree-like structure to facilitate the representation of a dialogue). Apart from the attributes that they inherit from *Node*, *InternalNodes* have also:
    - The *hasChildNode* attribute which indicates the descendants of the current node. There can be more than one descendants, which actually represent the services rules that are trigerred after the successful validation of a specific service rule. For example, after the validation of the eligibility rule of the example, a service variant rule to be validated is: it is obligatory that each new business that registers in the Chamber of Commerce in the first semester of the year pays the full annual fee.
    - The *hasQuestion* attribute which refers to a specific question asked to the citizen. This is an object type property connecting the *IntenalNode* to one or more instances of *Question*. It always links a specific *IntenalNode* with the next *Question* to be asked.

    - The *hasCondition* attribute which links the *InternalNode* to the machine-readable implementation of the corresponding service rule. The deontic logical experessions of the service rules are encoded in the form of SPARQL SELECT queries as explained later.
    - The *isRoot* attribute which indicates whether the specific node is the first node of the dialogue or not. This property is used for helping the traversal of a specific instance of the Dialogue Ontology.
- *LeafNode*. This class represents those *Nodes* of the Dialogue Ontology that have no descendants. *LeafNodes* indicate the termination of the dialogue, whether successful or not. This means that once a *LeafNode* is reached, all relevant service rules have been validated and either a service version has been identified or it is decided that the customer is not eligible for the service. Therefore, apart from the attributes that they inherit from Node, *LeadNodes* have also the isNotEligible attribute which if true indicates that the citizen is not allowed to use the specific public service, i.e. she does not qualify for it.
- *Question*. This class represents the questions that the portal prompts to the citizen. Each *Question* aims to collect information for validating one service rule, let it be an eligibility rule or a service variant rule. A *Question* has two attributes:
    - *hasData* (implemented as dcterms:description) models the question itself, e.g. "What is the legal status of your company?"
    - *hasAnswer* models the possible answers. This can point to a list of controlled values, e.g. S.A, Association, Ltd., Personal Company etc., or may expect values of a specific type, e.g. date, string, number.
- *ServiceRule*. This class represents formally an operative service rule, covering both eligibility and service variant rules. In this pilot, service rules are expressed in the form of SPARQL SELECT queries. The deontic logical expression of the rule is translated into the conditions of the WHERE part of the SPARQL query. Implementing the service rules in machine-readable format as SPARQL SELECT queries improves their reusability in different instances of the Dialogue Ontology. This results in significant effort savings as service share many similar rules, especially those related to core attributes of a customer, such as age, marital status, sex, citizenship, etc. The main attribute ot the the *ServiceRule* is:
    - *hasQuery* which holds a string serialisaiton of the SPARQL SELECT query itself (see Table 48).

Table 48 presents some examples of an instance of the Dialogue Ontology for the Registration of a business in the Chamber of Commerce public service. The full example is presented in Annex III.

Table 48: Examples of InternalNode and LeafNode for the Registration of a business in the Chamber of Commerce public service

:ObligesRegistration_Association a do:InternalNode ;

dcterms:descriptions “The eligibility rule validated in this internal node is: it is obligatory for each association to register in the Chamber of Commerce."@en;

do:hasChildNode :firstHalf, :secondHalf ; *// the service version rules which are trigerred if this eligibility rule is fulfilled.*

do:hasCondition :LicencedAssociation ; *//linking the eligibility rule to the respective query which encodes the deontic logical expression in machine-readable format.*

dcterms:requires doc:BusinessInceptionCertificate; *//the related administrative document that contains the information needed for validating the eligibility rule.*

do:hasQuestion :qstnRegistrationDate. *//linking the eligibility rule to the next question to be asked for collecting the required information from the citizen.*

:firstHalf a do:InternalNode ;

dcterms:description “The service variant rule validated in this internal node is: it is obligatory that each new business that registers in the Chamber of Commerce in the first semester of the year pays the full annual fee."@en;

do:hasChildNode :EU, :NonEU ; *// the service version rules which are trigerred if this eligibility rule is fulfilled.*

do:hasCondition :Before ; *//linking the eligibility rule to the respective query which encodes the deontic logical expression in machine-readable format.*

do:hasQuestion :qstnCitizenship . *//linking the eligibility rule to the next question to be asked for collecting the required information from the citizen.*

:qstnRegistrationDate a do:Question ; *//the question to be asked after validating the condition of* InternalNode *ObligesRegistration_Association*

do:hasAnswer ""^^xsd:dateTime ;

do:hasData "What is the date of business registration?"@en .

:qstnCitizenship a do:Question ; *//the question to be asked after validating the condition of InternalNode firstHalf*

do:hasAnswer ""^^xsd:string ;

do:hasData "What is your citizenship?"@en .

:LicencedAssociation a do:SparqlQuery ; *//the query implementing the deontic logical expression of IntenalNode ObligesRegistration_Association*

do:hasData "PREFIX bo:<http://www.owl-ontologies.com/BusinessOntology.owl#>
PREFIX rdf:<http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX xsd:<http://www.w3.org/2001/XMLSchema#>

SELECT ?x FROM http://www.owl-ontologies.com/BusinessOntology.owl

WHERE {?x rdf:type ?t. FILTER(?t=bo:SME).
?x bo:hasInstitutionForm ?it. FILTER(?it=bo:Association).}"^^xsd:string ;

rdfs:comment "Checks if the EU applicant requires licencing and is registering an association"^^xsd:string .

:Before a csm:ServiceRule ; *//the query implementing the deontic logical expression of the service rule of IntenalNode firstHalf*

```
do:hasQuery "PREFIX bo:<http://www.owl-ontologies.com/BusinessOntology.owl#>
             PREFIX rdf:<http://www.w3.org/1999/02/22-rdf-syntax-ns#>
             PREFIX xsd:<http://www.w3.org/2001/XMLSchema#>

             SELECT ?x FROM http://www.owl-ontologies.com/BusinessOntology.owl

             WHERE { ?x rdf:type ?t.  FILTER(?t=bo:SME).
                     ?x bo:hasRegistrationDate ?date.
                     ?date bo:hasName ?name.
                      FILTER(regex(?name,\"first half\",\"i\")).}"^^xsd:string ;

             rdfs:comment "Checks if the Registration is before"^^xsd:string .
```

Once an instance of the Dialogue Ontology for a specific public service, such as the Registration of a business in the Chamber of Commerce (see also Annex III), is created, it is stored in the RDF repository. Hence, the RDF repository may contain more than one instances of the Dialogue Ontology, each representing the customer dialogue for a different service.

During push service search on S-PSP, citizens can can enter keywords in the portal's UI to describe the service that they are looking for. These keywords are used for searching matching instance of the Dialogue Ontology. The keywords are matched against the titles and the descriptions of the Nodes of an instance of the Dialogue Ontology. This matchmaking is performed by the Service Tree Locator component. In order to improve the accuracy of search queries and make search more effective, WordNet[49] is also used. Hence, the synonym of a search keyword are retrieved and are also appended to the search query.

5.4.2.2.2 Query mechanism

The Query Mechanism (QM) is the core component of the S-PSP as it traverses an instance of the Dialogue Ontology, which models the customer dialogue for the public service that the citizen/business wishes to consume, and selects the questions to be asked during the dialogue. Once a citizen selects the public service they are interested in, the dialogue page appears on the User Interface of the S-PSP, as shown in Figure 85.

[49] http://wordnet.princeton.edu/

Figure 85: The public-service dialogue to customize the public-service information

At this step, the QM loads the selected instance of the Dialogue Ontology and starts its traversal. Hence, a series of questions will be posed to the citizen, which will determine if she is eligible for this public service and what information they will need to provide/complete to consume a specific version of it. The QM implements the algorithm of Table 49, which we explain next.

Table 49: QM Traversal Arlgorithm

Precondition: using the Dialogue Ontology Locator the S-PSP has loaded from the RDF Repository the instance of the Dialogue Ontology that models the public service that the user wants to personalise.

BEGIN
Let IN be the set of *InternalNodes* of the selected instance of the Dialogue Ontology to be traversed
Let LN be the set of *LeafNodes* such as IN $\cup$ LN = N, where N the set of *Node* instances defined in the selected instance of the Dialogue Ontology to be traversed
Let root be the first IN of the of the selected instance of the Dialogue Ontology to be traversed
Let curr be the *Node* (either InternalNode or LeafNode) to be processed
Let validated be a variable that stores the result of the evaluation of IN's SPARQL Query *//i.e. it stores whether the condition of that specific IN has been validate (true) or not (false)*
Let ServiceBasedUserProfile be an instance of the user profile

curr := root *//start the traversal from the Root of the selected instance of the Dialogue Ontology to be traversed*

while (curr $\notin$ LN) *//while a LeafNode has not been reached*
    validated := false
    askQuestions(curr) *//retrieve the question of the current IN and pose it to the user*
    ServiceBasedUserProfile := readAnswers() *//collect the answer of the user and assign it as value it to the respective property of the user's profile*
    foreach descendant d of curr
        if (evaluate(d)=true) *//evaluate the conditions of all descendants of the current IN to select the next current node*
            curr := d

```
                    validated := true
                    break
            end_if
        end_foreach
        if (validated = false) //in case none of the conditions of the descendants of the current IN can be
        validated
            informNonEligible() //inform the user that she is not eligible for this public service
            break
        end_if
end_while
displayPersonalisedServiceDescription (ServiceBasedUserProfile) //if this step is reached, the user is eligible
for the public service and the matching service version has been identified; the S-PSP presents to the user the
description of the service version (focusing on the required service input).
 END
```

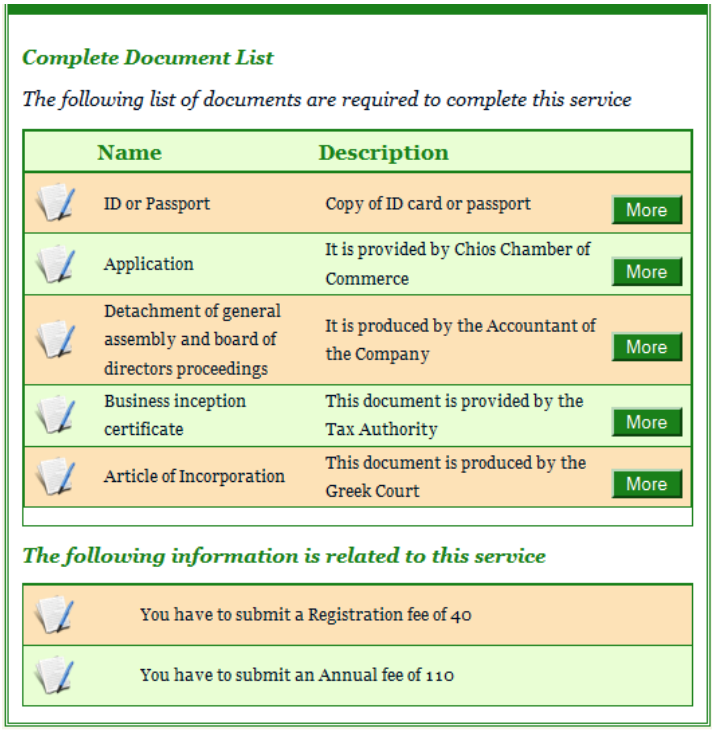
The QM starts the traversal by retrieving the *RootNode* of the instance of the Dialogue Ontology and asking the associated question. Based on the answer given by the citizen the conditions (which as we have explained are expressed as *SPARQL* SELECT queries) of the descendants of the *RootNode* are checked and the *Node* whose condition is validated is selected as the next node (new current node). Each time, the answers given are used for populating the respective properties of the citizen's profile, hence building dynamically a profile for the specific individual.

If the current node is an *InternalNode* then the QM has to verify the conditions of all its descendants. Therefore, the QM selects the corresponding question for question from the instance of the Dialogue Ontology and forwards it to the UI so that the question can be displayed to the citizen.

In case the current node is a *LeafNode*, i.e. it has no descendants, then the end of the structured conversation has been reached. At this point the S-PSP has collected all the necessary information for identifying the specific public service version that matches the citizen's profile and for deciding on their eligibility. In case the process is successful, i.e. the citizen is eligible for consuming the service and the matching service version has been identied, S-PSP provides to the citizen the service input that she has to provide for consuming the identified service version (see Figure 86).

In case the citizen is not eligible for one of the service versions that are modelled in the traversed instance of the Dialogue Ontology, then the QM terminates its execution and returns a notification message, for example, 'You are not oblijed to consumer the Registration of a business in the Chamber of Commerce public service, as your type of business is exempt from registration'.

It is important to note that at each step of the traversal, only one *InternalNode* can be visitited. This means there is no case where the same citizen could follow two different paths in the same instance of the Dialogue Ontology.



Complete Document List

The following list of documents are required to complete this service

Name	Description	
ID or Passport	Copy of ID card or passport	More
Application	It is provided by Chios Chamber of Commerce	More
Detachment of general assembly and board of directors proceedings	It is produced by the Accountant of the Company	More
Business inception certificate	This document is provided by the Tax Authority	More
Article of Incorporation	This document is produced by the Greek Court	More

The following information is related to this service

You have to submit a Registration fee of 40
You have to submit an Annual fee of 110

Figure 86: The customised information required to utilize this public service

5.4.2.3 Evaluation

In order to evaluate the prototype of the S-PSP a set of evaluation activities were organised. The main objective of the evaluation was to assess the overall quality of S-PSP's in terms of usability, efficiency and user satisfaction.

For that reason, three evaluation workshops were organised in different public agencies, namely in the City of Turin in Italy, the Region of Central Macedonia in Thessaloniki and the Ministry of Interior in Greece. Approximately 50 citizens, both men and women of different ages and backgrounds, from all three areas participated in the workshops.

Questionnaires were prepared and were handed out to the participants, who were encouraged to write their opinions after using the service personalisation functionality provided by the S-PSP. The questionnaires included a set of 10 questions, i.e. was it easy to find the needed public service using S-PSP, which were answered by assigning a weight starting from 1 (very unlikely) to 7 (very likely). The questionnaires required also some personal information of the participant, i.e. age, gender, profession

To start with, the evaluation results were very motivating and supported the need for a portal, like the S-PSP facilitates the personalisation of services. 89% of the participants replied that it was easy for them to personalise the desired public service using S-PSP and 63% of managed to identify a matching service version.

The use of S-PSP is proven to be easy and straightforward as well. The evaluation showed us that more than 50% of the participants did not need any help when using it. Timewise, the users seemed to be quite happy as only 19% of them said that personalising the desired service took them too long. 89% of the participans indicated that they would like to see more public services made available for personalisation through the S-PSP.

Closing, we would also like to emphasise here that the effort of creating a well-defined instance of the Dialogue Ontology for one specific service should not be underestimated. As we explained in section 5.4.1, this requires a detailed analysis of the public service, elicitation and formalisation of its rules, and finally encoding these also in an instance of the Dialogue Ontology. In order to carry this task effectively, one should combine domain expertise, e.g. in our pilot we engaged eGovernment experts for analysing the domain-aspects of the public service, with technical expertise and ontology engineering skills. Our experience has shown that, in average, 8-10 person-days are required for completing this task for a service of medium complexity.

5.4.3 A semantically-enhanced, dialogue-based expert system for public service personalisation

Implementing the dialogue-based approach presented in section 5.4.1, this pilot also aims to guide customers through the personalisation of a desired service in order to:

- Inform a citizen whether she is eligible for a specific service;
- Identify the specific public service version that matches the profile, needs (see section 4.3.2.1) and requirements and context of the citizen. We have modelled the customer context in section 4.4.4.1. Two of the dimensions of customer context are of particular interest in this case: the personal dimension, i.e. her experiences, characteristics, habits and obligations, and the spatio-temporal dimension, i.e. the location where the customer will consume the service and the particular point in time that this will happen; and
- Inform the citizen about the personalised service input required for consuming the matching service version.

The main difference between this prototype and the S-PSP lies mainly in the technological solution employed for implementing the dialogue engine. The major advantage of the use of expert system technologies it that we can implement a truly frame-based strategy where no pre-defined question order exists. This simplifies the modelling of the dialogue and makes it easier to adapt to changing needs, thus saving time and cost.

5.4.3.1 System architecture

The system architecture of the dialogue-based expert system developed in the context of this pilot implementation follows a three-tier architecturing comprising the following components (see also Figure 87):

- The Presentation Layer, which facilitates the interaction between the citizens and the expert service system by means of a customer dialogue. The *User Interface* collects the answers of the citizens in order to build up their profiles. These answers are then used for evaluating the eligibility and service variant rules in the Rule-based Engine. This bottom-up dynamically created citizen profile is termed working memory in the field of expert systems (Feigenbaum, 1993).
- The Application Layer, which consists of two components, which are discussed in detail in sections 5.4.3.1.1 and 5.4.3.1.2, as these are the core components that implement the customer dialogue :
    - The Dialogue Ontology and the Dialogue Engine; and
    - The Rule-based Engine.
- The Data Layer, which contains the OWL Ontology Repository where all the semantic artefacts (ontologies) used by the dialogue-based expert service system are stored. It is used to permanently store service-specific information, such as *(i)* question and answers texts by the Dialogue Engine component (see 5.4.3.1.1) and *(ii)* information for the service versions, i.e. the required service inputs and the produced service outcomes, modelled using the Unified Service Model of section 4.3 (see for example Table 50). In fact, this prototype demonstrates the following elements of the Unified Service Model and the Customer Service Model: *customer*, *service version, service rules, service input* and *service outcome*.

The dialogue-based expert system has been implemented using the SWI-Prolog framework[50]. It is an open source implementation and is commonly used for combining Prolog with semantic technologies, in particular with ontologies. More specifically, prefixes of RDF schemata and OWL ontologies can be included in the program as shown below:

```
?- rdf_register_prefix(csm, 'http://islab.uom.gr/csm/')
```

As we show in section 5.4.3.1.1, this allows to include in the Prolog rules references to OWL individuals, which in turn provide information for validating the rule.

[50] http://www.swi-prolog.org/

Additionally, SWI-Prolog provides a Web server which allows to create and serve the HTML pages that present the questions and ansers to be prompted to the citizens (i.e. implements the User Inteface).

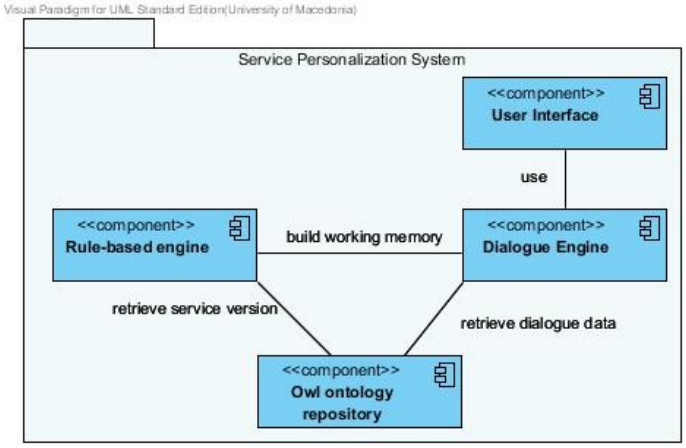


Figure 87: Semantically-enhance dialogue-based expert system architecture

This section describes the technical development aspects of the pilot and explains how the different service model elements are demonstrated.

For the sake of clarity, we will use a walkthrough example, based on the Greek Naturalisation public service. A detailed documentation of the public service following the Unified Service Model and the Customer Service Model is provided in Annex II.A.

5.4.3.1.1 Dialogue Ontology and the Dialogue Engine

This pilot is implementing the Customer Dialogue Model of section 5.4.1 in the form of OWL ontologies, following the OWL Lite variant. Adopting an ontology-based approach reaps the benefit of the flexibility of the RDF model and allows the reusability of questions and answers modelled as OWL individuals.

Unlike S-SPS, the deontic logical expressions of eligibility rules and service variant rules, are modelled in this case using Prolog rules, which are linked to the associated questions using Prolog queries. This is explained in detail in the next section. The definition of interdependent questions, i.e. questions which have to be prompted following a sequence, is done through the ranking of the associated Prolog queries specified in the the Rule-based Engine (see section 5.4.3.1.2). As a result, the Dialogue Ontology in this case is simpler than in the case of the S-PSP.

In the context of this pilot, the Dialogue Ontology comprises the following classes and properties:

- *Question*. This class represents the questions that the system poses to the citizen. Each *Question* aims to collect information for validating one service rule, let it be an eligibility rule or a service variant rule. A *Question* has two attributes:
    - *hasData* (implemented as dcterms:description) models the question itself, e.g. “What is your marital status?”
    - *hasAnswer* models the possible answers. This can point to a list of controlled values, e.g. single, married, divorced etc..
- *Answer*. This class models a possible anwers that can be given by the citizen for the case of closed-type questions. The same instance of Answer may be linked to more than one instances of Question. An Answer has one attribute:
    - *hasData* (implemented as dcterms:description) which holds the value of an instance of Answer, e.g. “Single”.
- *ServiceRule*. This class is the ontological representation of an operative service rule, covering both eligibility and service variant rules. In this pilot, the deontic logical expressions of service rules are expressed in the form of Prolog rules. The instances of the *ServiceRule* class connect the implementation of a Prolog rule (see section 5.4.3.1.2) to the service input required in order to satisfy this rule. Therefore, the naming of the service rule have to be consistent in the Dialogue Ontology and the Prolog program. For example, :naturalisation_married a csm:ServiceRule (appears in the Dialogue Ontology) and node(greek_naturalisation,naturalisation_married):- citizenship(naturalisation), naturalisation(do:ansSpouse) (the associated Prolog rule).
    - validatedBy which associates a *ServiceRule* to the specific service input(s) that contain(s) information that can satisfy it.

Table 50: Example of instances of Questions, Answers and ServiceRules for the Greek Naturalisation public service

```
:qrDeportation a :Question, owl:NamedIndividual; #one of the first eligibilityrules to be checked in: It is obligatory that each alien that applies for the Greek citizenship does not have a pending deportation decision.
        dterms:description "Do you have a pending deportation decision?";
        :hasAnswer :ansNo, :ansYes.

:ansNo a :Answer, owl:NamedIndividual; #one of the associated answers of qrDeportation
        dterms:description "No".

:ansYes a :Answer; #one of the associated answers of qrDeportation
        dterms:description "Yes".

:notEligible_deportation a csm:ServiceRule, owl:NamedIndividual ;
   :validatedBy :NonDeportationCertificate.
```

```
:qrMaritalStatus a :Question, owl:NamedIndividual;  #one of the service variant rules of the service checks
the marital status of the alien. Depending on it, different service input has to be provided.
        dterms:description "What is your marital status";
        :hasAnswer :ansSingle, ansMarried, ansWidowed, ansDivorced.

:ansSingle a :Answer, owl:NamedIndividual;  #one of the associated answers of qrMaritalStatus
        dterms:description "Single".

:ansMarried a :Answer, owl:NamedIndividual;  #one of the associated answers of qrMaritalStatus
        dterms:description "Married".

:naturalisation_married a csm:ServiceRule, owl:NamedIndividual ;
  :validatedBy :MaritalStatusCertificate.
```

Once the instances of the Dialogue Ontology are created, they stored in the OWL Ontology Repository, where they can be retrieved by the Dialogue Engine. The Dialogue Engine is responsible for building the working memory in an interactive way with the citizen. It coordinates the interaction between the system and the citizen throughout the customer dialogue. This is achieved by prompting questions and collecting the answers of citizens, and by forwarding them to the Rule-based Engine, where they are validated against the Prolog rules. The dialogue has two discreet end states, either the citizen is not eligible for the public service, or the specific public service version is identified.

As in the case of the S-PSP, a hybrid frame-based approach is used for the dialogue where some questions precede others e.g. questions associated with eligibility rules must precede the questions associated with service variant rules. The dialogue is system-initiative since the system is in charge of guiding the dialogue at each step.

The Dialogue Engine implements the algorithm of Table 51. The algorithm takes as input the full set of eligibility rules and service variant rules that a specific service comprises, and, given that it is successfully run, it identifies the service version that matches the profile of the citizen. The algorithm first examines the eligibility rules (i.e. ask related question, get answer, validate rule). If the eligibility rule is satisfied then the system selects the next eligibility rule, otherwise the algorithm terminates and the citizen is informed that she is not eligible for consuming the specific service. The validation of rules is done by the Rule-based engine, which is also the component that selects the next rule. The Dialogue Engine retrieves from the OWL Ontology Repository, using a SPARQL SELECT query, the question that corresponds to this rule and the associated answers, and pushes them to the User Interface so that they can be presented to the citizen.

After all the eligibility rules are validated, the algorithm checks the service variant rules following the same process. However, at this stage the successful validation of the last service variant rule indicates that the public service version that matches the profile of the citizen has been identified.

Once a service version is identified, information about the personalised service input and the service outcome are returned to the citizen.

Table 51: Dialogue Engine Algorithm

```
Let er be an eligibility rule
Let svr be a service variant rule
Let c be the customer
Let S be a service where S={{er1, er2, …, erN,}, {svr1, svr2,…, svrN}} //the service comprises a set of
eligibilityand service variant rules.
Let Sv be a service version of S where Sv={{er1, er2, …, erN,}, {svr1, svr2,…, svrK}}, where K<N //we
assume that a specific service version Sv contains all the eligibility rules of S but only a subset of the
service variant rules.
For each er in S //for every eligibility rule
        q = retrieve(er) //retrieve from the OWL Ontology Repository the question associated to er
        a[] = retrieve (q) //retrieve OWL Ontology Repository the possible answers associated to q
        Ask(q) //prompt the question via the User Interface
        Get answer() //collect the citizen's answer
        Validate(er) //validate the associated service rule based on the citizen's answer (validation is
        done by the Rule-based Engine)
        If er not validated
                nonEligible(c)
                Exit //if the customer is not eligible inform her and exit the dialogue
For each svr in S //for every service variant rule
        q = retrieve(svr) //retrieve OWL Ontology Repository the question associated to the svr
        a[] = retrieve (q) //retrieve OWL Ontology Repository the possible answers associated to q
        Ask(q) //prompt the question via the User Interface
        Get answer() //collect the citizen's answer
        Validate(er) //validate the associated service rule based on the citizen's answer (validation is
        done by the Rule-based Engine)
        If svr validated
                Sv = Sv + svr //start defining the service version
Return Sv //finally the service version of the customer will be returned
```

Figure 88 presents a walkthrough the prototype implementation for Greek Naturalisation public service. The arrows between the screenshots show the steps of the customer dialogue. On top of the arrows the answer provided by the citizen is depicted. Two possible scenarios are illustrated in the figure:

1. In the first scenario (screen path: (a) →(d)), the expert system starts with the validation of the following eligibility rule: "It is obligatory that each alien who applies for the Greek citizenship does not have a pending decision of deportation". Based on the answer of the customer, who says that she does have a pending deportation decision, the eligibility rule is not satisfied. Hence the customer dialogue is terminated (see also Table 51) and the system displays an automated message to inform her that she is not eligible for the public service.

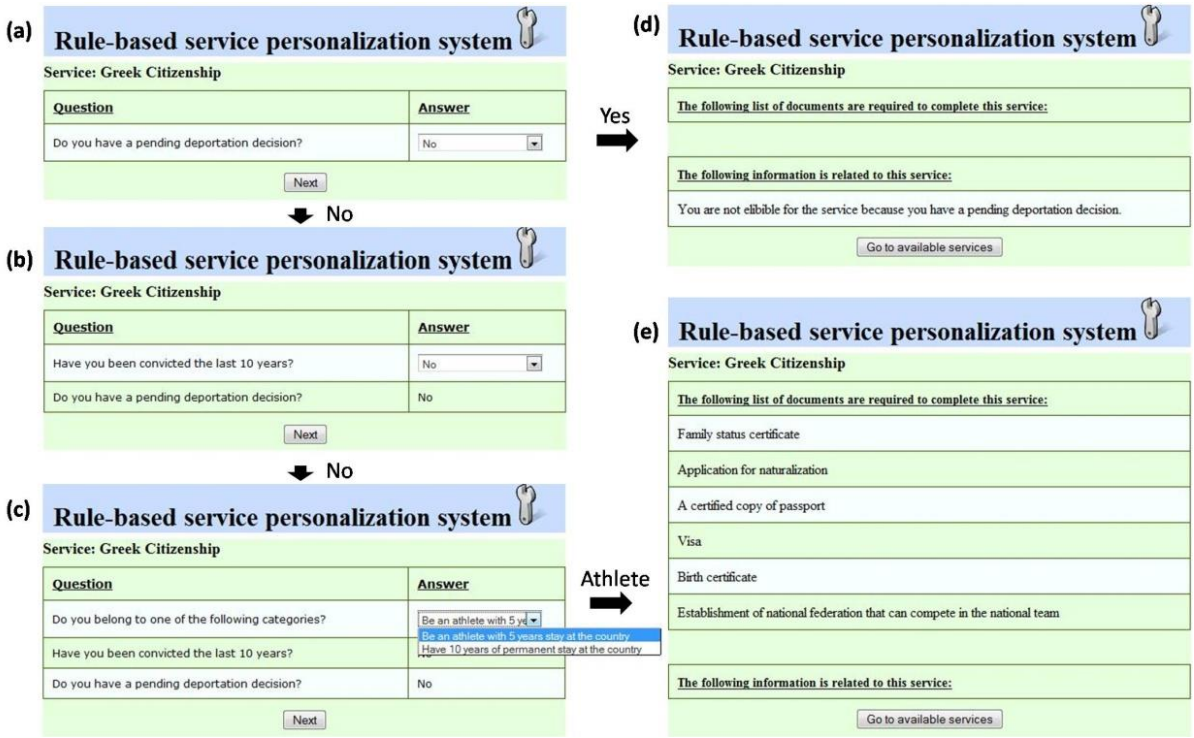


Figure 88: Citizenship Service implementation

2. The second scenario (screen path: (a) → (b) → (c) → (e)), is featuring the customer dialogue for atheletes with Greek roots who have won medals in the Olympic Games. First the eligibility rules are validated, i.e. screens (a) and (b). The eligibility rules illustrated here are the following:
    - It is obligatory that each alien who applies for the Greek citizenship does not have a pending decision of deportation; and
    - It is obligatory that each alien who applies for the Greek citizenship has not been convicted the last decade before the submission of the naturalisation application for sentences as described in Par. 1β' of L. 3284/2004.

    We can see that the citizen responds "No" in both cases. Then the following service variant rule is satisfied by the customer's answer: "It is obligatory for aliens who are Olympic Athletes to be legal residents for five years before the submission of the application" (see screen (c)).

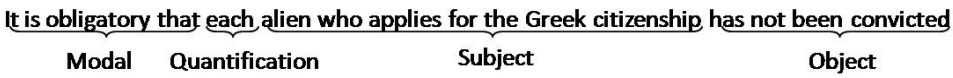
    After answering all the questions, the customer finds out that he is eligible for the publiv service. Therefore the system identifies the appropriate service version and provides him with personalised information about this, i.e. the personalised service input that he will have to provide (see screen (d)).

5.4.3.1.2 The Rule-based Engine

The Rule-based Engine is the main component responsible for validating the elibiligy of the citizen, by checking whether eligibility rules are satisfied, and by identifying the matching service version, which comprises all the service variant rules that are satisfied during the customer dialogue. As such, the Rule-based Engine contains all the operative service rules, both eligibility and service variant rules, implemented as Prolog rules and the respectice queries defined in Prolog.

A Prolog rule is a predicate expression that uses logical implication (:-) to describe a relationship among facts. It takes the form: *left_hand_side :- right_hand_side .*

A Prolog fact is a predicate expression that makes a declarative statement about a problem domain. In our case, a prolog fact corresponds to the object of the expression of a service rule in formal English. For example, in the case of the eligibility rule presented below, the predicate would be *not convicted.*



The syntax of a Prolog rule must be interpreted as left_hand_side if right_hand_side. The left_hand_side is restricted to a single, positive, literal, which means it must consist of a positive atomic expression. right_hand_side may contain one or more predicates. The Prolog rule for the example above would be the following: *naturalisation_eligibility(X):- not (convicted(X)).*

The validation of the right_hand_side can either be true or false, all predicates have to be satisfied for the outcome of validation of the right_hand_side to be positive. In order to satisfy a predicate Prolog searches either for a fact, i.e. a piece of information from the working memory, to prove it or for another rule whose left_hand_side is the same as the predicate to be validated.

An advantage of Prolog rules is that they can interact with the user in order to collect information needed for validating a predicate (i.e. build the working memory). In our pilot, each of the rules is linked to one such statement, which is in turned associated the respective instance of question from the Dialogue Ontology. Questions are promted using the menuask() function, which allows the citizen to select one of the answers associated with a specific question.

For example in the case of the convicted predicate, the statement is the following convicted(X):- menuask(do:qrConvicted,X) and refers to the qrConvicted, which is an instance of Question defined in the Dialogue Ontology. More specifically:

```
:qrConvicted a :Question, owl:NamedIndividual ;
        dcterms:description "Have you been convicted the last 10 years?".
        :hasAnswer :ansNo, :ansYes.
```

Every time information needs to be collected from the citizen, the Rule-based Engine calls the Dialogue Engine, which in turn retrieves the representation of a question and the associated answers from the OWL Ontology Repository and prompts them to the citizen via the User Interface. In order to shorten the customer dialogue, all eligibility rules are validated first, hence the associated questions are the first to be asked. The sequence of the remaining questions is dynamically computed with depending on the citizen's answers and the remaining service variant rules.

We are concluding this section by list below the Prolog rule defined for a sample of the eligibility rules and the service variant rules of our walthrough example, i.e the Greek Naturalisation public service:

Eligibility rules:

1. It is obligatory that each alien who applies for the Greek citizenship has not been convicted the last decade before the submission of the naturalisation application for sentences as described in Par. 1β' of L. 3284/2004.

   naturalisation_eligibility(X):- not (convicted(X)). (the rule)

   convicted(X):-menuask(do:qrConvicted,X). (prompting the question to collect information from the citizen)

2. It is obligatory that each alien who applies for the Greek citizenship is an adult during the time of submission of the naturalisation application.

   naturalisation_eligibility(X):- adult(X). (the rule)

   adult(X):-menuask(do:qrAdult,X). (prompting the question to collect information from the citizen)

3. It is obligatory that each alien who applies for the Greek citizenship does not have a pending decision of deportation.

   naturalisation_eligibility(X):- not (deported(X)). (the rule)

   deported(X):-menuask(do:qrDeportation,X). (prompting the question to collect information from the citizen)

4. It is obligatory that each alien who applies for the Greek citizenship has adequate knowledge of the Greek language, history and civilisation.

   naturalisation_eligibility(X):- languageAndHistory(X). (the rule)

   languageAndHistory(X):-menuask(do: qrGreek,X). (prompting the question to collect information from the citizen)

In fact, based on the rules defined above, we conclude that the eligibilityrules is defined as follows: *naturalisation_eligibility(X):- not (convicted(X)), adult(X), (deported(X)), languageAndHistory(X)*

Hence, for every alien that is eligible for this public service, the following fact will hold true:

naturalisation_eligibility(eligible):- not (convicted(do:ansNo)), adult(do:ansYes), not (deported(do:ansNo)), languageAndHistory(do:ansYes) .

The same pattern applies also to the design of Prolog rules and facts for service variant rules (see Annex IV.A for the full collection of Prolog rules for this example). For example, the service version that is targeting atheletes with Greek roots who have won medals in the Olympic Games and can thus receive the Greek Citizenship to be honoured, would we expressed as a Prolog rule as follows: *naturalisation(X):- naturalisation_eligibility(X) , olympicAthlete(X)*.

(The service variant rule here is "It is obligatory for aliens who are Olympic Athletes to be legal residents for five years before the submission of the application".)

Hence, for every alien that is eligible for this public service version, the following fact will hold true: *naturalisation(honorary_naturalisation):- naturalisation_eligibility(eligible) , olympicAthlete(do:ansYes).*

5.4.3.2 Evaluation

Validating the rigor of our approach is critical, as inaccuracies in the *operative service rules* will result in inaccurate service personalisation. Our objective was to ensure that the actual outcome of the expert service system per case is the same as the expected one. For this reason we use verification and validation methods and techniques to examine the quality of the methodology proposed. We employ the following criteria (O'Leary 1988; O'Keefe and Lee 1990; Grogono, Batarekh et al. 1991; O'Keefe and O'Leary 1993; Tsai, Vishnuvajjala et al. 1999; Mosqueira-Rey and Moret-Bonillo 2000):

- *Consistency.* A consistent methodology does not produce rules that contain contradictions.
- *Completeness.* A methodology is complete if no rules are omitted. A way to check completeness is to check if new rules can be inferred by induction from the existing ones.
- *Correctness.* A methodology is correct if the produced rules lead to the creation of a correct result (i.e. the right personalisation)
- *Redundancy.* A methodology creates redundant rules if two or more rules succeed at the same situation with the same result.

We use two different test cases. The first one relies on the Greek Naturalisation public service (described also in Annex II.A), while the second one deals with a public service regarding the provision of grants for new farmers in Greece (described in Annex II.C). Based on our analysis, the Greek

Naturalisation public service comprises a total of 60 operative service rules, namely 6 eligibility rules and 54 service variant rules defined in Prolog (see Annex IV.A). The second test service comprises 61 operative service rules, namely 16 eligibility rules and 45 service variant rules defined in Prolog (see Annex IV.B).

The rules (eligibility and service variant) for both test cases have been successfully evaluated in terms of consistency, completeness, correctness and redundancy. Moreover, we measured the benefit, in terms of dialogue length, of the eligibility check (i.e. when non-eligibility is detected by the system, the dialogue is terminated).

For each of the two test cases we produced a set of test user profiles (10 for Greek naturalisation and 20 for the grants for new farmers public service) using randonmly selected values for their properties (see Annex IV.C). In fact, each test user profile comprises as a set of characteristics derived from possible answers that can be given by the citizen during the dialogue. We used the test set in order to verify that eligibility rules are validated correctly and the right service version is detected, based on the successful validation of service variant rules. After a thorough examination of the produced versus the expected results for each of the test user profiles we observed that the accuracy of both services is 100%; this means that the appropriate service version is always detected for all test user profiles in both test cases. The high accuracy of the dialogue-based expert service system is mainly due to the rigorous modeling and accurate definition of eligibility rules and service variant rules.

Summarising our discussion so far, Table 52 indicates that all the evaluation criteria have been adequately satisfied.

Table 52: Evaluation of Service Personalisation Methodology

Criterion	Result
Consistency	The eligibilityrules and the service variant rules defined do not contain contradictions.
Completeness	No new rules can be inferred by the existing ones with induction.
Correctness	After a thorough examination, the service versions proposed based on the service variant rules the rules were always the ones that matched the profile of the respective test user.
Redundancy	The eligibilityrules and the service variant rules defined do not contain redundancies.

In the context of the evaluation exercise, we also measured the length of the customer dialogue using two variants of the approach presented in section 5.4.1: i) validating all eligibility rules before service variant rules, and terminating the dialogue once proven that the citizen is not eligible for a specific service; and ii) validating eligibility rules and service variant rules in random order. We used both test

services, i.e. the Greek Naturalisation public service and the public service for providing benefits for new farmers in Greece, for evaluating the two variants, using also the test user profiles discussed earlier.

In the case of the Greek naturalisation public service, we observed that there is a decrease in the length of the customer dialogue (varies between 4 and 6 steps) when applying first the eligibility rules for test user profiles that are not eligible for the public service (see Figure 89). For use profiles that are eligible, the length of the customer dialogue is not impacted by the sequence of operative service rules.

For the public service for providing benefits for new farmers in Greece the benefit from checking eligibility rules first is higher. For test user profiles that are not eligible for the public service, the saving from checking eligibility rules first varies between 4 and 19 dialogues steps (see Figure 90).

We observed that the decrease in the dialogue length depends on the number of eligibility rules and on how early or late in the dialogue the non-eligibility of the customer would be detected. Hence, in order to optimise the customer dialogue, it is important to assign higher priority to the questions that are more likely to signal non-eligibility.

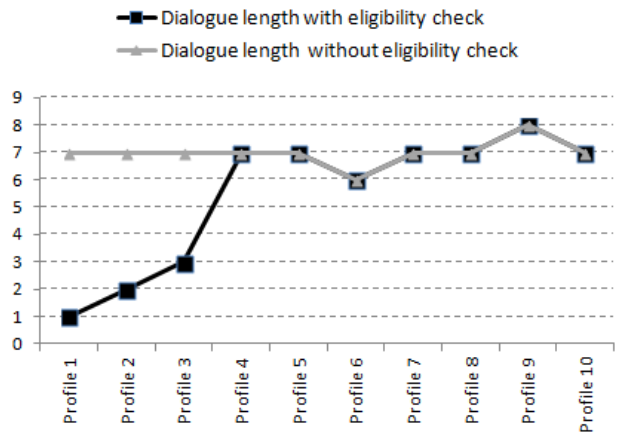


Figure 89: Dialogue length of Greek naturalisation service

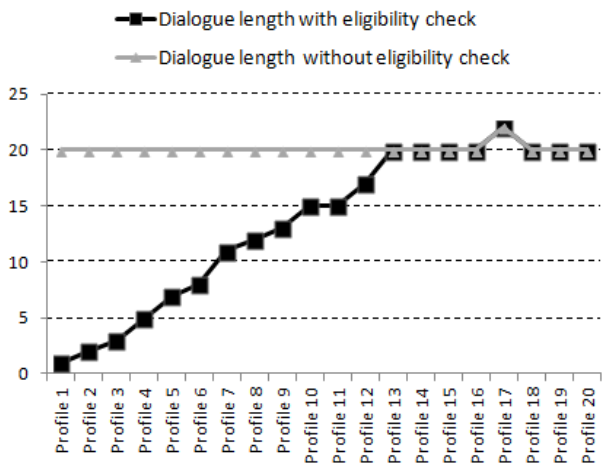


Figure 90: Dialogue length for the New farmer service

Chapter 6
Conclusions and Future Research

Prediction is very difficult, especially if it's about the future.
Niels Bohr

6.1 Introduction

This chapter summarises the research contributions of this *Thesis* and discusses possible directions for future research.

6.2 Research contributions and implications

The combination of semantics with service-oriented systems allows the enrichment of service descriptions with information about their behavioural and functional characteristics, such as service capabilities and interfaces, service inputs and outputs etc. This *Thesis* identified **two opportunities for improvement** of existing service modelling efforts in order to support more efficient, customer-centric service delivery:

1. Unifying the variety of provider-driven, heterogeneous and non-interoperable vocabularies for service.
2. Enhancing service models with concepts expressing the view of the customers (e.g. perceptions, expectations and feedback) and allowing its implementation in machine-readable formats, thus making it usable in different value-adding co-production interactions throughout the service lifecycle.

As we have thoroughly discussed in this work service modelling frameworks perceive service descriptions as purely provider-oriented constructs limiting the participation of the customers, which in turn results in poor and incomplete service descriptions which provide a fragmented view of the specific service. In this work, we have **made a clear case for rethinking service modelling and the service description paradigm in order to unify the provider and the customer viewpoints**. This results in a high-quality, complete view of a specific service and, as we showed also in the research prototypes discussed in Chapter 5, will leverage and empower service provision by means of intelligent and highly-adaptive service search, personalisation and evaluation.

With our work we bring back in the spotlight the importance of service evaluation. Although business-related disciplines, such as marketing and operations management, evangelise the importance of involving the customer throughout the service lifecycle, and pay particular attention to the evaluation of services by customers, this co-production interaction has been up to now by and large ignored in the Web of Services, which is the research and application field where this *Thesis* is positioned. We remind the reader that in this work, service evaluation is defined as an interaction between the service provider and the customer, which runs throughout the service lifecycle. During the evaluation of a service, customers express their expectations of and feedback on the service. Facilitating, capturing and utilising information about the service originating directly from the customers allows service providers to understand the needs and expectations of customers. Customer expectations and feedback, collected during the evaluation of services, can be considered and taken into account in the design of new services, in the evolution of existing ones and can spark innovative ideas for the integration of services and other types of resources.

Integrating the service provider and the customer viewpoints effectively means harmonising the vocabulary that the two use for describing services, allowing them to speak the same language. Heterogeneity in the way that services are currently formally represented and described has a number of practical implications on service provision. It makes it for example hard to identify the latent relationships between services modelled using different frameworks, or to decide whether two services represented using different frameworks share common inputs or produce the same output or can be used in the same context. **The Unified Service Model** and its customer-oriented extension developed in this *Thesis*, i.e. **the Customer Service Model, provide such a common vocabulary not only between customers and providers, but also between providers themselves**.

In order to bring the two complementary viewpoints of service together, it was necessary for us to **understand and frame the lifecycle of service from the customer's perspective** as well as the ways through which customers participate in service. Customers partake in service delivery undertaking different roles in the context of different co-production interactions and collaborate with other types of service agents.

In sections 4.3.3 and 4.4.1, we defined different service agents and their roles; while in section 3.2.2 we identified 9 different co-production interactions were identified, such as service search, service personalisation and service evaluation. In this vein, we also introduced a five-phased service lifecycle model and positioned every co-production interaction in the phase that it takes place, thus illustrating the role that customers play in the different phases of the service's lifecycle. This allows us to study customer participation as an integral part of the service, starting from the need realisation and design and moving down to service development, delivery, consumption and post-consumption.

Modelling the roles of service agents, focusing on the customer, and the lifecycle of service, in terms of phases and co-production interactions, lay the ground for formally modelling the way that a service is perceived by its customers; hence defining the Customer Service Model. It also helped us to formally define and model a new paradigm for modelling services, that of social descriptions, where customers and service providers collaborate in order to create descriptions of services that reflect both viewpoints.

Social descriptions of services are able to capture and model **customer expectations** and **feedback**. For example, social descriptions may include the reason why a customer used a service, the occasion, e.g. to book a flight, the situational context, e.g. details about the travelling context or the nature of the trip or other useful services, evaluation of service quality, e.g. happy with the service quality or not, and valuation of the customer's experience, e.g. enjoyed the service or feel better (or even worse) after using the service. Social descriptions can act either supplementary to the description initially provided by the service providers or replace it in case this does not exist.

Summarising, the main theoretical outcomes produced by this *Thesis* are presented in the table below.

Table 53: The theoretical outcomes of this Thesis

1	**The lifecycle of the service from the customer viewpoint**, which illustrates our understanding of customers participation in service and presents service provision as experienced by the customer. It comprises 5 phases, namely need realisation; service search; service personalisation; service delivery; and service evaluation phase. This has been discussed in Chapter 3.
2	**The Unified Service Model** which puts in place a common vocabulary shared between the different service models and definitions studied in the literature, all of which implicitly approach the modelling of service from the provider viewpoint, i.e. the way that service providers perceive, understand and model service. Consequently, the Unified Service Model also expresses the service provider viewpoint of service. This has been discussed in Chapter 4.
3	**The Customer Service Model**, which constitutes a representation of service from the customer viewpoint. The model emphasises customer participation in service delivery by introducing concepts such as sacrifice, expectation, feedback and perceived value, and organises them according to the Who, Why, What, and Where and When views of the Zachman framework. The Customer Service Model is an extension of the Unified Service Model. This has been discussed in Chapter 4.
4	**Social descriptions**, as a new way to model at the implementation level many parts of the Customer Service Model, which expresses customer expectations and feedback, and introduces the bottom-up annotation of services, implicitly or explicitly, by customers, complementing or even replacing (in case they do not exist) the service descriptions created by the providers in a top-down fashion. This has been discussed in Chapters 3 and 4.

In order to validate and evaluate the rigor, the usability and the usefulness of the theoretical outcomes of this *Thesis*, we first created a machine-readable representation of the Customer Service Model in RDF (see section 5.2.1) and then used it in four proof-of-concept prototypes that address the needs and the requirements of a demanding service industry, that of public administration. More specifically the four prototypes, discussed in the previous section, demonstrate:

- The use of the Unified Service Model and the Customer Service Model for pull and push service search, and service evaluation (discussed in section 5.3); and
- The use of the Unified Service Model and the Customer Service Model for service personalisation (discussed in section 5.4).

Push service search is improved for two reasons: on the one hand social descriptions of the Customer Service Model allow customers to search for services using their own vocabulary, which is now integrated in the authoritative description of a service; on the other hand the Unified Service Model can harmonise the representation of services, hence one can search for services described using different formalisms using a single vocabulary.

Service recommendation (seen also as push service search) is made more accurate as there is a positive correlation between the quality and completeness of the description of a service and the accuracy of recommendations made to the customer. More complete service descriptions, which comprise the customer viewpoint, collected through explicit service evaluation (see section 5.3.1.1) and service mining (see section 5.3.1.2), match better against the customer's profile and context, hence more relevant services are recommended.

Service personalisation is made more efficient and the appropriate service versions can be identified with less effort from the customer because of the modelling approach that we follow for service versions and service rules. Our dialogue-based approach (see section 5.4.1), which gives priority to the validation of eligibility rules, guarantees that the customer will not have go through the whole service personalisation process if it is not certain that she is eligible for the service. Additionally, it ensures that irrelevant or mutually exclusive service variant rules will not be validated and the respective questions will not be prompted to the customer. Hence, on average, less steps are required for a service to be personalised.

Concluding, the main theoretical implications of this *Thesis* are summarised in the following:

- It contributes to the conceptual modelling of service, focusing on customer-centric service modelling, which continues to be an open and active research field (refer to Chapter 2 for a complete review and analysis of the field), and works towards a harmonised view of service, covering both the modelling of service itself and the service lifecycle.

- It is an enabler towards the implementation of the customer-centricity requirement for services, which is prevalent both in the Web of Services and in Service Science, by emphasising and studying customer participation in the service lifecycle, and approaching the modelling of service from the customer viewpoint materialised through the definition of theoretical concepts such as perceived value, customer expectation and service feedback.
- It is one of the few efforts which spans across several areas, e.g. information systems or marketing. It combines fruitfully and brings together two major fields that study service, namely Service Science and the Web of Services, and transfers knowledge from one to the other.
- By introducing a common model for service, which aligns all existing efforts, it lowers the semantic interoperability barriers and contributes to the semantic interlinking and reusability of existing services, which are described using different semantic service models. Apart from benefiting customers and improving service provision in the Web of Services, this last point can also play a role in encouraging the industrial uptake of semantic services, which is often questioned, as it is not easy to prove that the benefits of applying semantic technologies to service systems always offset the implementation costs (Nixon et al., 2009).

6.3 Future research directions

This *Thesis* opens up potential for future research initiatives towards service modelling and standardisation as well as towards the development of service-based applications that will exploit customer-driven descriptions of services to realise real-life scenarios.

We identify four broad areas in the context of which the results of this *Thesis* can be utilised to foster further research and development, namely:

- Service modelling and standardisation (section 6.3.1);
- Next-generation service provision and applications (section 6.3.2);
- Linked services (section 6.3.3);
- Collection of social descriptions through social media (section 6.3.4); and
- Management of service portfolios (section 6.3.5).

6.3.1 Service modelling and standardisation

Standardisation of service models has attracted a lot of interest in the last decade. Numerous standardisation bodies, including all the major ones, i.e. W3C, OASIS and OMG, have worked on standards for services, focusing mostly on e-services and Web services. Such initiatives were detailed

in section 2.2. In October 2011, a large-scale service standardisation effort carried out in the context of W3C USDL XG[51] concluded its operation and published an all-inclusive report, documenting a big part of existing service modelling activities[52]. An early version of the service model introduced by this *Thesis* (Loutas et al., 2011) has been included in this report. The report, similar to the literature review of this *Thesis*, proves that currently numerous competing candidate service standards exist, thus leading to a fragmented view of the service.

Similarly, in the Web of Services, different service modelling efforts such as WSMO-Lite and USDL, are currently competing for the creation of machine-readable descriptions of RESTful services. Hence, the need for a Unified Service Model remains.

Our work contributes to the adoption of a unified (common) service representation. We acknowledge that the adoption of a reference model is primarily a social process that requires bringing together the community and building consensus on the meaning and the representation of service. Hence, the first steps should be towards creating awareness and engaging the community to the specific problem. Providing a first approach for triggering discussion is always a prerequisite to attract and create real possibilities for future adoption and take up, and this is what we did in this *Thesis*. Further steps need now to be taken in order to align existing efforts.

We also want to underline the fact that cross-discipline collaboration is required in order to develop a reference service system model that will combine a business view, i.e. coming from the business and marketing fields, a social view, i.e. coming from cognitive science, psychology and sociology, and a technological view, i.e. coming from computer science and information systems. This should not be overlooked.

The ISA process and methodology for developing semantic agreements[53], a collaborative approach for developing commonly-agreed domain models, which has been co-developed by the author of this *Thesis*, can be of use in this context.

6.3.2 Next-generation service provision and applications

The active engagement of customers in the service lifecycle – especially in the Web of Services – calls for advanced, customer-centric service platforms and architectures that will enable easy and controlled development and deployment of value-added services through innovative, easy to use and

[51] http://www.w3.org/2005/Incubator/usdl/wiki/Main_Page
[52] http://www.w3.org/2005/Incubator/usdl/XGR-usdl-20111027/
[53] https://joinup.ec.europa.eu/community/core_vocabularies/document/process-and-methodology-developing-semantic-agreements

adaptive service front-ends. The outcomes of this *Thesis* can be utilised and extended further in order to design and build such customer-centric service platforms and architectures. Such platforms can be applied to different service industries, including e-business, e-government and collaborative work environments.

The detailed study of service and the service lifecycle, including co-production interactions, as well as the Customer Service Model can drive the design of holistic service architectures that manage to engage customers, listen to their expectations and feedback and build further on these. For example, the realisation of social descriptions will bridge the gap between customer expectations and services delivered by such platforms. Services with high demand will be developed and refined further, while those that lag behind will be re-engineered or decommissioned depending on the feedback provided by the customers and their service usage behaviour on the platform.

Working along the lines of the prototypes presented in Chapter 5, customer-centric service platforms can build further on the service models proposed by this *Thesis* in order to improve service search, personalisation, recommendation and lightweight composition. Imagine a service platform that would be aware of the customer's profile, expectations and feedback, and context, and would adapt the available services accordingly. Trigerred by updates in the customer's profile related services could be recommended, hence supporting different aspects of the customer's personal, professional and social life. Based on the preferences of customers, irrelevant services may be filtered out, and the feedback of the customers shall be formalised and shared with service providers and other customers. We observe that popular social networking platforms, such as Facebook, are actually moving towards this direction already, and are bringing the service provision aspect in the social network. This is done as a source of revenue and so far is about advertising services, but the first step has definitely been done. The wealth of customers' feedback and the rich customer profiles stored in such platforms can be exploited to implement pure customer-centric service provision as defined in this *Thesis*.

The adaptation shall not be only in terms of service availability, but also in terms of accessibility, hence personalising not only the service input, but personalising also the interaction of the customer with the digital service.

Advanced, customer-centric service platforms and architectures will also lower the barriers for customers who want to co-develop and combine existing services into new value-added ones, often referred to under the term apps. The rapid growth of the app economy, in the EU alone valued at EUR 17,5 million in revenues in 2013[54], proves that this next-generation of services and applications

[54] Sizing the EU app economy, http://ec.europa.eu/digital-agenda/en/news/sizing-eu-app-economy (Feb, 2004)

developed by enterpreneurs and not necessarily by traditional service providers is already a reality, and the need exists for a new generation of service infrastructures to support development, provision and hosting. From a business perspective, this will boost entrepreneurship and will lead to a wave of individuals being service providers themselves. From a scientific perspective, the study of how ideas, knowledge and competencies are shared and integrated during service lifecycle will advance our understanding of service, thus benefiting Service Science as well as other social and economic disciplines involved. Interestingly however, apps are bound to face with all the challenges of traditional services, such as the need for proper descriptions, effective search and personalisation, easy access etc. Hence, the Customer Service Model can once again play a role, as the means for bridging the gap between app demand and supply by bringing together the customer and the provider viewpoint.

6.3.3 Connecting services with data on the Web

The Customer Service Model emerges at the time when the Web of Services meets the rapidly growing Web of Data. We see three main sources of data which can be linked to services in order to create new service offerings and to create more complete descriptions of existing services:

i. Open data published by governments, academia and civic organisation;
ii. Social data co-created by people on social media (see also section 6.3.3); and
iii. Real-time data produced by sensors, such as traffic and weather data.

This wealth of data can lead to new ways of describing services. Instead of having static descriptions of services, comprising “hard-coded” information typed in by the service provider, we propose moving to dynamic descriptions of services. Based on service models, such as the Unified Service Model and the Customer Service Model, we envision machine-readable descriptions of services which are created through the reuse of existing data sources. Linked data technologies can play a key role here, for connecting a service with the relevant data resources describing it. Imagine for example dynamic, machine-readable of service descriptions where, for example, texts describing the service provider or the service input are replaced by the URI of the organisation or that of a document respectively. Resolving these URIs would deliver to the customer even more information about the service. Service feedback would be populated from posts and information coming from social media, where customers are discussing services (see also 6.3.4). The service context and the customer context can be determined based on sensor data, and services can be adapted accordingly. Service relationships would be expressed as links between service URIs in a linked data fashion, hence allowing humans and machines to browse through the Web of Services.

6.3.4 Social descriptions and social media

In this work, we argue that service providers need to gather as much information as possible on customers' feedback and expectations on their services and organisation, to be included in social descriptions. We have discussed that having access to this information is crucial for service providers to determine their marketing strategy, reach out to new customers, improve their service offerings and lead service innovation.

A 2010 IBM whitepaper[55] highlights that in the U.S., over 92% of adults conduct research online and seek the opinions of others before they ever purchase a product from a store. Likewise, a recent article in the Huffington Post[56] emphasises on the influence that social media, twitter and facebook in particular, have on customers' intention and final decision to purchase a product. The situation is obviously similar in the service market.

As part of our future research, we aim to export customer opinions, expectations and feedback from social media posts and integrate these into service descriptions. This would require employing sentiment analysis and opinion mining techniques in order to elicit, formalise and represent in machine-readable formats the customer expectations and feedback from structured and unstructured text posted by customers on social networks.

The following generic steps should be followed in order to elicit from social media sentiment and opinions for a specific service:

- A semantic description of the service based on the RDF implementation of the Customer Service Model has to be created.
- Named Entity Recognition framrworks, such as GATE ANNIE[57], Lingpipe[58] and the Stanford NER[59], can be applied in order to identify and collect social media posts that refer to the specific service (the service name is modeled as an entity).
- Sentiment analysis and opinion mining techniques can then be employed in order to extract from the collected social media posts the sentiment of the customers for the specific service as well as opinions hidden in the text of posts (Liu and Zhang, 2012).

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[55] IBM Corporation, "Attention shoppers on a smarter planet" in the "A series of conversations for a smarter planet", available at http://www.ibm.com/smarterplanet/global/files/us__en_us__retail__smarterplanet_retail.pdf

[56] http://www.huffingtonpost.com/2012/04/02/twitter-business-shopping_n_1397799.html

[57] http://gate.ac.uk/ie/annie.html

[58] http://alias-i.com/lingpipe/

[59] http://nlp.stanford.edu/software/CRF-NER.shtml

- Sentiment and opinions can be formally represented using appropriate sentiment and opinion ontologies and published as linked data.
- Finally, sentiment and opinion data can be linked to a particular service as service feedback.

These service descriptions, which will be updated continuously, due to the continuous interactions of customers on social media, not only help service providers understand customer expectations, but also allow them to observe at real-time what is the sentiment of their (target) customers with regards to their services. This allows them to manage their branding and reputation, monitor and adapt their marketing strategies with greater flexibility, and react promptly when their reputation is at risk. For the customers, bringing their opinions and expectations into service descriptions, is the ultimate way of ensuring that their needs and requiremens will be considered in the design and delivery of services.

6.3.5 Management of service portfolios

We believe that work conducted in this Thesis with regards to modelling and capturing the customers' perspective on service can provide useful insights into methodologies about the management of service portfolios, such as ITIL[60]. The key objective of service portfolio management is to allow service providers to ensure that they have the right services to meet customers' needs at an appropriate level of investment. A key enabler to service portfolio management is the use of standardised service description templates for documenting the services that comprise a portfolio. Their use will result in standardised service descriptions which can help service providers with the rationalisation of their service portfolios. Its use can facilitate the discovery of relationships between services, such as related services, services with an output-input relationship and other relationships which we have introduced in 4.4.3.1.

In this vein, the Unified Service Model and the Customer Service Model can provide the basis for developing such templates by providing the different elements of service, from which an organisation can select those which have to be documented in the context of a specific scenario of use or application domain. Simple examples of service description templates have been used for documenting the public services piloted in Chapter 5. These examples can be found in Annex II.

Service description templates based on the Unified Service Model and the Customer Service Model are by definition also aligned with existing service standards (such as the ones described in Chapter 2), due to the way that these service models have been defined. Additionally, however, they force service providers to view service from the customer viewpoint. Up to now, the service evaluation

[60] Information Technology Infrastructure Library (ITIL) https://www.axelos.com/itil

criteria employed by service portofolio management approaches are based on indicators related to service performance, frequency of use, uptake, financial indicators etc. They are defined, based on what the service provider wants to know about the service. But is this always enough in order to take well informed decisions on the management of their services. We argue that understanding what is important for the customers, by analysing customer expectations and feedback, and understanding perceived value, are key sources for eliciting additional customer-driven key performance indicators (KPIs) for the evaluation of services, which may still be unknown or unforeseen.

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Annex I: The Unified Service Model and the Customer Service Model as a linked open vocabulary

A. The RDF vocabulary

```
@prefix xsd: <http://www.w3.org/2001/XMLSchema#>.
@prefix dcterms: <http://purl.org/dc/terms/>.
@prefix dctype: <http://purl.org/dc/dcmitype/>.
@prefix foaf: <http://xmlns.com/foaf/0.1/>.
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#>.
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>.
@prefix vann: <http://purl.org/vocab/vann/>.
@prefix owl: <http://www.w3.org/2002/07/owl#>.
@prefix adms: <http://www.w3.org/ns/adms#>.
@prefix cpsv: <http://purl.org/vocab/cpsv#>.
@prefix fea: <http://vocab.data.gov/def/fea#>.
@prefix prov: <http://www.w3.org/ns/prov#>.
@prefix wslt: <http://www.wsmo.org/ns/wsmo-lite/#>.
@prefix org: <http://www.w3.org/TR/vocab-org/>.
@prefix person: <http://www.w3.org/ns/person#>.
@prefix rov: <http://www.w3.org/TR/vocab-regorg/>.
@prefix dolce: <http://www.loa.istc.cnr.it/ontologies/DOLCE-Lite.owl#>.
@prefix skos: <http://www.w3.org/2004/02/skos/core#>.
@prefix msm: <http://iserve.kmi.open.ac.uk/ns/msm>.
@prefix schema: <http://schema.org>

@prefix csm: <http://islab.uom.gr/csm>.

# metadata

<http://islab.uom.gr/csm> a owl:Ontology, adms:Asset;
  dcterms:title "Customer Service Model"@en;
  dcterms:description ""@en;
  vann:preferredNamespacePrefix "csm";
  dcterms:publisher [foaf:name "Nikos Loutas"];
  dcterms:creator <http://nikosloutas.com>;
  dcterms:type <http://purl.org/adms/assettype/Ontology>;
  adms:status <http://purl.org/adms/status/UnderDevelopment>;
  dcterms:license <http://creativecommons.org/licenses/by-sa/2.0/>.

# classes
```

```
csm:Service a rdfs:Class, owl:Class;
  rdfs:label "Service"@en;
  skos:broader fea:Process, msm:Service, wslt:Service;
  rdfs:subClassOf  dctype:Service, schema:Service;
  dcterms:isPartOf csm:ServiceBundle;
  dcterms:description "A service constitutes the logical representation of business logic, encapsulated in a process that is delivered by a service provider to a customer. A service involves the transformation of resources contributed by both the service provider and the customer, and produces an outcome that fulfils specific needs of the latter."@en.

cpsv:ServiceInput a rdfs:Class, owl:Class;
  rdfs:label "ServiceInput"@en;
  rdfs:subClassOf csm:Resource;
  dcterms:description "The resources that customers have to contribute/provide in order to have the service delivered to them. Service input may refer to different types of resources, e.g. a credit card number, the customer's preferences or ID card number, and to skills and competencies. Service input is either provided directly from the customer or is acquired from other sources, e.g. a database or as the outcome of another service. Service input is required for the service to be initiated."@en.

cpsv:ServiceOutcome a rdfs:Class, owl:Class;
  rdfs:label "Service Outcome"@en;
  dcterms:description "Service outcome is what the customer receives after the successful execution of the service.  No outcome is produced otherwise, i.e. if the service execution fails."@en.

csm:ServiceAgent a rdfs:Class, owl:Class;
        rdfs:label "Service Agent"@en;
        rdfs:subClassOf foaf:Agent, dcterms:Agent;
        dcterms:description "The service agent is an entity that partakes in the provision of a service under some role(s)."@en.

csm:Resource a rdfs:Class, owl:Class;
        rdfs:label "Resource"@en;
        rdfs:subClassOf fea:Resource;
        dcterms:description "A service requires/consumes resources in order to be delivered. These resources are contributed during the delivery of the service by the service provider (and other service stakeholders) as well as by customers."@en.

csm:ServiceQuality a rdfs:Class, owl:Class;
        rdfs:label "Service Quality"@en;
        dcterms:description "Every service, including its outcome, is made available at a pre-determined level of service quality (defined by the service provider and/or the service owner)."@en.

csm:ServiceActivity a rdfs:Class, owl:Class;
        rdfs:label "Service Activity"@en;
        rdfs:subClassOf prov:Activity, schema:Action;
        dcterms:description "A service activity is an atomic step carried out as part of the service process."@en.

cpsv:Rule a rdfs:Class, owl:Class;
```

```
  rdfs:label "Service Rule"@en;
  rdfs:comment "The Rule class represents the specific rules, guidelines or procedures that the service follows. We models rules following OMG's Semantics Of Business Vocabulary And Rules."@en.

csm:ServiceChannel a rdfs:Class, owl:Class;
        rdfs:label "Service Channel"@en;
        dcterms:description "A channel is a defined a way that the customer can use for interacting with the service, providing preferences and input and/or receiving the service outcome."@en.

csm:ServiceContext a rdfs:Class, owl:Class;
        rdfs:label "Service Context"@en;
        dcterms:description "A service is designed and provided in a wider environment that is influenced and formed by several factors, e.g. business, political and spatio-temporal."@en.

csm:CustomerContext a rdfs:Class, owl:Class;
        rdfs:label "Customer context"@en;
        rdfs:subClassOf csm:ServiceContext;
        dcterms:description "Customers act prior to, during and after service provision in a wider environment that has several dimensions."@en.

csm:Need a rdfs:Class, owl:Class;
        rdfs:label "Need"@en;
        dcterms:description "The Longman dictionary defines need as 'a strong feeling that you want something, want to do something, or that you must have something'. Customers have needs, e.g. I am hungry, I want to travel or I have to submit my annual tax declaration, which are satisfied via services."@en.

csm:PerceivedValue a rdfs:Class, owl:Class;
        rdfs:label "Perceived Value"@en;
        dcterms:description "Perceived value refers to the way that a customer understands and feels the benefit delivered by a service that she just consumed."@en.

csm:Sacrifice a rdfs:Class, owl:Class;
        rdfs:label "Sacrifice"@en;
        dcterms:description "Sacrifice models the cost that the customer had to undertake, e.g. in terms of effort, time and/or resources, in order to consume the service."@en.

csm:ServiceEffect a rdfs:Class, owl:Class;
        rdfs:label "Service Effect"@en;
        skos:broader wslt:Effect;
        dcterms:isPartOf cpsv:ServiceOutcome;
        dcterms:description "The acquisition of the outcome has an effect on the customer and/or her context, i.e. it changes/alters the current state of the customer and/or her context. "@en.

csm:CustomerExpectation a rdfs:Class, owl:Class;
        rdfs:label "Customer Expectation"@en;
        dcterms:hasPart schema:UserLikes , schema:UserComments;
        dcterms:description "Customer's expectation models the customer's anticipation of the service in terms of outcome and effect, experience and quality."en.
```

```
csm:ServiceFeedback a rdfs:Class, owl:Class;
        rdfs:label "Service Feedback"@en;
        rdfs:subClassOf schema:Review;
        dcterms:hasPart schema:UserLikes , schema:UserComments;
        dcterms:description "Service feedback represents evaluation, opinions and judgements with regards to the service that a customer recently consumed. Service feedback is tightly link to experiences gained during the consumption of the service."@en.

csm:ServiceBundle a rdfs:Class, owl:Class;
  rdfs:label "Service Bundle"@en;
  dcterms:description "A service bundle is defined as a group of complementary and/or tightly related services that fulfil a specific complex need of a customer or are targeted to a specific type of customers."@en.

schema:Demand a rdfs:Class, owl:Class;
        rdfs:label "Service Demand"@en;
        dcterms:description "Service demand represents the public, not necessarily binding, not necessarily exclusive, announcement by an organisation or person to seek a certain type of services."en.

csm:ServiceDescription a rdfs:Class, owl:Class;
        rdfs:label "Service Description"@en;
        dcterms:description "Service description represents a collection of machine-readable metadata about the service, like the ones defined in this vocabulary. The service description is co-created by the service provider and the customer, thus encompassing both viewpoints. "en.

csm:FunctionalDescriptions a rdfs:Class, owl:Class;
        rdfs:label "Functional Descriptions"@en;
        dcterms:isPartOf csm:ServiceDescription;
        dcterms:description "The Functional Descriptions describe the service's functionalities, namely what a service can offer to its customers if consumed and completed successfully."en.

csm:NonFunctionalDescriptions a rdfs:Class, owl:Class;
        rdfs:label "Non-Functional Descriptions"@en;
        dcterms:isPartOf csm:ServiceDescription;
        dcterms:description "The Non-Functional Descriptions describe the service's quality, delivery details or the context of the service."en.

csm:BehaviouralDescriptions a rdfs:Class, owl:Class;
        rdfs:label "Behavioural Descriptions"@en;
        dcterms:isPartOf csm:ServiceDescription;
        dcterms:description "The Behavioural Descriptions describe the behaviour of a service, namely the service's public choreography or the internal workflow of a service."en.

csm:TechnicalDescriptions a rdfs:Class, owl:Class;
        rdfs:label "Technical Descriptions"@en;
        dcterms:isPartOf csm:ServiceDescription;
        dcterms:description "The Behavioural Descriptions describe the details regarding the technology used by the service."en.

csm:SocialDescriptions a rdfs:Class, owl:Class;
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```
        rdfs:label "Social Descriptions"@en;
        dcterms:isPartOf csm:ServiceDescription;
        dcterms:description "Social descriptions encompass structured information about customers' expectations and feedback. They can express the customer viewpoint of the service and capture customer satisfaction. Social descriptions refer to information which includes knowledge regarding the customers' expectations (subjective opinion) from the service and customer satisfaction. Social descriptions provide valuable insights on the reputation of a specific service and service provider among the individuals that comprise the target market."en.

csm:ImplicitSocialDescriptions a rdfs:Class, owl:Class;
        rdfs:label "Implicit Social Descriptions"@en;
        rdfs:subClassOf csm:SocialDescriptions;
        dcterms:hasPart schema:UserPageVisits;
        dcterms:description "Implicit social descriptions refer mostly to service usage patterns and latent service relations that are created throughout the service lifecycle in the context of co-production interactions".en.

csm:ExplicitSocialDescriptions a rdfs:Class, owl:Class;
        rdfs:label "Explicit Social Descriptions"@en;
        rdfs:subClassOf csm:SocialDescriptions;
        dcterms:hasPart schema:UserLikes , schema:UserComments;
        dcterms:description "Explicit social descriptions represent information about a service expressed directly and consciously by customers, such as their expectations of and/or feedback on athe service"en.

csm:MarketSegment a rdfs:Class, owl:Class;
        rdfs:label "Market segment"@en;
        dcterms:description "Market segment represent arbitrary groupings of customers using different criteria, e.g. geographical, financial or demographic."en.

# properties (all of which are object type properties)

cpsv:produces a rdf:Property, owl:ObjectProperty;
  rdfs:label "produces"@en;
  rdfs:comment "The produces property links a service to one or more instances of the output class which is its range."@en;
  rdfs:range cpsv:ServiceOutcome, csm:ServiceEffect.

cpsv:receives a rdf:Property, owl:ObjectProperty;
  rdfs:label "receives"@en;
  rdfs:comment "The receives property links customer to outcome. After the successful execution of a service, the customer receives its outcome"@en;
  rdfs:comment "The receives property also links service to service feedback (inverse property of schema:about".

csm:commissions a rdf:Property, owl:ObjectProperty;
        rdfs:label "commissions"@en;
        rdfs:comment "A service owner may commission one or more service providers for making its service available to the customers."@en;
        rdfs:domain csm:ServiceAgent;
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        rdfs:range csm:ServiceAgent.

csm:delivers a rdf:Property, owl:ObjectProperty;
        rdfs:label "delivers"@en;
        rdfs:comment "The delivers property relates a service agent to a thing delivered by it."@en;
        rdfs:domain csm:ServiceAgent.

csm:governs a rdf:Property, owl:ObjectProperty;
        rdfs:label "governs"@en;
        rdfs:comment "The governs property relates a service agent the service context. The legal and
political dimensions of service context are governed by service regulators. "@en;
        rdfs:domain csm:ServiceAgent;
        rdfs:range csm:Service.

csm:communicatedTo a rdf:Property, owl:ObjectProperty;
        rdfs:label "communicated to"@en;
        rdfs:comment "The communicatedTo property relates service outcome to a service agent. The
outcome of a service may be communicated to zero or more follow-up recipients."@en;
        rdfs:range csm:ServiceAgent.

dcterms:type a rdf:Property, owl:ObjectProperty;
        rdfs:label "of type"@en;
        rdfs:comment "The dcterms:type property is used for indicating the type/category of any resource
in CSM."@en.

dcterms:isPartOf a rdf:Property, owl:ObjectProperty;
        rdfs:label "is part of"@en;
        rdfs:comment "The dcterms:isPartOf property is used for indicating a reflexive property between
two resources, where the the second if part of the first."@en.

dcterms:requires a rdf:Property, owl:ObjectProperty;
        rdfs:label "requires"@en;
        rdfs:comment "The dcterms:requires property is used for indicating the resources required by a
service."@en.
        rdfs:range csm:Resource.

dolce:has-quality a rdf:Property, owl:ObjectProperty;
        rdfs:label "has quality"@en;
        rdfs:comment "The dolce:has-quality property is used for relating a service to its predetermined
level of quality."@en.

csm:defines a rdf:Property, owl:ObjectProperty;
        rdfs:label "defines"@en;
        rdfs:comment "The defines property is used for indicating that a things is set by another thing."@en.

cpsv:follows a rdf:Property, owl:ObjectProperty;
  rdfs:label "follows"@en;
  rdfs:comment "The cpsv:follows property links a service to the service rule(s) under which it operates."@en.
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```
schema:deliveryMethod  a rdf:Property, owl:ObjectProperty;
  rdfs:label "delivered through"@en;
  rdfs:comment "The schema:deliveryMethod property links service and service outcome to the different service channels through which they are accessible."@en.

csm:hasContext a rdf:Property, owl:ObjectProperty;
  rdfs:label "has context"@en;
  rdfs:comment "The hasContext property links a service or a consumer to the context in which it is delivered/acts."@en;
  rdfs:range csm:ServiceContext.

csm:hasDimension a rdf:Property, owl:ObjectProperty;
  rdfs:label "has dimension"@en;
  rdfs:comment "The hasDimension property links contexts to its dimensions, e.g. legal, political etc."@en;
  rdfs:range skos:Concept.

csm:hasNeed a rdf:Property, owl:ObjectProperty;
  rdfs:label "has need"@en;
  rdfs:comment "The hasNeed property links a customer to her need(s)."@en;
  rdfs:domain csm:Customer;
  rdfs:range csm:Need.

csm:satisfiedBy a rdf:Property, owl:ObjectProperty;
  rdfs:label "satisfied by"@en;
  rdfs:comment "The satisfiedBy property links a need to the service(s) that fulfil it."@en;
  rdfs:domain csm:Need;
  rdfs:range csm:Service.

csm:feels a rdf:Property, owl:ObjectProperty;
  rdfs:label "feels"@en;
  rdfs:comment "The feels property relates a customer to the perceived value of a particular service. In the end, perceived value is a feeling, something that the customer can sense and experience."@en;
  rdfs:domain csm:Customer;
  rdfs:range csm:PerceivedValue.

csm:participatesInAs a rdf:Property, owl:ObjectProperty;
  rdfs:label "participates in as"@en;
  rdfs:comment "This very general property links an service agent to the role(s) that it plays in a service."@en;
  rdfs:domain dcterms:Agent.

csm:interacts a rdf:Property, owl:ObjectProperty;
  rdfs:label "interacts"@en;
  rdfs:comment "The interacts property relates customer to service channel to express the fact that a customer interacts with a service through different service channels."@en.

dcterms:relation a rdf:Property, owl:ObjectProperty;
  rdfs:label "relates"@en;
  rdfs:comment "The dcterms:relation property fully represents the different types of relations between services, e.g. services that are related because of: (i) targeting the same audience; (ii) being provided by the
```

same provider; (iii) being complementary - i.e. they have to/should be executed together in order to satisfy a customer's need; (iv) being similar to other services that a customer has consumed in the past. A service may relate to zero or more other services."@en.

csm:providesInputTo a rdf:Property, owl:ObjectProperty;
  rdfs:label "provides input to"@en;
  rdfs:subPropertyOf dcterms:relation;
  rdfs:comment "The provides input to property expresses cases when a service has to be executed prior to another one in order for the outcome of the first to be used as input for the second."@en.

csm:executedAfter a rdf:Property, owl:ObjectProperty;
  rdfs:label "executed after"@en;
  rdfs:subPropertyOf dcterms:relation;
  rdfs:comment "The executed after property is used in situations when a service has to be executed after another one. Executed after indicates a special case of complementary services where their execution sequence is well-defined."@en.

csm:substitutes a rdf:Property, owl:ObjectProperty;
  rdfs:label "substitutes"@en;
  rdfs:subPropertyOf dcterms:relation;
  rdfs:comment "The substitutes property in cases when a service can be used instead of another one. A service can have zero or more substitutes, i.e. other services that can deliver the same outcome. Different substitutes may require the same or different sacrifice by the customer and may be have different quality considerations."@en.

schema:isVariantOf a rdf:Property, owl:ObjectProperty;
  rdfs:label "is version of"@en;
  rdfs:subPropertyOf dcterms:relation;
  rdfs:comment "The schema:isVariantOf property fully represents the relationship between service version and service, in order to express that a service is specialised into one or more service versions"@en.

schema:about a rdf:Property, owl:ObjectProperty;
  rdfs:label "concerns"@en;
  rdfs:comment "The schema:about property fully represents the relationship between service feedback/customer's expectation and service. "@en.

dcterms:contributor a rdf:Property, owl:ObjectProperty;
  rdfs:label "contributes"@en;
  rdfs:comment "The dcterms:contributor property fully represents the different types of relations between service agents and resources and descriptions of services (including also feedback and expectations)."@en;
  rdfs:domain csm:ServiceAgent.

rdf:describedBy a rdf:Property, owl:ObjectProperty;
  rdfs:label "described by"@en;
  rdfs:comment "The rdf:describedBy property fully represents that a service is described by a service description."@en.

csm:impactedBy a rdf:Property, owl:ObjectProperty;
  rdfs:label "impacted by"@en;

```
  rdfs:comment "The impacted by property relates customer expectation to customer context, in order to indicate the fact that the expectations of customers are formed on the basis of different inputs and influence, coming among others from the customer context, e.g. through interactions with others who have previously consumed the service, and from the pre-determined level of service quality promised by the service provider.@en.

csm:actsIn a rdf:Property, owl:ObjectProperty;
  rdfs:label "acts in"@en;
  rdfs:comment "The acts in property relates customer to customer context, thus showing that customers experience services in their own context"@en
  rdfs:domain csm:ServiceAgent
  rdfs:range csm:ServiceContext.

csm:validatedBy a rdf:Property, owl:ObjectProperty;
  rdfs:label "validated by"@en;
  rdfs:comment "The validates property relates service input to service rule. A service rule requires information in order to be validated, this information is provided via the service input."@en
  rdfs:domain csm:ServiceRule
  rdfs:range csm:ServiceInput.
```

B. The SKOS taxonomies

```
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix foaf: <http://xmlns.com/foaf/0.1/> .
@prefix owl: <http://www.w3.org/2002/07/owl#> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix skos: <http://www.w3.org/2004/02/skos/core#> .


<http://islab.uom.gr/csm/service-agent-roles/ServiceProvider> a skos:Concept ;
        skos:prefLabel "Service Provider" ;
        skos:definition "The service provider is the entity that is responsible for the coordination of the overall provision of a service, i.e. designing the service, making it available to clients, coordinating and controlling other stakeholders involved in the process, and ensuring a rich and high-quality service experience. " ;
        skos:inScheme "http://islab.uom.gr/csm/service-agent-roles/1.00" .

<http://islab.uom.gr/csm/service-agent-roles/Customer> a skos:Concept ;
        skos:prefLabel "Customer" ;
        skos:definition "The customer is the entity that consumes/uses/experiences a service in order to satisfy a specific need, want or obligation. " ;
        skos:inScheme "http://islab.uom.gr/csm/service-agent-roles/1.00" .

<http://islab.uom.gr/csm/service-agent-roles/ServiceBroker> a skos:Concept ;
        skos:prefLabel "Service Broker" ;
```

skos:definition "The service broker is an independent mediator that facilitates the contact and the transactions between a service provider and a customer, e.g. a yellow page service or a service marketplace. The service broker may advertise, promote and sell the services of a specific provider to customers. " ;
skos:inScheme "http://islab.uom.gr/csm/service-agent-roles/1.00" .

<http://islab.uom.gr/csm/service-agent-roles/ServiceStakeholder> a skos:Concept ;
skos:prefLabel "Service Stakeholder" ;
skos:definition "A service stakeholder is an entity (natural or legal) that carries out (part of) a service activity and/or has an interest in the service." ;
skos:inScheme "http://islab.uom.gr/csm/service-agent-roles/1.00" .

<http://islab.uom.gr/csm/service-agent-roles/ServiceOwner> a skos:Concept ;
skos:prefLabel "Service owner" ;
skos:definition "The service owner is the entity that has the primary responsibility to design and deliver a service. The service owner is also responsible for decision-making or escalation of decisions. Normally, the service provider is the same as the owner of the service. However, there are cases where the service owner may commission a third organisation to provide the service on their behalf." ;
skos:broader "http://islab.uom.gr/csm/service-agent-roles/ServiceStakeholder" ;
skos:inScheme "http://islab.uom.gr/csm/service-agent-roles/1.00" .

<http://islab.uom.gr/csm/service-agent-roles/ResourceProvider> a skos:Concept ;
skos:prefLabel "Resource provider" ;
skos:definition "A resource provider is an entity that contributes operant resources, materials and tangible goods or technical infrastructure that are required for delivering the service activities. " ;
skos:broader "http://islab.uom.gr/csm/service-agent-roles/ServiceStakeholder" ;
skos:inScheme "http://islab.uom.gr/csm/service-agent-roles/1.00" .

<http://islab.uom.gr/csm/service-agent-roles/FrontstageEntity> a skos:Concept ;
skos:prefLabel "Frontstage entity" ;
skos:definition "The frontstage entity undertakes the the communication between service provider and service customer, e.g. the exchange of information regarding customer preferences and needs or the delivery of the outcome to the customer. " ;
skos:broader "http://islab.uom.gr/csm/service-agent-roles/ServiceStakeholder" ;
skos:inScheme "http://islab.uom.gr/csm/service-agent-roles/1.00" .

<http://islab.uom.gr/csm/service-agent-roles/ServiceRegulator> a skos:Concept ;
skos:prefLabel "Service regulator" ;
skos:definition "The service regulator sets and governs the context of service provision. " ;
skos:broader "http://islab.uom.gr/csm/service-agent-roles/ServiceStakeholder" ;
skos:inScheme "http://islab.uom.gr/csm/service-agent-roles/1.00" .

<http://islab.uom.gr/csm/service-agent-roles/FollowUpRecipient> a skos:Concept ;
skos:prefLabel "Follow-up recipient" ;
skos:definition "Follow-up recipients are notified with regards to the outcome of the service and may have to act upon it." ;
skos:broader "http://islab.uom.gr/csm/service-agent-roles/ServiceStakeholder" ;
skos:inScheme "http://islab.uom.gr/csm/service-agent-roles/1.00" .

<http://islab.uom.gr/csm/service-agent-roles/ServiceCollaborator> a skos:Concept ;

skos:prefLabel "Service collaborator" ;
skos:definition "Apart from the roles already defined, different stakeholders may partake in the service process by undertaking fully or participating in the delivery of any of the service activities, e.g. validating information, performing a specific step of the service process or providing approval. We group this type of stakeholders under the term service collaborator. The nature of the tasks and the activities performed by the service collaborators depends heavily on the characteristics of the specific service and on the service industry. " ;
skos:broader "http://islab.uom.gr/csm/service-agent-roles/ServiceStakeholder" ;
skos:inScheme "http://islab.uom.gr/csm/service-agent-roles/1.00" .

<http://islab.uom.gr/csm/service-agent-roles/SecondaryBeneficiary> a skos:Concept ;
skos:prefLabel "Secondary beneficiary" ;
skos:definition "In some cases, other entities, apart from the service user, may also benefit from a service and its outcome. " ;
skos:broader "http://islab.uom.gr/csm/service-agent-roles/ServiceStakeholder" ;
skos:inScheme "http://islab.uom.gr/csm/service-agent-roles/1.00" .

<http://islab.uom.gr/csm/service-agent-roles/CriticalAudience> a skos:Concept ;
skos:prefLabel "Critical audience" ;
skos:definition "The critical audience refers to a service agent or a group of service agents that are interested in learning about the service but do not intend to or cannot use/experience it themselves. " ;
skos:broader "http://islab.uom.gr/csm/service-agent-roles/ServiceStakeholder" ;
skos:inScheme "http://islab.uom.gr/csm/service-agent-roles/1.00" .

<http://islab.uom.gr/csm/service-agent-roles/ProspectiveCustomer> a skos:Concept ;
skos:prefLabel "Prospective customer" ;
skos:definition "The prospective customer refers to an entity that is interested in using the service in order to receive its outcome or to integrate it with other services and/or resources." ;
skos:broader "http://islab.uom.gr/csm/service-agent-roles/Customer" ;
skos:inScheme "http://islab.uom.gr/csm/service-agent-roles/1.00" .

<http://islab.uom.gr/csm/service-agent-roles/ServiceConsumer> a skos:Concept ;
skos:prefLabel "Service consumer " ;
skos:definition "We define the term service consumer, specialising the generic term customer, to refer to the entity that successfully completed the service search phase, found a service that addresses his need, purchased, initiated and experienced this service, and received its outcome. The service user is the primary beneficiary of the service." ;
skos:broader "http://islab.uom.gr/csm/service-agent-roles/Customer" ;
skos:inScheme "http://islab.uom.gr/csm/service-agent-roles/1.00" .

<http://islab.uom.gr/csm/service-agent-roles/OperantResourceProvider> a skos:Concept ;
skos:prefLabel "Operant resource provider" ;
skos:definition "Operant resource providers bring knowledge, information, skills, human capital, competencies and capabilities to the service process" ;
skos:broader "http://islab.uom.gr/csm/service-agent-roles/ResourceProvider" ;
skos:inScheme "http://islab.uom.gr/csm/service-agent-roles/1.00" .

<http://islab.uom.gr/csm/service-agent-roles/OperandResourceProvider> a skos:Concept ;
skos:prefLabel "Operant resource provider" ;

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skos:definition "Operand resource providers contribute materials, tangible resources and goods that are required for the provision of a specific service." ;
skos:broader "http://islab.uom.gr/csm/service-agent-roles/ResourceProvider" ;
skos:inScheme "http://islab.uom.gr/csm/service-agent-roles/1.00" .

<http://islab.uom.gr/csm/service-agent-roles/InfrastructureProvider> a skos:Concept ;
skos:prefLabel "Infrastructure provider" ;
skos:definition "The infrastructure provider provides the technological infrastructure required for delivering a specific service." ;
skos:broader "http://islab.uom.gr/csm/service-agent-roles/ResourceProvider" ;
skos:inScheme "http://islab.uom.gr/csm/service-agent-roles/1.00" .

<http://islab.uom.gr/csm/service-agent-roles/ICTInfrastructureProvider> a skos:Concept ;
skos:prefLabel "ICT infrastructure provider" ;
skos:definition "An ICT infrastructure provider is defined as the entity that provides ubiquitous and on-demand access to computing resources, e.g. computing power, storage and networks." ;
skos:broader "http://islab.uom.gr/csm/service-agent-roles/InfrastructureProvider" ;
skos:inScheme "http://islab.uom.gr/csm/service-agent-roles/1.00" .

<http://islab.uom.gr/csm/service-agent-roles/PhysicalInfrastructureProvider> a skos:Concept ;
skos:prefLabel "Physical infrastructure provider" ;
skos:definition "A physical infrastructure provider contributes buildings and equipment to the service process based on a fixed contract or on a pay-per-use base" ;
skos:broader "http://islab.uom.gr/csm/service-agent-roles/InfrastructureProvider" ;
skos:inScheme "http://islab.uom.gr/csm/service-agent-roles/1.00" .

<http://islab.uom.gr/csm/service-agent-types/NaturalPerson> a skos:Concept ;
skos:prefLabel "Natural Person" ;
skos:exactMatch "http://www.w3.org/ns/person#Person" ;
skos:inScheme "http://islab.uom.gr/csm/service-agent-types/1.00" .

<http://islab.uom.gr/csm/service-agent-types/Organisation> a skos:Concept ;
skos:prefLabel "Organisation" ;
skos:exactMatch "http://www.w3.org/TR/vocab-org/Organisation" ;
skos:inScheme "http://islab.uom.gr/csm/service-agent-types/1.00" .

<http://islab.uom.gr/csm/service-agent-types/LegalEntity> a skos:Concept ;
skos:prefLabel "Legal Entity" ;
skos:broader "http://islab.uom.gr/csm/service-agent-types/Organisation" ;
skos:exactMatch "http://www.w3.org/TR/vocab-regorg/RegisteredOrganisation" ;
skos:inScheme "http://islab.uom.gr/csm/service-agent-types/1.00" .

<http://islab.uom.gr/csm/service-agent-types/PublicOrganisation> a skos:Concept ;
skos:prefLabel "Public Organisation" ;
skos:definition "A public administration operating at any level of government, i.e. local, regional, national or international. " ;
skos:broader "http://islab.uom.gr/csm/service-agent-types/Organisation" ;
skos:inScheme "http://islab.uom.gr/csm/service-agent-types/1.00" .
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<http://islab.uom.gr/csm/service-agent-types/OtherOrganisation> a skos:Concept ;
skos:prefLabel "Other Organisaton" ;
skos:definition "e.g. an NGO or a professional association " ;
skos:broader "http://islab.uom.gr/csm/service-agent-types/Organisation" ;
skos:exactMatch "http://www.w3.org/TR/vocab-org/FormalOrganisation" ;
skos:inScheme "http://islab.uom.gr/csm/service-agent-types/1.00" .

<http://islab.uom.gr/csm/context-dimension/Business> a skos:Concept ;
skos:prefLabel "Business dimension" ;
skos:definition "The business dimension of context models the business and organisational environment of service provision. It covers the motivation and the business case for delivering a particular service and defines the main roles and responsibilities. This is usually encapsulated in a business policy." ;
skos:inScheme "http://islab.uom.gr/csm/context-dimension/1.00" .

<http://islab.uom.gr/csm/context-dimension/Social> a skos:Concept ;
skos:prefLabel "Social dimension" ;
skos:definition "The social dimension of context models the cultural and societal environment that the service and/or the customer operates in, e.g. moral values and attitudes. We assume that demographics are included in the social dimension as well. " ;
skos:inScheme "http://islab.uom.gr/csm/context-dimension/1.00" .

<http://islab.uom.gr/csm/context-dimension/PoliticalLegal> a skos:Concept ;
skos:prefLabel "Political and legal dimension" ;
skos:definition "The political and legal dimension of context models the system of government, the national and international laws, government regulations, directives and policies that govern the delivery of a service. The service agents and the service activities must conform to these laws and regulations" ;
skos:inScheme "http://islab.uom.gr/csm/context-dimension/1.00" .

<http://islab.uom.gr/csm/context-dimension/Economic> a skos:Concept ;
skos:prefLabel "Economic dimension" ;
skos:definition "The economic dimension of context models the set of economic factors, benchmarks and indices that influence the service, e.g. income, inflation, interest rates, productivity, and wealth." ;
skos:inScheme "http://islab.uom.gr/csm/context-dimension/1.00" .

<http://islab.uom.gr/csm/context-dimension/SpatioTemporal> a skos:Concept ;
skos:prefLabel "Spatio-temporal dimension" ;
skos:definition "A service is delivered at a specific place on a specific date and at a specific point in time. The date and time of service delivery is agreed upon between service provider and customer. Additionally, a service may also be available for a specific period, i.e. between a start and an end date and time. " ;
skos:inScheme "http://islab.uom.gr/csm/context-dimension/1.00" .

<http://islab.uom.gr/csm/context-dimension/Personal> a skos:Concept ;
skos:prefLabel "Personal dimension" ;
skos:definition "The personal dimension of customer context models the customer's unique experiences, peculiarities, habits and relationships to others, e.g. family, friends, co-workers. " ;
skos:inScheme "http://islab.uom.gr/csm/context-dimension/1.00" .

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<http://islab.uom.gr/csm/context-dimension/Emotional> a skos:Concept ;
        skos:prefLabel "Emotional dimension" ;
        skos:definition "The emotional dimension of customer context models the mood, the disposition and the motivation of the customer throughout the provision of a particular service. Emotional context directly related to cognitive activities, such as judgements, opinions, evaluations, and thoughts." ;
        skos:inScheme "http://islab.uom.gr/csm/context-dimension/1.00" .

<http://islab.uom.gr/csm/resource-type/OperantResource> a skos:Concept ;
        skos:prefLabel "Operant resource" ;
        skos:definition "Operant resources act upon other resources to create benefit and value (Vargo and Lusch 2004)" ;
        skos:inScheme "http://islab.uom.gr/csm/resource-type/1.00" .

<http://islab.uom.gr/csm/resource-type/OperandResource> a skos:Concept ;
        skos:prefLabel "Operand resource" ;
        skos:definition "Operand resources must be acted upon to create benefit and value (Vargo and Lusch 2004)" ;
        skos:inScheme "http://islab.uom.gr/csm/resource-type/1.00" .

<http://islab.uom.gr/csm/resource-type/FinancialResource> a skos:Concept ;
        skos:prefLabel "Financial resource" ;
        skos:definition "Financial resources act as facilitators for the provision of a specific service, e.g. a bank loan or (own) funding. " ;
        skos:inScheme "http://islab.uom.gr/csm/resource-type/1.00" .

<http://islab.uom.gr/csm/resource-type/KnowledgeResource> a skos:Concept ;
        skos:prefLabel "Knowledge resource" ;
        skos:broader "http://islab.uom.gr/csm/resource-type/OperantResource" ;
        skos:inScheme "http://islab.uom.gr/csm/resource-type/1.00" .

<http://islab.uom.gr/csm/resource-type/InformationResource> a skos:Concept ;
        skos:prefLabel "Information resource" ;
        skos:broader "http://islab.uom.gr/csm/resource-type/OperantResource" ;
        skos:inScheme "http://islab.uom.gr/csm/resource-type/1.00" .

<http://islab.uom.gr/csm/resource-type/Skill> a skos:Concept ;
        skos:prefLabel "Skill" ;
        skos:broader "http://islab.uom.gr/csm/resource-type/OperantResource" ;
        skos:inScheme "http://islab.uom.gr/csm/resource-type/1.00" .

<http://islab.uom.gr/csm/resource-type/NaturalResource> a skos:Concept ;
        skos:prefLabel "Natural resource" ;
        skos:broader "http://islab.uom.gr/csm/resource-type/OperandResource" ;
        skos:inScheme "http://islab.uom.gr/csm/resource-type/1.00" .

<http://islab.uom.gr/csm/resource-type/Good> a skos:Concept ;
        skos:prefLabel "Good" ;
        skos:broader "http://islab.uom.gr/csm/resource-type/OperandResource" ;
        skos:inScheme "http://islab.uom.gr/csm/resource-type/1.00" .
```

```
<http://islab.uom.gr/csm/resource-type/TechnicalInfrastructure> a skos:Concept ;
        skos:prefLabel "Technical infrastructure" ;
        skos:broader "http://islab.uom.gr/csm/resource-type/OperandResource" ;
        skos:inScheme "http://islab.uom.gr/csm/resource-type/1.00" .

<http://islab.uom.gr/csm/rule-type/EligibilityRule> a skos:Concept ;
        skos:prefLabel "Eligibility rule" ;
        skos:definition "Eligibility rules define conditions that have to be met by the customer in order for the service execution to be initiated, e.g. she has to be over 18 years old or she has to be physically present. " ;
        skos:broader "http://islab.uom.gr/csm/rule-type/OperativeRule" ;
        skos:inScheme "http://islab.uom.gr/csm/rule-type/1.00" .

<http://islab.uom.gr/csm/rule-type/ServiceVariantRule> a skos:Concept ;
        skos:prefLabel "Service variant rule" ;
        skos:definition "Service variant rules are used for defining the Service Version that best matches the profile and circumstances of a particular type of customers (e.g. customer that are below 18 years old must use the version of the service for minors)." ;
        skos:broader "http://islab.uom.gr/csm/rule-type/OperativeRule" ;
        skos:inScheme "http://islab.uom.gr/csm/rule-type/1.00" .

<http://islab.uom.gr/csm/rule-type/BehaviouralRule> a skos:Concept ;
        skos:prefLabel "Behavioural rule" ;
        skos:definition "Behavioural rules govern the conduct and delivery of service activities, i.e. define and control the workflow of the service.  " ;
        skos:broader "http://islab.uom.gr/csm/rule-type/OperativeRule" ;
        skos:inScheme "http://islab.uom.gr/csm/rule-type/1.00" .

<http://islab.uom.gr/csm/rule-type/OperativeRule> a skos:Concept ;
        skos:prefLabel "Operative service rule" ;
        skos:definition "SBVR (2013) defines operative rules as rules that govern the conduct of service activities." ;
        skos:inScheme "http://islab.uom.gr/csm/rule-type/1.00" .

<http://islab.uom.gr/csm/coproduction-interaction/CustomerCoprodInter> a skos:Concept ;
        skos:prefLabel "Customer-driven co-production interaction" ;
        skos:inScheme "http://islab.uom.gr/csm/coproduction-interaction/1.00" .

<http://islab.uom.gr/csm/coproduction-interaction/ProviderCoprodInter> a skos:Concept ;
        skos:prefLabel "Provider-driven co-production interaction" ;
        skos:inScheme "http://islab.uom.gr/csm/coproduction-interaction/1.00" .

<http://islab.uom.gr/csm/coproduction-interaction/ServiceSearch> a skos:Concept ;
        skos:prefLabel "Service search" ;
        skos:broader "http://islab.uom.gr/csm/coproduction-interaction/CustomerCoprodInter" ;
        skos:inScheme "http://islab.uom.gr/csm/coproduction-interaction/1.00" .

<http://islab.uom.gr/csm/coproduction-interaction/ServicePersonalisation> a skos:Concept ;
```

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        skos:prefLabel "Service personalisation" ;
        skos:broader "http://islab.uom.gr/csm/coproduction-interaction/CustomerCoprodInter" ;
        skos:inScheme "http://islab.uom.gr/csm/coproduction-interaction/1.00" .

<http://islab.uom.gr/csm/coproduction-interaction/ServiceNegotiation> a skos:Concept ;
        skos:prefLabel "Service terms negotiation" ;
        skos:broader "http://islab.uom.gr/csm/coproduction-interaction/CustomerCoprodInter" ;
        skos:inScheme "http://islab.uom.gr/csm/coproduction-interaction/1.00" .

<http://islab.uom.gr/csm/coproduction-interaction/ServiceInitiation> a skos:Concept ;
        skos:prefLabel "Service initiation" ;
        skos:broader "http://islab.uom.gr/csm/coproduction-interaction/CustomerCoprodInter" ;
        skos:inScheme "http://islab.uom.gr/csm/coproduction-interaction/1.00" .

<http://islab.uom.gr/csm/coproduction-interaction/ServiceEvaluation> a skos:Concept ;
        skos:prefLabel "Service evaluation" ;
        skos:broader "http://islab.uom.gr/csm/coproduction-interaction/CustomerCoprodInter" ;
        skos:inScheme "http://islab.uom.gr/csm/coproduction-interaction/1.00" .

<http://islab.uom.gr/csm/coproduction-interaction/ServiceMining> a skos:Concept ;
        skos:prefLabel "Service mining" ;
        skos:broader "http://islab.uom.gr/csm/coproduction-interaction/ProviderCoprodInter" ;
        skos:inScheme "http://islab.uom.gr/csm/coproduction-interaction/1.00" .

<http://islab.uom.gr/csm/coproduction-interaction/ServiceDesign> a skos:Concept ;
        skos:prefLabel "(New) services (re)design" ;
        skos:broader "http://islab.uom.gr/csm/coproduction-interaction/ProviderCoprodInter" ;
        skos:inScheme "http://islab.uom.gr/csm/coproduction-interaction/1.00" .

<http://islab.uom.gr/csm/coproduction-interaction/DisputeResolution> a skos:Concept ;
        skos:prefLabel "Dispute resolution" ;
        skos:broader "http://islab.uom.gr/csm/coproduction-interaction/ProviderCoprodInter" ;
        skos:inScheme "http://islab.uom.gr/csm/coproduction-interaction/1.00" .
```

Annex II: Description public services using the Unified Service Model and the Customer Service Model

A. Greek Naturalisation public service

Service	**Naturalisation of adult alien** This service is executed in the case that the alien wants to acquire the Greek citizenship with naturalisation.
Service outcome	Decision regarding the acquisition of the greek citizenship
Service effect	The alien acquires the Greek citizenship
Customer	Alien (that wants to acquire the Greek citizenship)
Service Provider	Region of Central Macedonia – Department of Civil Status, Aliens and Immigration
Service rules	Eligibility rules: • Must not have been convicted during the last decade before the submission of the naturalisation application for sentences as described in Par. 1β' of L. 3284/2004; • Must be an adult during the time of submission of the naturalisation application; • Must not have a pending decision of deportation; • Must have adequate knowledge of the Greek language, history and civilisation. Service variant rules: • The alien be a legal resident in Greece for ten (10) years during the last twelve (12) years before the submission of the application (excluding the time spent in the country as a diplomatic or administrative employee of a foreign country – if any). • In the case of refugees (alien or without citizenship), it is required to be a Greek resident for five (5) years in the last twelve (12) years (except from the time spend in the country as a diplomatic or administrative employee of a foreign country). • In the case of the husband/wife of Greek citizen who has a child with a Greek, it is required to be a Greek resident for three years (the time period is counted from the date of marriage). • In case of aliens that that were born and are residents of Greece, there is no time requirement. • For the husband/wife of Greek diplomatic employees that have completed one year of residency in Greece and serve abroad, the time period includes the residency in a foreign country due to husband's/wife's diplomatic service.

	• In case of medal winners in the Olympic Games, honorary naturalisation is applied, provided that they are staying legally in Greece for a minimum of five years.
Legal context	L. 3284/2004
Service stakeholders	Municipality *(Frontstage entity)*; Ministry of Administrative Reform and eGovernance *(service collaborator)*; Greek Police *(service collaborator* & *follow-up recipient).*
Service input	Application of naturalisation, Statement of Naturalisation, Copy of Passport, Residence Permit, Birth certificate, Tax Statement of the last fiscal year, Penal Certificate for Court use, Certificate of non-deportation

B. Registration of a business in the Chamber of Commerce

Service	Registration in the Chios Chamber of Commerce
Service outcome	Registration Certificate.
Service effect	The business is registerd in the Chamber of Commerce and can commence its activities.
Customer	The businesses that are active are obliged to register in the Chamber of Commerce.
Service Provider	Chamber of Commerce
Service rules	Eligibility rules: • The legal name or the business to be registered must be available in the registry of the Chamber of Commerce, i.e. it must no be in use by another company. Service variant rules: • All companies must pay the full registration fee if they are registered in the first half of the year. The amount of the fee depends on the type of the company. • All companies must pay half of the registration fee if they are registered in the second half of the year. The amount of the fee depends on the type of the company. • All companies must pay the annual fee. The amount of the fee depends on the type of the company. • Owners of companies (or board members) who are not Greek citizens or citizens of an EU Member State must be residing legally in Greece. • Owners of companies (or board members) who are not Greek citizens or citizens of an EU Member State must have a work permit.
Legal context	Law 1712/1987, Law 3419/2005
Service stakeholders	Court Authority *(service collaborator);* Tax Authority *(service collaborator & follow up recipient).*
Service input	Common for all service versions: • Copy of the Identification Card or Passport of the members of the Board. • Copy of the Business Inception Certificate (and any alterations) Service-version-specific service input (depending on the company type: • Accredited Copy of the Article of Incorporation and possible alterations (SA, Ltd. Association, General Partnership) • Detachment of the General Assembly (Association) • Copy of the registration of the company to the Chios Perfecture SA companies Record (SA)

	• Copy of Chios Perfecture Statement regarding the Board of Directors composition (or any alterations) or Copy of the corresponding Government Gazette (SA)

C. Provision of grant to new farmers in Greece public service

Service	Provision of grant to new farmers in Greece
Service outcome	The grant itself
Service effect	The new farmer receives the grant to start up a new settlement
Customer	A new farmer wishing to receive a grant in order to start up a new establishment
Service Provider	Ministry of Rural Development
Service rules	Eligibility Rules • Each applicant must be leading the operation of an agricultural holding of magnitude more that 0.5 Units of Human Work (UHW). • Each applicant must be over 18 years old and under 40 years old (at the submission day for subsidy). • Each applicant has settled for the first time at his own agricultural holding of magnitude more than 0.5 units of human work (UHW). • Each applicant has become for the first time leader on farmland within 18 months from the date of the incorporation decision. • Each applicant must be a natural person. • Each applicant must not fall into the following categories: civil servants (permanent or with contract) , everyone working at a Public Entity or a private legal entity, military staff, employees, freelancers, owners of companies, pensioners, students. • Each applicant must not receive a handicap allowance having handicap of 67% or more. • Each applicant must have a total family income (applicant, spouse and their children) of less than 150% of the reference income. • Each applicant must have a total personal non-agricultural income of less than 100% of the reference income. • Each applicant must not be serving prison service or pending against them a prosecution for cultivation, possession, or trading of drugs, animal stealing, environmental destruction, or fraud against the state, or it has not passed more than three years from the serving of any penalty for offenses. Service variant rules • The subsidy amount differs taking into account the permanent place of residence • The subsidy amount differs taking into account the direction of the agricultural holding at the business plan. • The amount of subsidy differs taking into account the total income of the agricultural holding at the business plan. • Each applicant who is not a Greek citizen or a citizen of an EU Member State must be residing legally in Greece. • Each applicant who is not a Greek citizen or a citizen of an EU Member State must have a work permit. • If the applicant does not submit an income declaration, he should prove that he is not obliged to do so.

	• Each applicant who wants to establish a new beehive must ensure that the beehives are registered at the registers of the Ministry of Rural Development and Food.
Legal context	Law 17371/20.11.2008 (704/2008), Law 2655/30.3.2010
Service stakeholders	Municipality where the applicant resides *(service front-end)*
Service input	Common for all service versions: • Aid application • Signed long-standing business plan • Solemn declaration of the law 1599/86 • Accredited copy of the ID card or passport • Accredited copy of the Unified Declaration of Holding of the applicant and his/her spouse for all the years a declarations has been submitted. • Family status document • Certification of the permanent place of residence from the mayor, with resent date. • Copies of income statement of the last 3 years (documents E1, E3) and the corresponding liquidation notes • Property statement (document E9) initial declaration and any modifications made • Copy of service bulletin of the editor of the business plan • Accredited copy of the major title. • Documents approving the first settlement of the applicant as leader of the agricultural holding • Income statements that include incomes from agricultural holdings • Certification of the registration at the Farmer and Farmer Holdings Registry of the local Directorate of Rural Development • Purchase contracts of farmland that include crop (if not sublet to others) • Documents approving the lease of farm land containing crops For non-Greek citizens: • Document of permanent residence certification for an EU citizen, or • Permanent residence card for a family member of an EU citizen For employees and freelancers: • Accredited copy of business closure by the IRS • Firing document (accredited by the Unemployment Office) • Voluntary leave (accredited by the Unemployment Office) • Pause of unemployment fund • Certificate of interruption from the insurance agency For employees that have a fix term contract or a seasonal contract and for those paid with wage: • Term specific contracts • Copy of the insured person's account by the Social Insurance Institution For beehive • Documents approving the possession of bees. • Sales invoice or consignment note (in case of special VAT) for the purchase of beehives • Private contract for the purchase of livestock accredited by the Directorate of Rural Development.

	• Proof of donation of livestock/beehives if the donation is made by parents, accredited by the Directorate of Rural Development. • Accredited copy of the beekeeping book of the candidate. For livestock • Documents approving the possession of livestock. • Pass permission or copy of pass lists to community grasslands. • Accredited copy of the registry of livestock/poultry holding • Milk percentage document from the Hellenic Organisation of Dairy and Meat • Documents approving the transfer of livestock: • Sales invoice or consignment note (in case of special VAT) for the purchase of livestock • Private contract for the purchase of livestock accredited by the Directorate of Rural Development. For those not submitting tax declaration: • Solemn declaration, declaring that the reasons.

Annex III: S-PSP: Instance of the Dialogue Ontology for the Registration of a business in the Chamber of Commerce public service

```
@prefix doc: <http://www.owl-ontologies.com/DocumentOntology.owl#> .
@prefix owl: <http://www.w3.org/2002/07/owl#> .
@prefix do: <http://www.owl-ontologies.com/DialogueOntology.owl#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
@prefix dcterms:: < http://purl.org/dc/terms/> .
@prefix csm: <http://islab.uom.gr/csm/>.

<http://www.owl-ontologies.com/RegistrationOntology.owl> a owl:Ontology ;
   rdfs:label "Business Registration public service"^^xsd:string ;
   do:hasKeywords "business registration, registration, SME"^^xsd:string ;
   rdfs:comment "This service is going to be used by SMEs that want to register their busines to Chios's
Chamber of Commerce"^^xsd:string .

:DetermineOccupation a do:InternalNode ;
   do:hasChildNode :OccupationExemptsRegistration,
      :OccupationObligesRegistration ;
   do:hasCondition :OccupationObligesRegistering ;
   do:hasDescription "Applicant with an occupation that requires registration"^^xsd:string ;
   do:hasQuestion :qstnCompanyType ;
   do:isRoot true .

:EquityBetween a csm:ServiceRule ;
   do:hasQuery "PREFIX bo:<http://www.owl-ontologies.com/BusinessOntology.owl#>          PREFIX
rdf:<http://www.w3.org/1999/02/22-rdf-syntax-ns#>          PREFIX
xsd:<http://www.w3.org/2001/XMLSchema#>          SELECT ?x FROM <http://www.owl-
ontologies.com/BusinessOntology.owl>          WHERE { ?x rdf:type ?t.  FILTER(?t=bo:SME). ?x
bo:hasEquityCapital ?it. FILTER(?it=bo:Fund_between_64000_and_16000).}"^^xsd:string ;
   rdfs:comment "Checks if the EU applicant requires licencing and is registering an association"^^xsd:string.

:EquityLess a csm:ServiceRule ;
   do:hasQuery "PREFIX bo:<http://www.owl-ontologies.com/BusinessOntology.owl#>          PREFIX
rdf:<http://www.w3.org/1999/02/22-rdf-syntax-ns#>          PREFIX
xsd:<http://www.w3.org/2001/XMLSchema#>          SELECT ?x FROM <http://www.owl-
ontologies.com/BusinessOntology.owl>          WHERE { ?x rdf:type ?t.  FILTER(?t=bo:SME). ?x
bo:hasEquityCapital ?it. FILTER(?it=bo:Fund_less_Than_64000).}"^^xsd:string ;
   rdfs:comment "Checks if the EU applicant requires licencing and is registering an association"^^xsd:string.

:EquityMore a csm:ServiceRule ;
```

```
   do:hasQuery "PREFIX bo:<http://www.owl-ontologies.com/BusinessOntology.owl#>          PREFIX
rdf:<http://www.w3.org/1999/02/22-rdf-syntax-ns#>          PREFIX
xsd:<http://www.w3.org/2001/XMLSchema#>          SELECT ?x FROM <http://www.owl-
ontologies.com/BusinessOntology.owl>            WHERE { ?x rdf:type ?t.  FILTER(?t=bo:SME). ?x
bo:hasEquityCapital ?it. FILTER(?it=bo:Fund_more_than_160000).}"^^xsd:string ;
   rdfs:comment "Checks if the EU applicant requires licencing and is registering an association"^^xsd:string.

:IsEUCitizen a csm:ServiceRule ;
   do:hasQuery "PREFIX bo:<http://www.owl-ontologies.com/BusinessOntology.owl#>              PREFIX
rdf:<http://www.w3.org/1999/02/22-rdf-syntax-ns#>              PREFIX
xsd:<http://www.w3.org/2001/XMLSchema#>              SELECT ?x              FROM <http://www.owl-
ontologies.com/BusinessOntology.owl>              WHERE { ?x rdf:type ?t. FILTER(?t=bo:SME).
?x bo:hasCitizenship ?c.                    ?c rdf:type ?ct.
FILTER(?ct=bo:EUCitizenship).}"^^xsd:string ;
   rdfs:comment "Checks if the applicant is an EU citizen"^^xsd:string .

:IsNonEUCitizen a csm:ServiceRule ;
   do:hasQuery "PREFIX bo:<http://www.owl-ontologies.com/BusinessOntology.owl#>    PREFIX
rdf:<http://www.w3.org/1999/02/22-rdf-syntax-ns#>    PREFIX
xsd:<http://www.w3.org/2001/XMLSchema#>    SELECT ?x FROM <http://www.owl-
ontologies.com/BusinessOntology.owl>    WHERE { ?x rdf:type ?t. FILTER(?t=bo:SME).          ?x
bo:hasCitizenship ?c.          ?c rdf:type ?ct.          FILTER(?ct=bo:NonEUCitizenship).}"^^xsd:string ;
   rdfs:comment "Checks if the applicant is not an EU citizen"^^xsd:string .

:LicencedAssociation a csm:ServiceRule ;
   do:hasQuery "PREFIX bo:<http://www.owl-ontologies.com/BusinessOntology.owl#>          PREFIX
rdf:<http://www.w3.org/1999/02/22-rdf-syntax-ns#>          PREFIX
xsd:<http://www.w3.org/2001/XMLSchema#>          SELECT ?x FROM <http://www.owl-
ontologies.com/BusinessOntology.owl>            WHERE { ?x rdf:type ?t.  FILTER(?t=bo:SME). ?x
bo:hasInstitutionForm ?it. FILTER(?it=bo:Association).}"^^xsd:string ;
   rdfs:comment "Checks if the EU applicant requires licencing and is registering an association"^^xsd:string.

:LicencedGenlPartnership a csm:ServiceRule ;
   do:hasQuery "PREFIX bo:<http://www.owl-ontologies.com/BusinessOntology.owl#>          PREFIX
rdf:<http://www.w3.org/1999/02/22-rdf-syntax-ns#>          PREFIX
xsd:<http://www.w3.org/2001/XMLSchema#>          SELECT ?x FROM <http://www.owl-
ontologies.com/BusinessOntology.owl>            WHERE { ?x rdf:type ?t.  FILTER(?t=bo:SME). ?x
bo:hasInstitutionForm ?it. FILTER(?it=bo:General_Partnership).}"^^xsd:string ;
   rdfs:comment "Checks if the EU applicant requires licencing and is registering a general
partnership"^^xsd:string .

:LicencedLtdCompany a csm:ServiceRule ;
   do:hasQuery "PREFIX bo:<http://www.owl-ontologies.com/BusinessOntology.owl#>          PREFIX
rdf:<http://www.w3.org/1999/02/22-rdf-syntax-ns#>          PREFIX
xsd:<http://www.w3.org/2001/XMLSchema#>          SELECT ?x FROM <http://www.owl-
ontologies.com/BusinessOntology.owl>            WHERE { ?x rdf:type ?t.  FILTER(?t=bo:SME). ?x
bo:hasInstitutionForm ?it. FILTER(?it=bo:LTD_Company).}"^^xsd:string .

:LicencedSACompany a csm:ServiceRule ;
```

```
   do:hasQuery "PREFIX bo:<http://www.owl-ontologies.com/BusinessOntology.owl#>          PREFIX
rdf:<http://www.w3.org/1999/02/22-rdf-syntax-ns#>          PREFIX
xsd:<http://www.w3.org/2001/XMLSchema#>          SELECT ?x FROM <http://www.owl-
ontologies.com/BusinessOntology.owl>            WHERE { ?x rdf:type ?t.  FILTER(?t=bo:SME). ?x
bo:hasInstitutionForm ?it. FILTER(?it=bo:SA_Company).}"^^xsd:string ;
   rdfs:comment "Checks if the EU applicant requires licencing and is registering an association"^^xsd:string.

:LicencedSoleProprietorship a csm:ServiceRule ;
   do:hasQuery "PREFIX bo:<http://www.owl-ontologies.com/BusinessOntology.owl#>          PREFIX
rdf:<http://www.w3.org/1999/02/22-rdf-syntax-ns#>          PREFIX
xsd:<http://www.w3.org/2001/XMLSchema#>          SELECT ?x FROM <http://www.owl-
ontologies.com/BusinessOntology.owl>            WHERE { ?x rdf:type ?t.  FILTER(?t=bo:SME). ?x
bo:hasInstitutionForm ?it. FILTER(?it=bo:Sole_Proprietorship).}"^^xsd:string ;
   rdfs:comment "Checks if the applicant requires licencing and has a Sole Proprietorship"^^xsd:string .

:ObligesRegistration_Association a do:InternalNode ;
   do:hasChildNode :firstHalf, :secondHalf ;
   do:hasCondition :LicencedAssociation ;
   dcterms:requires doc:Application,
      doc:ArticleOfIncorporation,
      doc:BusinessInceptionCertificate,
      doc:DetachmentOfGenAssemblyAndBoDProceedings,
      doc:IDorPassport,
      doc:annualRegistrationFeeAss ;
   do:hasQuestion :qstnRegistrationDate.

:ObligesRegistration_GenlParnership a do:InternalNode ;
   do:hasChildNode :firstHalf,
      :secondHalf ;
   do:hasCondition :LicencedGenlPartnership ;
   dcterms:requires doc:Application,
      doc:ArticleOfIncorporation,
      doc:BusinessInceptionCertificate,
      doc:IDorPassport,
   doc:annualRegistrationFeeAss ;
   do:hasQuestion :qstnRegistrationDate.

:ObligesRegistration_LtdCompany a do:InternalNode ;
   do:hasChildNode :firstHalf, :secondHalf ;
   do:hasCondition :LicencedLtdCompany ;
   dcterms:requires doc:Application,
      doc:ArticleOfIncorporation,
      doc:BusinessInceptionCertificate,
      doc:IDorPassport,
      doc:annualRegistrationLtd ;
   do:hasQuestion :qstnRegistrationDate.

:ObligesRegistration_SA a do:InternalNode ;
   do:hasChildNode :SA_equitybetween, :SA_equityless, :SA_equitymore ;
```

```
   do:hasCondition :LicencedSACompany ;
   dcterms:requires doc:Application,
      doc:ArticleOfIncorporation,
      doc:BusinessInceptionCertificate,
      doc:Chios_Perfecture_Statement,
      doc:IDorPassport,
     doc:annualRegistrationFeeSA ;
   do:hasQuestion :qstnEquityCapital.

:ObligesRegistration_SoleProprietorship a do:InternalNode ;
   do:hasChildNode :Personal_firstHalf,  :Personal_secondHalf ;
   do:hasCondition :LicencedSoleProprietorship ;
   dcterms:requires doc:Application,
      doc:BusinessInceptionCertificate,
      doc:IDorPassport,
      doc:annualRegistrationFeeSP ;
   do:hasQuestion :qstnRegistrationDate.

:OccupationExemptsRegistration a do:LeafNode ;
      dcterms:requires  doc:Exception;
   do:hasCondition :OccupationsExemptsRegistering ;
   do:hasDescription """If your profession is not in the list, you do not need to complete this service.
      Please return to the main page to see the complete list of services."""^^xsd:string;
   do:isDeadNode true .

:OccupationObligesRegistration a do:InternalNode ;
   do:hasChildNode :ObligesRegistration_Association,
      :ObligesRegistration_GenlParnership,
      :ObligesRegistration_LtdCompany,
      :ObligesRegistration_SA,
      :ObligesRegistration_SoleProprietorship ;
   do:hasCondition :OccupationObligesRegistering ;
   do:hasQuestion :qstnCompanyForm .

:OccupationsExemptsRegistering a csm:ServiceRule ;
   do:hasData "     PREFIX bo:<http://www.owl-ontologies.com/BusinessOntology.owl#>          PREFIX
rdf:<http://www.w3.org/1999/02/22-rdf-syntax-ns#>          PREFIX
xsd:<http://www.w3.org/2001/XMLSchema#>          SELECT ?x FROM <http://www.owl-
ontologies.com/BusinessOntology.owl>            WHERE { ?x rdf:type ?t.  FILTER(?t=bo:SME). ?x
bo:hasOccupation ?occ. ?occ bo:obligesRegistration ?y.  FILTER(xsd:boolean(?y)=false).}"^^xsd:string .

:Personal_firstHalf a do:InternalNode ;
   dcterms:requires  doc:annualRegistrationFeePersonal;
   do:hasChildNode :EU,
      :NonEU ;
   do:hasCondition :Before ;
   do:hasQuestion :qstnCitizenship .

:Personal_secondHalf a do:InternalNode ;
```

```
   dcterms:requires  doc:annualRegistrationFeePersonalHalf;
   do:hasChildNode :EU,
      :NonEU ;
   do:hasCondition :After ;
   do:hasQuestion :qstnCitizenship .

:SA_equitybetween a do:InternalNode ;
   do:hasChildNode :SA_equitybetween_firstHalf,
      :SA_equitybetween_secondHalf ;
   do:hasCondition :EquityBetween ;
   do:hasQuestion :qstnRegistrationDate .

:SA_equitybetween_firstHalf a do:InternalNode ;
   dcterms:requires  doc:FeeSA;
   do:hasChildNode :EU,
      :NonEU ;
   do:hasCondition :Before ;
   do:hasQuestion :qstnCitizenship .

:SA_equitybetween_secondHalf a do:InternalNode ;
   dcterms:requires  doc:FeeSAHalf;
   do:hasChildNode :EU,
      :NonEU ;
   do:hasCondition :After ;
   do:hasQuestion :qstnCitizenship .

:SA_equityless a do:InternalNode ;
   do:hasChildNode :SA_equityless_firstHalf,
      :SA_equityless_secondHalf ;
   do:hasCondition :EquityLess ;
   do:hasQuestion :qstnRegistrationDate .

:SA_equityless_firstHalf a do:InternalNode ;
   dcterms:requires  doc:annualFeeSAEqLess;
   do:hasChildNode :EU, :NonEU ;
   do:hasCondition :Before ;
   do:hasQuestion :qstnCitizenship .

:SA_equityless_secondHalf a do:InternalNode ;
   dcterms:requires  doc:annualFeeSAEqLessHalf;
   do:hasChildNode :EU, :NonEU ;
   do:hasCondition :After ;
   do:hasQuestion :qstnCitizenship.

:SA_equitymore a do:InternalNode ;
   do:hasChildNode :SA_equitymore_firstHalf, :SA_equitymore_secondHalf ;
   do:hasCondition :EquityMore ;
   do:hasQuestion :qstnRegistrationDate .
```

```
:SA_equitymore_firstHalf a do:InternalNode ;
   dcterms:requires  doc:annualFeeSAEqMore;
   do:hasChildNode :EU, :NonEU ;
   do:hasCondition :Before ;
   do:hasQuestion :qstnCitizenship .

:SA_equitymore_secondHalf a do:InternalNode ;
   dcterms:requires  doc:annualFeeSAEqMoreHalf;
   do:hasChildNode :EU, :NonEU ;
   do:hasCondition :After ;
   do:hasQuestion :qstnCitizenship .

:qstnCompanyForm a do:Question ;
   do:hasData "What is the legal status of your company?"@en ;
   rdfs:comment "SA Company, Association etc."^^xsd:string .

:qstnCompanyType a do:Question ;
   do:hasData "What is your profession?"@en ;
   rdfs:comment "Different professions"^^xsd:string .

:qstnEquityCapital a do:Question ;
   do:hasAnswer ""^^xsd:string ;
   do:hasData "What is the equity capital?"@en .

:OccupationObligesRegistering a csm:ServiceRule ;
   do:hasQuery "PREFIX bo:<http://www.owl-ontologies.com/BusinessOntology.owl#>          PREFIX
rdf:<http://www.w3.org/1999/02/22-rdf-syntax-ns#>          PREFIX
xsd:<http://www.w3.org/2001/XMLSchema#>          SELECT ?x WHERE { ?x rdf:type ?t.  FILTER(?t=bo:SME).
?x bo:hasOccupation ?occ. ?occ bo:obligesRegistration ?y.  FILTER(xsd:boolean(?y)=true).}"^^xsd:string ;
   rdfs:comment "Checks if the applicant has specified an occupation that requires registration"^^xsd:string.

:firstHalf a do:InternalNode ;
   dcterms:requires  doc:annualFee;
   do:hasChildNode :EU,  :NonEU ;
   do:hasCondition :Before ;
   do:hasQuestion :qstnCitizenship .

:secondHalf a do:InternalNode ;
   dcterms:requires  doc:annualFeeHalf;
   do:hasChildNode :EU, :NonEU ;
   do:hasCondition :After ;
   do:hasQuestion :qstnCitizenship .

:After a csm:ServiceRule ;
   do:hasQuery "PREFIX bo:<http://www.owl-ontologies.com/BusinessOntology.owl#>          PREFIX
rdf:<http://www.w3.org/1999/02/22-rdf-syntax-ns#>          PREFIX
xsd:<http://www.w3.org/2001/XMLSchema#>  SELECT ?x FROM <http://www.owl-
ontologies.com/BusinessOntology.owl>       WHERE { ?x rdf:type ?t.  FILTER(?t=bo:SME). ?x
```

```
bo:hasRegistrationDate ?date. ?date bo:hasName ?name. FILTER(regex(?name,\"second
half\",\"i\")).}"^^xsd:string ;
   rdfs:comment "Checks if the Registration is before"^^xsd:string .

:Before a csm:ServiceRule ;
   do:hasQuery "PREFIX bo:<http://www.owl-ontologies.com/BusinessOntology.owl#>          PREFIX
rdf:<http://www.w3.org/1999/02/22-rdf-syntax-ns#>          PREFIX
xsd:<http://www.w3.org/2001/XMLSchema#>  SELECT ?x FROM <http://www.owl-
ontologies.com/BusinessOntology.owl>       WHERE{ ?x rdf:type ?t.  FILTER(?t=bo:SME).  ?x
bo:hasRegistrationDate ?date. ?date bo:hasName ?name. FILTER(regex(?name,\"first
half\",\"i\")).}"^^xsd:string ;
   rdfs:comment "Checks if the Registration is before"^^xsd:string .

:qstnRegistrationDate a do:Question ;
   do:hasAnswer ""^^xsd:string ;
   do:hasData "What is the date of business registration?"@en .

:EU a do:LeafNode ;
   do:hasCondition :IsEUCitizen ;
   do:hasDescription "EU citizen (other than plumber or electrician) who wishes to register a
company"^^xsd:string,
      "EU plumber or electrician who wishes to register an association"^^xsd:string ;
   do:isDeadNode false .

:NonEU a do:LeafNode ;
   do:hasCondition :IsNonEUCitizen ;
   do:hasDescription "EU citizen (other than plumber or electrician) who wishes to register a
company"^^xsd:string,
      "EU plumber or electrician who wishes to register an association"^^xsd:string ;
   dcterms:requires doc:WorkPermitAndResidencePermit ;
   do:isDeadNode false .

:qstnCitizenship a do:Question ;
   do:hasAnswer ""^^xsd:string ;
   do:hasData "What is your citizenship?"@en .
```

Annex IV: Rule-based expert service system

A. Prolog rules for the Greek Naturalisation public service

Prolog rules and facts

```
adult(X):-menuask(do:qrAdult,X).
deportation(X):-menuask(do:qrDeportation,X).
convicted(X):-menuask(do:qrConvicted,X).
greek(X):-menuask(do:qrGreek,X).
naturalisation(X):-menuask(do:qrNaturalisation,X).
firstApplication(X):-menuask(do:qrFirstApplication,X).
prosfora(X):-menuask(do:qrProsfora,X).
consulate_registry(X):-menuask(do:qrConsulate_registry,X).
lausanne(X):-menuask(do:qrLausanne,X).
essd(X):-menuask(do:qrESSD,X).
decision_ESSD(X):-menuask(do:qrDecision_ESSD,X).
noMarried(X):-menuask(do:qrNoMarried,X).
decision_nonESSD(X):-menuask(do:qrDecision_nonESSD,X).
recognitionDate(X):-menuask(do:qrRecognitionDate,X).
legal_adoption(X):-menuask(do:qrLegal_adoption,X).
noAdult_at_adoption(X):-menuask(do:qrNoAdult_at_adoption,X).
adoptionDate(X):-menuask(do:qrAdoptionDate,X).
arrenwn(X):- menuask(do:qrArrenwn,X).
childOfGreek(X):-menuask(do:qrchildOfGreek,X).
citizenship_revocation(X):-menuask(do:qrCitizenship_revocation,X).

%----------------------ELIGIBILITY--------------------------------------------
naturalisation_eligibility(eligible):-
convicted(do:ansNo),citizenship_revocation(do:ansNo),deportation(do:ansNo).

node(greek_naturalisation,eligibility):- naturalisation_eligibility(eligible).
node(greek_naturalisation,notEligible_convicted):-
convicted(do:ansYes),(http_session_data(recommend(no))->!;[]).
node(greek_naturalisation,notEligible_citizenship_revocation):-
citizenship_revocation(do:ansYes),(http_session_data(recommend(no))->!;[]).
node(greek_naturalisation,notEligible_deportation):-
deportation(do:ansYes),(http_session_data(recommend(no))->!;[]).

%----------------------naturalisation-------------------------------------------
citizenship(naturalisation):-naturalisation_eligibility(eligible),adult(do:ansYes), greek(do:ansYes),
naturalisation(do:ansStay).
citizenship(naturalisation):-naturalisation_eligibility(eligible),adult(do:ansYes), greek(do:ansYes),
naturalisation(do:ansSpouse).
citizenship(naturalisation):-naturalisation_eligibility(eligible),adult(do:ansYes), greek(do:ansYes),
naturalisation(do:ansNoCitizenship).
```

```
citizenship(naturalisation):-naturalisation_eligibility(eligible),adult(do:ansYes), greek(do:ansYes),
naturalisation(do:ansAthlete).

node(greek_naturalisation,naturalisation):-  citizenship(naturalisation).
node(greek_naturalisation,naturalisation_married):-     citizenship(naturalisation),
naturalisation(do:ansSpouse).
node(greek_naturalisation,naturalisation_athlete):-     citizenship(naturalisation),
naturalisation(do:ansAthlete).
node(greek_naturalisation,naturalisation_first):-  citizenship(naturalisation),
firstApplication(do:ansYes),(http_session_data(recommend(no))->!;[]).
node(greek_naturalisation,naturalisation_second):-  citizenship(naturalisation),
firstApplication(do:ansNo),(http_session_data(recommend(no))->!;[]).

%----------------honorary naturalisation----------------------------------------
citizenship(honorary_naturalisation):- naturalisation_eligibility(eligible),adult(do:ansYes),
prosfora(do:ansYes).
node(greek_naturalisation,honorary_naturalisation):-
citizenship(honorary_naturalisation),(http_session_data(recommend(no))->!;[]).

%---------------ORKWMOSIA-----------------------------------------------------
citizenship(swearing):-
naturalisation_eligibility(eligible),essd(do:ansYes),adult(do:ansYes),greek(do:ansYes),consulate_registry(do:
ansYes),lausanne(do:ansNo).
node(greek_naturalisation,swearing):-citizenship(swearing),(http_session_data(recommend(no))->!;[];[]).

%--------------EKDOSH APOFASHS ESSD-------------------------------------------
citizenship(decision_ESSD):-naturalisation_eligibility(eligible),essd(do:ansYes), adult(do:ansYes),
lausanne(do:ansNo),decision_ESSD(do:ansParent_born_greek).
citizenship(decision_ESSD):-naturalisation_eligibility(eligible),essd(do:ansYes), adult(do:ansYes),
lausanne(do:ansNo),decision_ESSD(do:ansArmy).
citizenship(decision_ESSD):-naturalisation_eligibility(eligible),essd(do:ansYes), adult(do:ansNo),
lausanne(do:ansNo),decision_ESSD(do:ansFather_army), noMarried(do:ansYes).

node(greek_naturalisation,decision_ESSD):-citizenship(decision_ESSD).
node(greek_naturalisationdecision_ESSD_parent_born_greek):-citizenship(decision_ESSD),
decision_ESSD(do:ansParent_born_greek),(http_session_data(recommend(no))->!;[]).
node(greek_naturalisation,decision_ESSD_army):-citizenship(do:decision_ESSD),
decision_ESSD(do:ansArmy),(http_session_data(recommend(no))->!;[]).

%------------EKDOSH APOFASH EKTOS ESSD-------------------------------------------
citizenship(decision_nonESSD):-naturalisation_eligibility(eligible),essd(do:ansNo),
decision_nonESSD(do:ansGreek_ancestor).
citizenship(decision_nonESSD):-naturalisation_eligibility(eligible),essd(do:ansNo),
decision_nonESSD(do:ansRecognition),adult(do:ansNo), noMarried(do:ansYes),recognitionDate(do:ansYes).
citizenship(decision_nonESSD):-
naturalisation_eligibility(eligible),essd(do:ansNo),decision_nonESSD(do:ansAdoption),legal_adoption(do:an
sYes),noAdult_at_adoption(do:ansYes),adoptionDate(do:ansYes).
citizenship(decision_nonESSD):-
naturalisation_eligibility(eligible),essd(do:ansNo),decision_nonESSD(do:ansArmy).
```

```
citizenship(decision_nonESSD):-
naturalisation_eligibility(eligible),essd(do:ansNo),decision_nonESSD(do:ansMuslim).
citizenship(decision_nonESSD):-
naturalisation_eligibility(eligible),essd(do:ansNo),decision_nonESSD(do:ansRefugee).
citizenship(decision_nonESSD):-
naturalisation_eligibility(eligible),essd(do:ansNo),decision_nonESSD(do:ansConsulate_registry),
arrenwn(do:ansYes).
citizenship(decision_nonESSD):-naturalisation_eligibility(eligible),essd(do:ansNo),
decision_nonESSD(do:ansChildOfGreek),childOfGreek(do:ansCivil_marriage).
citizenship(decision_nonESSD):-
naturalisation_eligibility(eligible),essd(do:ansNo),decision_nonESSD(do:ansChildOfGreek),childOfGreek(do:
ansGreek_mother).
citizenship(decision_nonESSD):-naturalisation_eligibility(eligible),essd(do:ansNo),
decision_nonESSD(do:ansChildOfGreek),childOfGreek(do:ansFather_army).

node(greek_naturalisation,decision_nonESSD):-citizenship(decision_nonESSD).
node(greek_naturalisation,decision_nonESSD_greek_ancestor):-citizenship(decision_nonESSD),
decision_nonESSD(do:ansGreek_ancestor),(http_session_data(recommend(no))->!;[]).
node(greek_naturalisation,decision_nonESSD_recognition):-citizenship(decision_nonESSD),
decision_nonESSD(do:ansRecognition),(http_session_data(recommend(no))->!;[]).
node(greek_naturalisation,decision_nonESSD_adoption):-citizenship(decision_nonESSD),
decision_nonESSD(do:ansAdoption),(http_session_data(recommend(no))->!;[]).
node(greek_naturalisation,decision_nonESSD_army):-
citizenship(decision_nonESSD),decision_nonESSD(do:ansArmy),(http_session_data(recommend(no))->!;[]).
node(greek_naturalisation,decision_nonESSD_muslim):-citizenship(decision_nonESSD),
decision_nonESSD(do:ansMuslim),(http_session_data(recommend(no))->!;[]).
node(greek_naturalisation,decision_nonESSD_refugee):-citizenship(decision_nonESSD),
decision_nonESSD(do:ansRefugee),(http_session_data(recommend(no))->!;[]).
node(greek_naturalisation,decision_nonESSD_consulate_registry):-citizenship(decision_nonESSD),
decision_nonESSD(do:ansConsulate_registry),(http_session_data(recommend(no))->!;[]).
node(greek_naturalisation,decision_nonESSD_childOfGreek):-citizenship(decision_nonESSD),
decision_nonESSD(do:ansChildOfGreek),(http_session_data(recommend(no))->!;[]).

node(greek_naturalisation,notEligible):-true,(http_session_data(recommend(no))->!;[]).
```

OWL individual – Questions and Aswers

```
:qrAdoptionDate a :Question, owl:NamedIndividual ;
   :hasAnswer :ansNo, :ansYes ;
   dcterms:description "Was the adoption made before 10-11-2004?".

:qrAdult a :Question, owl:NamedIndividual ;
   :hasAnswer :ansNo, :ansYes ;
   dcterms:description "Are you an adult?".

:qrArrenwn a :Question, owl:NamedIndividual ;
   :hasAnswer :ansNo,    :ansYes
   dcterms:description "Are you enrolled at the Greek male registry?".
```

```
:qrCitizenship_revocation a :Question, owl:NamedIndividual ;
   :hasAnswer :ansNo, :ansYes ;
   dcterms:description "Do you have a pending decision for citizenship revocation?".

:qrConsulate_registry a :Question,  owl:NamedIndividual ;
   :hasAnswer :ansNo,  :ansYes ;
   dcterms:description "Are you registered at the Greek consulate registry?”.

:qrConvicted a :Question, owl:NamedIndividual ;
   :hasAnswer :ansNo, :ansYes ;
   dcterms:description "Have you been convicted the last 10 years?" .

:qrDecision_ESSD a :Question,  owl:NamedIndividual ;
   :hasAnswer :ansArmy, :ansFather_army, :ansNothing, :ansParent_born_Greek ;
   dcterms:description "Do you belong to one of the following categories?" .

:qrDecision_nonESSD a :Question, owl:NamedIndividual ;
   :hasAnswer :ansAdoption, :ansArmy, :ansChildOfGreek, :ansConsulate_registry, :ansGreek_ancestor,
      :ansMuslim, :ansNothing, :ansRecognition, :ansRefugee ;
   dcterms:description "Do you belong to one of the following categories?”.

:qrDeportation a :Question, owl:NamedIndividual ;
   :hasAnswer :ansNo, :ansYes ;
   dcterms:description "Do you have a pending deportation decision?" .

:qrESSD a :Question, owl:NamedIndividual ;
   :hasAnswer :ansNo, :ansYes ;
   dcterms:description "Are you an expatriate Greek from the former USSR?".

:qrFirstApplication a :Question, owl:NamedIndividual ;
   :hasAnswer :ansNo, :ansYes ;
   dcterms:description "Is this the first application for citizenship?" .

:qrGreek a :Question, owl:NamedIndividual ;
   :hasAnswer :ansNo,  :ansYes ;
   dcterms:description "Do you have sufficient knowledge of the Greek language, Greek history and Greek
culture?".

:qrLausanne a :Question, owl:NamedIndividual ;
   :hasAnswer :ansNo, :ansYes ;
   dcterms:description "Have you acquired the Greek citizen ship from the treaties of Ankara or Lausanne?".

:qrLegal_adoption a :Question, owl:NamedIndividual ;
   :hasAnswer :ansNo, :ansYes ;
   dcterms:description "Has the adoption been made legally?" .

:qrNaturalisation a :Question, owl:NamedIndividual ;
   :hasAnswer :ansAthlete, :ansNoCitizenship, :ansNothing, :ansSpouse, :ansStay ;
   dcterms:description "Do you belong to one of the following categories?".
```

```
:qrNoAdult_at_adoption a :Question, owl:NamedIndividual ;
   :hasAnswer :ansNo, :ansYes ;
   dcterms:description "Was the adopted underaged at the date of adoption?”.

:qrNoMarried a :Question, owl:NamedIndividual ;
   :hasAnswer :ansNo, :ansYes ;
   dcterms:description "Are you not married?".

:qrProsfora a :Question, owl:NamedIndividual ;
   :hasAnswer :ansNo, :ansYes ;
   dcterms:description "Do you have provided exceptional actions to the country?" .

:qrRecognitionDate a :Question, owl:NamedIndividual ;
   :hasAnswer :ansNo, :ansYes ;
   dcterms:description "Is the recognition made before 10-11-2004?".

:qrchildOfGreek a :Question, owl:NamedIndividual ;
   :hasAnswer :ansCivil_marriage, :ansFather_army, :ansGreek_mother, :ansNothing ;
   dcterms:description "Do you belong to one of the following categories?" .

:ansAdoption a :Answer, owl:NamedIndividual ;
   dcterms:description "Has been adopted by a Greek" .

:ansAthlete a :Answer, owl:NamedIndividual ;
   dcterms:description "Be an athlete with 5 years stay at the country".

:ansChildOfGreek a :Answer,  owl:NamedIndividual ;
   dcterms:description "Child of Greek".

:ansCivil_marriage a :Answer, owl:NamedIndividual ;
   dcterms:description "Has born before 16/7/1982 from parents married with civil marriage" .

:ansConsulate_registry a :Answer, owl:NamedIndividual ;
   dcterms:description "Greek of the East and is enrolled in a Consular Register".

:ansGreek_ancestor a :Answer, owl:NamedIndividual ;
   dcterms:description "Has an ancestor that has gained the Greek citizenship" .

:ansGreek_mother a :Answer, owl:NamedIndividual ;
   dcterms:description "Has been born before 8/5/1984 from a Greek mother".

:ansMuslim a :Answer,  owl:NamedIndividual ;
   dcterms:description "Muslim from the population exchange under the treaty or Ankara or without
citizenship" .

:ansNoCitizenship a :Answer, owl:NamedIndividual ;
   dcterms:description "Do not have a citizenship and has stayied at the country more than 5 years the last
12 years".
```

```
:ansParent_born_Greek a :Answer, owl:NamedIndividual ;
   dcterms:description "Adult that has a parent who getted the Greek citizenship by birth".

:ansRecognition a :Answer,  owl:NamedIndividual ;
   dcterms:description "Has been recogised by a Greek" .

:ansRefugee a :Answer, owl:NamedIndividual ;
   dcterms:description "Recognised political refugee that has a 5 years stay at the country the last 12 years".

:ansSpouse a :Answer, owl:NamedIndividual ;
   dcterms:description "Be spouce of Greek and has a child and has stayied at the country more that three
years after the wedding date.".

:ansStay a :Answer,  owl:NamedIndividual ;
   dcterms:description "Have 10 years of permanent stay at the country".

:ansArmy a :Answer, owl:NamedIndividual ;
   dcterms:description "Adult that has been classified to the Greek army as a volunteer at mobilisation or at
war".

:ansFather_army a :Answer, owl:NamedIndividual ;
   dcterms:description "Underage and single whose has gained teh Greek citizenship by serving at the Greek
army".

:ansNothing a :Answer,  owl:NamedIndividual ;
   dcterms:description "None".

:ansNo a :Answer,  owl:NamedIndividual ;
   dcterms:description "No" .

:ansYes a :Answer,  owl:NamedIndividual ;
   dcterms:description "Yes” .
```

B. Prolog rules for the provision of grants to new farmers in Greece public service

Prolog rules and facts

```
entity(X):-menuask(do:qrEntity,X).
age(X):-menuask(do:qrAge,X).
student(X):-menuask(do:qrStudent,X).
graduate(X):-menuask(do:qrGraduate,X).
formerFarmer(X):-menuask(do:qrFormerFarmer,X).
handicaped(X):-menuask(do:qrHandicaped,X).
osde(X):-menuask(do:qrOSDE,X).
```

```
holdingAtResidence(X):- menuask(do:qrHoldingAtResidence,X).
declare(X):-menuask(do:qrDeclare,X).
firstDeclaration(X):-menuask(do:qrFirstDeclaration,X).
approval(X):-menuask(do:qrApproval,X).
residence(X):-menuask(do:qrResidence,X).
natureOfWork(X):-menuask(do:qrNatureOfWork,X).
mainHolding(X):- menuask(do:qrMainHolding,X).
secondaryHolding(X):-menuask(do:qrSecondaryHolding,X).
married(X):-menuask(do:qrMarried,X).
noMarriedIncome(X):- menuask(do:qrNoMarriedIncome,X).
marriedIncome(X):- menuask(do:qrMarriedIncome,X).
taxDeclarationLast3Years(X):-menuask(do:qrTaxDeclarationLast3Years,X).
registryChanged(X):-menuask(do:qrRegistryChanged,X).
spouseFarmer(X):- menuask(do:qrSpouseFarmer,X).
spouseLeaderFarmer(X):-menuask(do:qrSpouseLeaderFarmer,X).
marriedLast3Years(X):-menuask(do:qrMarriedLast3Years,X).
holdingIncome(X):-menuask(do:qrHoldingIncome,X).
previousOccupation(X):-menuask(do:qrPreviousOccupation,X).
nationality(X):-menuask(do:qrNationality,X).

%--------------------------ELIGIBILITY-------------------------------------
farmer_eligibility(eligible_common):-entity(do:ansPhysical),
age(do:ansBetween18and40),student(do:ansNo),graduate(do:ansYes),
formerFarmer(do:ansNo),handicaped(do:ansNo),osde(do:ansYes),
holdingAtResidence(do:ansYes), declare(do:ansYes),firstDeclaration(do:ansYes),
approval(do:ansNo), residenceEligible(yes),natureOfWorkEligible(yes).

residenceEligible(yes):- residence(do:ansMountain),!.
residenceEligible(yes):- residence(do:ansDisadvantagedArea),!.
residenceEligible(yes):- residence(do:ansSmallArea),!.
residenceEligible(no) :- residence(do:ansOtherArea),!.

natureOfWorkEligible(yes):- natureOfWork(do:ansTemporary),!.
natureOfWorkEligible(yes):- natureOfWork(do:ansUnemployed),!.
natureOfWorkEligible(no) :- natureOfWork(do:ansPermanent),!.

farmer_eligibility(eligible):-farmer_eligibility(eligible_common),married(do:ansNo),
noMarriedIncome(do:ansLess100),!.
farmer_eligibility(eligible):-farmer_eligibility(eligible_common),married(do:ansYes),
marriedIncome(do:ansLess150),spouseLeaderFarmer(do:ansNo),!.

%------------------------NOT ELIGIBLE----------------------------------------
node(new_farmer_registration,noteligible_legal):- entity(do:ansLegal),!.
node(new_farmer_registration,noteligible_age):- age(do:ansLess18),!.
node(new_farmer_registration,noteligible_age):- age(do:ansMore40),!.
```

```
node(new_farmer_registration,noteligible_student):- student(do:ansYes),!.
node(new_farmer_registration,noteligible_graduate):- graduate(do:ansNo),!.
node(new_farmer_registration,noteligible_formerfarmer):- formerFarmer(do:ansYes),!.
node(new_farmer_registration,noteligible_handicaped):- handicaped(do:ansYes),!.
node(new_farmer_registration,noteligible_osde):- osde(do:ansNo),!.
node(new_farmer_registration,noteligible_holdingResidence):- holdingAtResidence(do:ansNo),!.
node(new_farmer_registration,noteligible_declare):- declare(do:ansNo),!.
node(new_farmer_registration,noteligible_firstDeclaration):- firstDeclaration(do:ansNo),!.
node(new_farmer_registration,noteligible_approval):- approval(do:ansYes),!.
node(new_farmer_registration,noteligible_residence):- residenceEligible(no),!.
node(new_farmer_registration,noteligible_work):- natureOfWorkEligible(no),!.
node(new_farmer_registration,noteligible_bigincome):-
farmer_eligibility(eligible_common),married(do:ansNo),noMarriedIncome(do:ansMore100),!.
node(new_farmer_registration,noteligible_bigincome):- farmer_eligibility(eligible_common),
married(do:ansYes),marriedIncome(do:ansMore150),!.
node(new_farmer_registration,noteligible_spoucefarmer):- farmer_eligibility(eligible_common),
married(do:ansYes),marriedIncome(do:ansLess150),spouseLeaderFarmer(do:ansYes),!.

%-----------------------------------------------------------------------------------------------------------------------
node(new_farmer_registration,eligible):-farmer_eligibility(eligible).

node(new_farmer_registration,mountain):-farmer_eligibility(eligible),residence(do:ansMountain).
node(new_farmer_registration,smallArea):-farmer_eligibility(eligible),
residence(do:ansSmallArea).
node(new_farmer_registration,disadvantagedArea):-farmer_eligibility(eligible),
residence(do:ansDisadvantagedArea).

node(new_farmer_registration,temporary):-farmer_eligibility(eligible),
natureOfWork(do:ansTemporary).

node(new_farmer_registration,mainLivestock):-farmer_eligibility(eligible),
mainHolding(do:ansLivestock).
node(new_farmer_registration,mainCrop):-farmer_eligibility(eligible),mainHolding(do:ansCrop).
node(new_farmer_registration,mainBeehive):-farmer_eligibility(eligible),
mainHolding(do:ansBeehive).

node(new_farmer_registration,secondaryLivestock):-farmer_eligibility(eligible),
secondaryHolding(do:ansLivestock).
node(new_farmer_registration,secondaryCrop):-farmer_eligibility(eligible),
secondaryHolding(do:ansCrop).
node(new_farmer_registration,secondaryBeehive):-farmer_eligibility(eligible),
secondaryHolding(do:ansBeehive).

node(new_farmer_registration,spouceLeaderFarmer):- farmer_eligibility(eligible),
married(do:ansYes),spouseFarmer(do:ansYes).
```

```
node(new_farmer_registration,marriedLast3Years):- farmer_eligibility(eligible),
married(do:ansYes),marriedLast3Years(do:ansYes).
node(new_farmer_registration,noMarriedLast3Years):- farmer_eligibility(eligible),
married(do:ansYes),marriedLast3Years(do:ansNo).

node(new_farmer_registration,taxDeclarationLast3Years):-farmer_eligibility(eligible),
married(do:ansNo), taxDeclarationLast3Years(do:ansYes).
node(new_farmer_registration,noTaxDeclarationLast3Years):-farmer_eligibility(eligible),
married(do:ansNo), taxDeclarationLast3Years(do:ansNo).

node(new_farmer_registration,taxRegisterChange):-farmer_eligibility(eligible),
married(do:ansNo), taxDeclarationLast3Years(do:ansNo),registryChanged(do:ansYes).
node(new_farmer_registration,noTaxRegisterChange):-farmer_eligibility(eligible),
married(do:ansNo), taxDeclarationLast3Years(do:ansNo),registryChanged(do:ansNo).

node(new_farmer_registration,smallIncome):-
farmer_eligibility(eligible),holdingIncome(do:ansLess80).
node(new_farmer_registration,mediumIncome):-
farmer_eligibility(eligible),holdingIncome(do:ansBetween80and120).
node(new_farmer_registration,largeIncome):-
farmer_eligibility(eligible),holdingIncome(do:ansMore120).

node(new_farmer_registration,freelancer):- farmer_eligibility(eligible),
previousOccupation(do:ansFreelancer).
node(new_farmer_registration,employee):- farmer_eligibility(eligible),
previousOccupation(do:ansEmployee).
node(new_farmer_registration,unemployed):- farmer_eligibility(eligible),
previousOccupation(do:ansUnemployed).
node(new_farmer_registration,contract):- farmer_eligibility(eligible),
previousOccupation(do:ansContract).
node(new_farmer_registration,foreigner):-farmer_eligibility(eligible), nationality(do:ansNoGreek).
```

OWL individuals – Questions and Aswers

```
:qrAge a :Question, owl:NamedIndividual ;
   :hasAnswer :ansBetween18and40, :ansLess18, :ansMore40 ;
   dcterms:description "What is your age?".

:qrApproval a :Question,  owl:NamedIndividual ;
   :hasAnswer :ansNo, :ansYes ;
   dcterms:description "Does the date of the first settlement to the agricultural holding and the date of the
approval differ more than 18 months?".

:qrDeclare a :Question, owl:NamedIndividual ;
   :hasAnswer :ansNo, :ansYes ;
   dcterms:description "Has the entire agricultural holding  been declared the last two years?" .
```

```
:qrEntity a :Question, owl:NamedIndividual ;
   :hasAnswer :ansLegal, :ansPhysical ;
   dcterms:description "Are you a physical or a legal entity?".

:qrFirstDeclaration a :Question, owl:NamedIndividual ;
   :hasAnswer :ansNo,  :ansYes ;
   dcterms:description "Is the first declaration of the agricultural holding less than 14 months old?".

:qrFormerFarmer a :Question, owl:NamedIndividual ;
   :hasAnswer :ansNo, :ansYes ;
   dcterms:description "Have you ever practiced agricultural activity of 0.5 Units of Human Work or above? [One Unit of Human Labour corresponds to 1,750 man-hours annually. In order to compute the Units of Human Labour for your agricultural holding please go <a target=\"_new\" href=\"http://www.rural-observatory.eu/dtoDownload.htm?id=298\">here</a>]".

:qrGraduate a :Question, owl:NamedIndividual ;
   :hasAnswer :ansNo, :ansYes ;
   dcterms:description "Do you have or expect to receive within the next 36 months a degree relevant with the direction of the agricultural holding?" .

:qrHandicaped a :Question, owl:NamedIndividual ;
   :hasAnswer :ansNo, :ansYes ;
   dcterms:description "Do you receive handicap allowance having a handicap of 67% or above?".

:qrHoldingAtResidence a :Question, owl:NamedIndividual ;
   :hasAnswer :ansNo, :ansYes ;
   dcterms:description "Is the agricultural holding at your place of residence?".

:qrHoldingIncome a :Question,  owl:NamedIndividual ;
   :hasAnswer :ansBetween80and120, :ansLess80, :ansMore120 ;
   dcterms:description "What is your total agricultural holding income?" .

:qrMainHolding a :Question, owl:NamedIndividual ;
   :hasAnswer :ansBeehive, :ansCrop, :ansLivestock ;
   dcterms:description "What is the productive direction of the agricultural holding  (more than 50% of the total Units of Human Work)?".

:qrMarried a :Question, owl:NamedIndividual ;
   :hasAnswer :ansNo, :ansYes ;
   dcterms:description "Are you married?".

:qrMarriedIncome a :Question,  owl:NamedIndividual ;
   :hasAnswer :ansLess150, :ansMore150 ;
   dcterms:description "What is your non agricultural income?".

:qrMarriedLast3Years a :Question, owl:NamedIndividual ;
   :hasAnswer :ansNo, :ansYes ;
```

```
   dcterms:description "Have you been married within  the last 3 years? [so no common tax declaration exists]".

:qrNationality a :Question, owl:NamedIndividual ;
   :hasAnswer :ansGreek, :ansNoGreek ;
   dcterms:description "What is your nationality?".

:qrNatureOfWork a :Question, owl:NamedIndividual ;
   :hasAnswer :ansUnemployed, :ansPermanent, :ansTemporary ;
   dcterms:description "What is the nature of your work?" .

:qrNoMarriedIncome a :Question,  owl:NamedIndividual ;
   :hasAnswer :ansLess100, :ansMore100 ;
   dcterms:description "What is your non agricultural income?" .

:qrOSDE a :Question, owl:NamedIndividual ;
   :hasAnswer :ansNo, :ansYes ;
   dcterms:description "Are your registered at OSDE (Integrated Management and Control System)?”.

:qrPreviousOccupation a :Question, owl:NamedIndividual ;
   :hasAnswer :ansContract, :ansEmployee, :ansFreelancer, :ansNone, :ansUnemployed ;
   dcterms:description "What was your previous employment?" .

:qrRegistryChanged a :Question, owl:NamedIndividual ;
   :hasAnswer :ansNo, :ansYes ;
   dcterms:description "Is there any modification at your IRS registry?" .

:qrResidence a :Question, owl:NamedIndividual ;
   :hasAnswer :ansDisadvantagedArea, :ansMountain, :ansOtherArea, :ansSmallArea ;
   dcterms:description "In what type of area will the agricultural holding be settled?".

:qrSecondaryHolding a :Question, owl:NamedIndividual ;
   :hasAnswer :ansBeehive, :ansCrop, :ansLivestock, :ansNone ;
   dcterms:description "Are there secondary agricultural holdings?" .

:qrSpouseFarmer a :Question, owl:NamedIndividual ;
   :hasAnswer :ansNo, :ansYes ;
   dcterms:description "Is your spouce a farmer?” .

:qrSpouseLeaderFarmer a :Question,  owl:NamedIndividual ;
   :hasAnswer :ansNo, :ansYes ;
   dcterms:description "Is your spouse a farmer or a  leader of an agricultural holding (greater than 0.5 Units of Human Work)?" .

:qrStudent a :Question, owl:NamedIndividual ;
   :hasAnswer :ansNo, :ansYes ;
   dcterms:description "Are you a student within the projected years of study?".

:qrTaxDeclarationLast3Years a :Question,  owl:NamedIndividual ;
```

```
    :hasAnswer :ansNo, :ansYes ;
    dcterms:description "Did you have a tax declaration the past 3 years?".

:ansBetween18and40 a :Answer, owl:NamedIndividual ;
    dcterms:description "Between 18 and 40".

:ansBetween80and120 a :Answer, owl:NamedIndividual ;
    dcterms:description "Between 12,000 and 18,000 Euros." .

:ansContract a :Answer, owl:NamedIndividual ;
    dcterms:description "Contract".

:ansDisadvantagedArea a :Answer, owl:NamedIndividual ;
    dcterms:description "Disadvantaged area".

:ansEmployee a :Answer,
        owl:NamedIndividual ;
    dcterms:description "Employee"^^xsd:string .

:ansFreelancer a :Answer,  owl:NamedIndividual ;
    dcterms:description "Freelancer" .

:ansGreek a :Answer, owl:NamedIndividual ;
    dcterms:description "Greek".

:ansLegal a :Answer, owl:NamedIndividual ;
    dcterms:description "Legal".

:ansLess100 a :Answer, owl:NamedIndividual ;
    dcterms:description "Less than 15,000 Euros.".

:ansLess150 a :Answer, owl:NamedIndividual ;
    dcterms:description "Less than 22,500 Euros.".

:ansLess18 a :Answer, owl:NamedIndividual ;
    dcterms:description "Less than 18".

:ansLess80 a :Answer, owl:NamedIndividual ;
    dcterms:description "Less than 12,000 Euros.".

:ansMore100 a :Answer, owl:NamedIndividual ;
    dcterms:description "More than 15,000 Euros.".

:ansMore120 a :Answer, owl:NamedIndividual ;
    dcterms:description "More than 18,000 Euros.".

:ansMore150 a :Answer, owl:NamedIndividual ;
    dcterms:description "More than 22,500 Euros." .
```

```
:ansMore40 a :Answer, owl:NamedIndividual ;
   dcterms:description "Over 40".

:ansMountain a :Answer, owl:NamedIndividual ;
   dcterms:description "Mountain area".

:ansNoGreek a :Answer, owl:NamedIndividual ;
   dcterms:description "Non-Greek citizen".

:ansOtherArea a :Answer, owl:NamedIndividual ;
   dcterms:description "Other area".

:ansPermanent a :Answer, owl:NamedIndividual ;
   dcterms:description "Permanent or under contract staff of public entities, military, private sector staff,
freelancer, business owner, etc. ".

:ansPhysical a :Answer,  owl:NamedIndividual ;
   dcterms:description "Physical".

:ansSmallArea a :Answer, owl:NamedIndividual ;
   dcterms:description "Area with population less that 100,000 citizens".

:ansTemporary a :Answer, owl:NamedIndividual ;
   dcterms:description "Temporary staff or fixed-term staff ".

:ansUnemployed a :Answer, owl:NamedIndividual ;
   dcterms:description "Unemployed".

:ansBeehive a :Answer, owl:NamedIndividual ;
   dcterms:description "Beehive".

:ansCrop a :Answer,  owl:NamedIndividual ;
   dcterms:description "Crop".

:ansLivestock a :Answer, owl:NamedIndividual ;
   dcterms:description "Livestock".

:ansNone a :Answer, owl:NamedIndividual ;
   dcterms:description "None".

:ansNo a :Answer, owl:NamedIndividual ;
   dcterms:description "No".

:ansYes a :Answer, owl:NamedIndividual ;
   dcterms:description "Yes".
```

C. Test user profiles

Test user profiles for the Provision of grants to new farmers public service

	Profile 1	**Profile 2**	**Profile 3**	**Profile 4**	**Profile 5**	**Profile 6**	**Profile 7**	**Profile 8**	**Profile 9**	**Profile 10**
Physical or a legal entity?	Legal	Physical	Physical	Physical	Physical	Physical	Physical	Physical	Physical	Physical
What is your age?	-	45	30	30	30	30	30	30	30	30
Are you a student within the projected years of study?	-	-	Yes	No	No	No	No	No	No	No
Do you have a degree relevant with the agricultural holding?	-	-	-	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Have you ever practiced agricultural activity?	-	-	-	Yes	No	No	No	No	No	No
Do you receive handicap allowance?	-	-	-	-	No	No	No	No	No	No
Are you registered at Integrated Management Control System?	-	-	-	-	No	Yes	Yes	Yes	Yes	Yes
Is the agricultural holding at your place of residence?	-	-	-	-	-	No	Yes	Yes	Yes	Yes
Has the agricultural holding been declared the last two years?	-	-	-	-	-	-	Yes	Yes	Yes	Yes
Is the declaration of the agric. holding less than 14 months old?	-	-	-	-	-	-	Yes	Yes	Yes	Yes
Do the date of the first settlement to the	-	-	-	-	-	-	Yes	No	No	No

agricultural holding and the date of the approval differ more than 18 months?										
In what type of area will the agricultural holding be settled?	-	-	-	-	-	-	-	Other area	Mountain area	Mountain area
What is the nature of your work?	-	-	-	-	-	-	-	-	Permanent	Unemployed
Are you married?	-	-	-	-	-	-	-	-	-	No
What is your non agricultural income?	-	-	-	-	-	-	-	-	-	> 15,000
Is your spouse a farmer or a leader of an agricultural holding?	-	-	-	-	-	-	-	-	-	-
Have you been married within the last 3 years?	-	-	-	-	-	-	-	-	-	-
What is the productive direction of the agricultural holding?	-	-	-	-	-	-	-	-	-	-
Did you have a tax declaration the past 3 years?	-	-	-	-	-	-	-	-	-	-
What is your total agricultural holding income?	-	-	-	-	-	-	-	-	-	-
What was your previous employment?	-	-	-	-	-	-	-	-	-	-
What is your nationality?	-	-	-	-	-	-	-	-	-	-

	Profile 11	**Profile 12**	**Profile 13**	**Profile 14**	**Profile 15**	**Profile 16**	**Profile 17**	**Profile 18**	**Profile 19**	**Profile 20**

Physical or a legal entity?	Physical	Physical	Physical	Physical	Physical	Physical	Physical	Physical	Physical	Physical
What is your age?	30	30	30	30	30	30	30	30	30	30
Are you a student within the projected years of study?	No	No	No	No	No	No	No	No	No	No
Do you have a degree relevant with the agricultural holding?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Have you ever practiced agricultural activity?	No	No	No	No	No	No	No	No	No	No
Do you receive handicap allowance?	No	No	No	No	No	No	No	No	No	No
Are you registered at Integrated Management Control System?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Is the agricultural holding at your place of residence?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Has the agricultural holding been declared the	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

last two years?										
Is the declaration of the agric. holding less than 14 months old?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Do the date of the first settlement to the agricultural holding and the date of the approval differ more than 18 months?	No	No	No	No	No	No	No	No	No	No
In what type of area will the agricultural holding be settled?	Mountain area	Mountain area	mountain area	Population < 100000	Mountain area	Mountain area	Mountain area	Mountain area	Mountain area	Mountain area
What is the nature of your work?	Unemployed	Unemployed	Unemployed	Unemployed	Unemployed	Unemployed	Unemployed	Unemployed	Unemployed	Unemployed
Are you married?	Yes	Yes	No	No	No	No	Yes	No	No	No
What is your non agricultural income?	>22,500	<22,500	< 15,000	< 15,000	<15,000	<15,000	<22,500	<15,000	<15,000	<15,000
Have you been married within the last 3 years?	-	Yes	-	-	-	-	Yes	-	-	-

Is your spouse a farmer or a leader of an agricultural holding?	-	Yes	-	-	-	-	No	-	-	-
What is the productive direction of the agricultural holding?	-	-	Crop	beehive	crop	crop	crop	crop	crop	crop
Did you have a tax declaration the past 3 years?	-	-	Yes	Yes	Yes	Yes	-	Yes	Yes	Yes
What is your total agricultural holding income?	-	-	<12,000	<12,000	<12,000	<12,000	<12,000	12000<x<18000	x>18000	x>18000
What was your previous employment?	-	-	Unemployed	Unemployed	Free lancer	Contract	Contract	Contract	Contract	Contract
What is your nationality?	-		Greek	Greek	Greek	Greek	Greek	Greek	Greek	No Greek

Evaluation results for each test user profiles for the provision of grants to new farmers public service

Profile	Required documents	Subsidy
Profile 1		Not eligible
Profile 2		Not eligible
Profile 3		Not eligible
Profile 4		Not eligible
Profile 5		Not eligible
Profile 6		Not eligible
Profile 7		Not eligible
Profile 8		Not eligible
Profile 9		Not eligible

Profile 10	Not eligible	
Profile 11	Not eligible	
Profile 12	Not eligible	
Profile 13	Major title, ID or Passport, Copies of the United Declaration of Holding, tax declarations (3 years), Pause of the unemployment fund	15,000 € (7,500 for crop and 7,500 for mountain areas)
Profile 14	Same as profile 13	7,500 € (5,000 for beehive and 2,500 for areas with population < 100,000)
Profile 15	Major title, ID or Passport, Copies of the United Declaration of Holding, tax declarations (3 years), Certified copy of business closure by the IRS	15,000 € (7,500 for crop and 7,500 for mountain areas)
Profile 16	Major title, ID or Passport, Copies of the United Declaration of Holding, tax declarations (3 years), Time specific contracts	15,000 € (7,500 for crop and 7,500 for mountain areas)
Profile 17	Major title, ID or Passport, Copies of the United Declaration of Holding of applicant and his/her spouse, tax declarations of the applicant and his/her spouse (3 years), Time specific contracts	15,000 € (7,500 for crop and 7,500 for mountain areas)
Profile 18	Major title, ID or Passport, Copies of the United Declaration of Holding, tax declarations (3 years), Time specific contracts	17,500 € (7,500 for crop, 7,500 for mountain areas and 2,500 for agricultural holding incomes between 12,000 and 18,000)
Profile 19	Major title, ID or Passport, Copies of the United Declaration of Holding, tax declarations (3 years), Time specific contracts	20,000 € (7,500 for crop, 7,500 for mountain areas and 5,000 for agricultural holding incomes > 18,000)
Profile 20	Major title, ID or Passport, Copies of the United Declaration of Holding, tax declarations (3 years), Time specific contracts, Document of permanent residence	20,000 € (7,500 for crop, 7,500 for mountain areas and 5,000 for agricultural holding incomes > 18,000)

Test user profiles for the Greek naturalisation public service

	Profile1	**Profile 2**	**Profile 3**	**Profile 4**	**Profile 5**	**Profile 6**	**Profile 7**	**Profile 8**	**Profile 9**	**Profile 10**
Have you been convicted the last 10 years?	Yes	No	No	No	No	No	No	No	No	No
Do you have a pending decision for citizenship revocation?	-	Yes	No	No	No	No	No	No	No	No
Do you have a pending deportation decision?	-	-	Yes	No	No	No	No	No	No	No
Are you an adult?	-	-	-	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Do you have sufficient knowledge of the Greek language, history?	-	-	-	Yes	Yes	No	Yes	Yes	No	Yes
Do you have provided exceptional	-	-	-	-	-	Yes	-	-	No	-

actions to the country?										
Are you an expatriate Greek from the former USSR?	-	-	-	-	-	-	-	-	Yes	-
Have you acquired the greek citizenship from the treaties of Ankara or Lausanne?	-	-	-	-	-	-	-	-	Yes	-
Do you belong to one of the following categories?	-	-	-	10 years stay at the country	10 years stay at the country	-	Athlete with 5 years stay at the country	Spouse of Greek with a child who has stayed at the country more than three years after the wedding.	-	Spouse of Greek with a child who has stayed at the country more than three years after the wedding.
Is this the first application for citizenship?	-	-	-	No	Yes	-	Yes	No	-	Yes

Evaluation results for each test user profile for the Greek naturalisation public service

	Required documents	Fee
Profile 1	Not eligible	
Profile 2	Not eligible	
Profile 3	Not Eligible	
Profile 4	Application form, copy of passport and visa, Certificate of criminal record, Family status certificate, Certificate of non-deportation, Statement to acquire the Greek Naturalisation, Birth certificate	1467.35 € (1st application)
Profile 5	Same as Profile 4	733.67 €
Profile 6	Application form, Certificate of criminal record, Certificate of non-deportation	-
Profile 7	Documents for Profile 4 plus: Assent of the Greek Olympic Committee and Establishment of national federation that can compete in the national team	1467.35 € (1st application)
Profile 8	Documents for Profile 4 plus Certificate of marriage	733.67 €
Profile 9	Not Eligible	
Profile 10	Documents for Profile 8	1467.35 € (1st application)

Annex V: Selected Publications

Parts of this *Thesis* have been published or have been submitted for publication in international refereed journals and conferences.

Presentations in peer reviewed conferences

Loutas N., Peristeras V., Tarabanis K., Improving service provision through the use of customer-centric semantic service models, 24th Annual IBM Frontiers in Service Science, 2015, San Jose, CA, USA.

Book Chapters

1. Mocan A., Facca A., Loutas N., Goudos S., Peristeras V., Tarabanis K., Solving Semantic Interoperability Conflicts in Cross-Border E-Government Services. In A. Sheth (Ed.), Semantic Services, Interoperability and Web Applications: Emerging Concepts, pp. 1-47, IGI Global, 2011.
2. Loutas N., Giantsiou L., Peristeras V., Tarabanis K., A Semantically Enabled Portal for Facilitating the Public Service Provision. In Vitvar T., Peristeras V., Tarabanis K. (eds.) Semantic Technologies for E-Government, pp. 287-314, Springer, 2010

Journal Articles

3. Loutas N., Tarabanis K., Peristeras V., A multidisciplinary survey on service. In International Journal of Service Science, Management, Engineering, and Technology, vol. 3(4), pp. 13-37 2012 [scopus, dblp]
4. Loutas N., Peristeras V., Zeginis D., Tarabanis K., The Semantic Service Search Engine (S3E). In Journal of Intelligent Information Systems, vol. 38 (3), pp. 645-668, 2012 [isi (if: 0.875), scopus, dblp]
5. Loutas N., Peristeras V., Tarabanis K., The Public Service Ontology: A formal model for describing domain specific semantics. In International Journal of Metadata, Semantics and Ontologies, vol. 6 (1), p. 23-34, 2011 [scopus, dblp]
6. Loutas N., Peristeras V., Tarabanis K., Towards a Reference Service Model for the Web of Services. In Data & Knowledge Engineering, vol. 70 (9), pp. 753-774, 2011 [isi (if: 1.717), scopus, dblp]
7. Loutas N., Peristeras V., Tarabanis K., A citizen-centric semantically-enhanced governmental portal. In Electronic Government, An International Journal, vol. 8 (4), pp. 363-384, 2011 [scopus, dblp]
8. Wang X., Nazir, S., Loutas N., Peristeras V., Halang, W., Ontology-dependent Two-phase Semantic Web Service Discovery and Its eGovernment Implementation, In International Journal of Business Process Integration and Management, vol. 5 (2), pp. 173-184, 2011 [scopus]
9. Peristeras V., Goudos S., Loutas N., Tarabanis K., An ontological representation of public services: models, technologies and use cases. In Journal of Web Engineering, vol.8 (3), pp. 245-267, 2009 [isi (if: 0.3), scopus, dblp]
10. Mocan A., Facca A., Loutas N., Goudos S., Peristeras V., Tarabanis K., Solving Semantic Interoperability Conflicts in Cross-Border E-Government Services. International Journal of Semantic Web and Information Systems, vol. 5 (1), pp. 1-47, 2009 [isi (if: 2.345) , scopus, dblp]

11. Peristeras V., Loutas N., Goudos S., Tarabanis K., A Conceptual Analysis of Semantic Conflicts in Pan-European E-Government Services. In Journal of Information Science, vol. 34 (6), pp. 877-891, 2008 [isi (if: 1.406), scopus, dblp]

International Conference and Workshop papers

12. Loutas N., Lee D., Maali F. Peristeras V., Tarabanis K., The Semantic Public Service Portal (S-PSP). In Proceedings of 8th Extended Semantic Web Conference (ESWC 2011), Lecture Notes in Computer Science, Vol. 6644/2011, pp. 227-242, 2011, Heraklion, Greece.
13. Loutas N., Peristeras V., Tarabanis K., Rethinking the Semantic Annotation of Services. ICSOC/ServiceWave 2009 Workshops, Lecture Notes in Computer Science, Vol. 6275, pp. 540-549, 2009, Stockholm, Sweden
14. Giantsiou L., Loutas N., Peristeras V., Tarabanis K., Semantic Service Search Engine (S3E): An approach for finding services on the Web. In Proceedings of 2nd World Summit on the Knowledge Society, Lecture Notes in Computer Science, Vol. 5736/2009, pp. 316-325, 2009, Chania, Greece
15. Kopouki Papathanasiou, M., Loutas N., Peristeras V., Tarabanis K., Combining service models, semantic and Web 2.0 technologies to create a rich citizen experience. In Proceedings of 2nd World Summit on the Knowledge Society, Lecture Notes in Computer Science, Vol. 5736/2009, pp. 296-305, 2009, Chania, Greece
16. Loutas, N., Peristeras, V., Tarabanis, K.: Extending Service Models to Include Social Metadata. In Proceedings of the WebSci'09: Society On-Line, 2009, Athens, Greece
17. Fernandez, A., Hayes, C., Loutas, N., Peristeras, V., Polleres, A., Tarabanis, K.: Closing the Service Discovery Gap by Collaborative Tagging and Clustering Techniques. In Proceedings of ISCW 2008, Workshop on Service Discovery and Resource Retrieval in the Semantic Web, 2008, Karlsruhe, Germany
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