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MOONRISE

Modeling Open Semantic Service Relationships

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Abstract

The increased importance of the service sector in industrialized economies of today makes the interest in services, and in relationships they establish with other services, a relevant subject with growing interest. Understanding the graph structure of service networks is necessary to evaluate current systems, to design future service networks, and to understand the impact of these networks in economy. Interesting studies in different types of networks leads us to believe that, in service networks, we could also reach relevant findings for service economy. Although, the lack of research in the area of service networks, and the paucity of available service descriptions represent the main challenges of this work. Nevertheless, we propose to create an open semantic service network (OSSN) that addresses the concept of rich relationships between services. The resulting network will provide valuable knowledge to the global service economy and scientific purposes with the service networks representation and analysis.

Keywords: Services, Relationships, Networks.

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Diana São Miguel

Contents

List of Tables

List of Figures

List of Acronyms

BPM Business Process Management

CRM Customer Relationship Management

FOAF Friend of a Friend

IT Information Technology

KPI Key Performance Indicator

OSSN Open Semantic Service Networks

OSSR Open Semantic Service Relationship

OWL Web Ontology Language

RDF Resource Description Framework

SaaS Software as a Service

SIOC Semantically-Interlinked Online Communities

SOA Service Oriented Architecture

SNN Service Network Notation

SPARQL SPARQL Protocol and RDF Query Language

USDL Unified Service Description Language

WWW World Wide Web

XML Extensible Markup Language

Listings

1 Introduction

This chapter is organized in six sections. In first section we provide an overview of the background of services and the economy. The second section explains the motivation as well as the importance of our work for the economy and industry. Next, in third section, we expose our problem description. In fourth section we introduce our objectives and challenges during our work. The fifth section contains the approach for our service network research. In the last section we summarize the schedule of our work during the dissertation year.

1.1 Background

We are moving into a *service-based* society therefore, the importance of studying services, their relationships and the way they are linked is steady increasing.

Danylevych, Karastoyanova and Leymann [12] in a business perspective say that "Originally, the economical meaning of service was an intangible type of good or a value-increasing addition to a good. Nowadays, however, it has evolved to "the process of doing something for another party, without reference to goods as the primary focus of the exchange activity"". On the other hand, Sommerville [24] describes service, in a more technical perspective: "A loosely-coupled, reusable software component that encapsulates discrete functionality, which may be distributed and programmatically accessed.". Another definition is still given by ITIL publications [10]: "A service is a means of delivering value to consumers by facilitating outcomes customers want to achieve without the ownership of specific costs and risks". There are several definitions of service but, for this work, the ITIL [10] definition of *service* is the most suited.

The notion of *relationship* between services is difficult to define. However, a relationship can be described as a mutually oriented interaction between two committed parties, in our case services.

Services *per se* have a limited value however, when they are gathered within networks, their potential and interest increases. The scope of the service, as regards to consumers for instance, is higher when a service is a composition of different services than a single service because, if the services have different target users when aggregated their target users become bigger. The joint of different services by means of relationships between them create a service network. Cardoso, et al. state in [9] that *service networks* "(...) can be defined as a business structure made up of services which are nodes connected by one or more specific types of relationships" and that "The interconnection of services results in complex webs", which match with the definition of service networks presented by Spohrer, et al. in [26].

The interest in the study of *networks* has increased in the last decade. Cui, Kumara and Albert [11] focused their research in different types of networks, e.g. *biological*, *social*, *economic*, *physical*, *telecommunications*, *traffic* or *service networks*. Social networks, for example, are deeply studied by Tsvetovat and Kouznetsov [27].

Service networks have received lesser attention than most of networks mentioned above, and this contrasts with the exponentially growing interest in *services* by the industry and researchers in past. The possibility to relate services using meaningful relationships might increase their value in a way that they can be used more effectively in dynamic service outsourcing, efficient software service trading, and automatic service contract negotiation.

1.2 Motivation

Knowing how *services* are arranged in networks allows us to modify, manage, rearrange or define critical points[1] in networks as well as a better description of the type of services that composes the network by the type of relationships they establish with other services. Disorders that occur in one service of the network may also create consequences in other services of the network so that, if we ascertain the services that are linked we can predict what services will be affected.

Studies about networks have been made in the last years showing amazing results that contribute to a better understanding of how they behave, e. g. the study documented by Mislove et al. [21], regarding social networks. The successful results achieved in other research fields (e.g. social networks) lead us to believe that important discoveries can also be achieved by studying *service*

[1] Critical points in a network could be large aggregations of nodes because in case of rupture of the node will affect large part of the network

networks but is necessary to develop models, methods, mechanisms and tools to understand and manage service networks.

In this context, we identify three important groups of beneficiaries: *providers*, *consumers* and the *economy* itself.

Providers: Understanding how services interact within networks brings considerable advances to service providers. For instance, the possibility of companies learn in which of their services are related to one another, which compete with external services, or which compete within the same company. Understanding such relations allows us to better understand markets' structures and dynamics. For service providers it is fundamental to know which companies can be helpful and which ones constitute a threat to the financial health, due to competition. The study of relationships in service networks not only helps to understand the connectivity between service providers, but also facilitates the understanding of markets. The analysis of service networks can lead to the identification of interaction patterns between them that can possibly result in a better network restructuring, regarding in added value.

Consumers: Final costumers can easily express which services they want, as well as determine which services are related and compare them, in order to choose the best. For example, to know which is the more attractive price between two services with similar characteristics.

Economy: Cardoso [9] uses the 2008 economic crisis scenario to demonstrate that service networks could have been of help, predicting which services would have been affected: "Understanding the dynamics and laws governing service networks can provide authoritative insights on *why* and *how* financial service systems fail. For example, it can explain how 2007-2012 global financial crisis propagate throughout global service networks".

Holbrook [18] defines *butterfly effect* as how "the proverbial moth flapping its wings in Brazil can cause a tornado in Texas". Such definition, in this case applied in nature, can also be reused by us, applied in the field of services, in order to access the effect of propagation that occurs within networks. This effect points that a small change, taking place within a network (addressing relations or services), can alter other susceptible points of the network directly or indirectly related to the altered service or relation. Applied to service networks, a service at one end of a network, targeted by an event, can propagate, in different ways, to other nodes in the same network, changing them.

In order to study service networks, the first requirement that should be considered is the development or adoption of a formal and computer-understandable language to represent networks.

The recent development of Open Semantic Service Networks (OSSN)[2] that aims at representing *service networks*, provides a syntax representation language. New insights regarding the laws and dynamics that govern services, operating in a global interconnected world, facilitate the management of services between and inside organizations. The appliance of the models developed carries potential for market structure and economic performance, market simulation and the study of economic dynamics. A successful research will have a far reaching impact, as it will carry the knowledge of service-centric economies to a higher level.

1.3 Problem Description

In this work, we face three major problems:

1. Lack of research on the field of service networks;

2. Need for structured information regarding service descriptions;

3. Lack of methods for service networks analysis and visualization.

During the last decade, the interest on networks research has grown. Some areas such as social networks, product networks or internet networks, documented by Cui, Kumara and Albert [11], produced studies that have shown interesting results. On the other hand services networks, that faces a huge lack of research, are the networks that can bring more benefits for today's economy.

Information about services description available on-line is not structured, are spread through the Internet scattered in various sites. In light of the above it is difficult to identify possible and explicit relationships between services.

Methods for the analysis and visualization of service networks are few and are not specific of these type of networks. There is a need to develop new network models and analysis algorithms to perform service network research.

[2]OSSN is a model which is computer-understandable, represented with web languages, and defines the main concepts and properties required to established rich semantic relationships between service models.

1.4 Objectives and Challenges

Cui, Kumara and Albert [11] refer the fact that "Information Technology provides for rich connectivity and thus makes the world highly interconnected. This is an opportunity and a challenge as the networks tend to be of millions of nodes (e.g. YouTube/Facebook users, mobile phone owners) and heterogeneous (e.g. the nodes include devices and people)". This means that, the necessity of understanding and controlling these networks is steadily increasing and becoming important. Cui et. al. [11] also mention that "Tools and techniques developed in the past are applicable to networks of tens or hundreds or in extreme cases thousands of nodes. The growth and complexity of the systems (...) necessitate the development of the network science grounded principles regarding the representation and analysis of engineered networks". This reveals the need to introduce engineering studies and representations for networks.

There are some important points that should be considered during the development of this work, such as:

- **Objective 1:** Find sources of service descriptions on the internet, with useful information (range area, service specifications and descriptions, features, etc.).
- **Objective 2:** Collect information regarding possible relationships, between services, that is usually mixed with other data about that same service.
- **Objective 3:** Find information about possible relationships between services.
- **Objective 4:** Develop of algorithms to represent service relationships and analyse the network created.

The challenges associated to the objectives defined above are related to the information regarding services that are widespread on the Internet, as also as the gathering of information has to be performed manually. The extraction of that kind of information from such sources is not structured, and is also spread in various service websites so that, it can not be performed on the same manner as it is on the other networks. The representation of relationships of service networks using graphs is unexplored so that we have to adapt the mechanisms used in other types of networks. Methods and models for network analysis are not specific for service networks and need to be remodelled.

1.5 Approach to solve the problem

Considering the objectives and challenges presented we need to identify service providers, service descriptions, information about relationships between services, and extract that information. After this, we have to populate the models, export the data to a readable file and represent the network with graph tools. Finally, the analysis of service networks can be performed with network tools.

1.5.1 Service Providers

We identify three distinct groups of service providers, namely: **government**, **companies** and **individuals**. The government is typically the biggest service provider of a country. It provides *educational services*, *health services*, *legal services*, *social services*, *financial services*, *security services*, *governance services*, *information services* and *transport services*. Companies provide *information services*, *consulting services*, *catering services*, *health services*, etc. Individual provide services to other entities, e.g. *Mechanic services*, *babysitting services*, *tutoring services*, *cleaning services* and *plumbing services*. In this work we will focus in companies as providers, more precisely providers of software services.

Service providers recur to different means to spread information about services, such as *Internet*, *flyers*, *television*, *radio*, *journals* or even sticking papers in the *tree trunks* or *electricity poles* describing the service they provide. The Internet, more precisely the sites with description and / or comparison of services, will be our main point of research.

1.5.2 Information about services

In the specific case of the Internet, services appear in several and distinct websites. For example, the website *CraigsList.org*[3](figure 1.1), has information about all kind of services from several countries. The Portuguese government provides on-line services from their portal: *PortalDoCidadao.pt*[4] (figure 1.2). Companies also upload services description in websites. *MrsClean.com*[5] (figure 1.3) is an example of a cleaning business that publicizes their services through the Internet.

[3]http://www.craigslist.org/about/sites/

[4]http://www.portaldocidadao.pt/PORTAL/pt

[5]http://www.mrscleanusa.com/

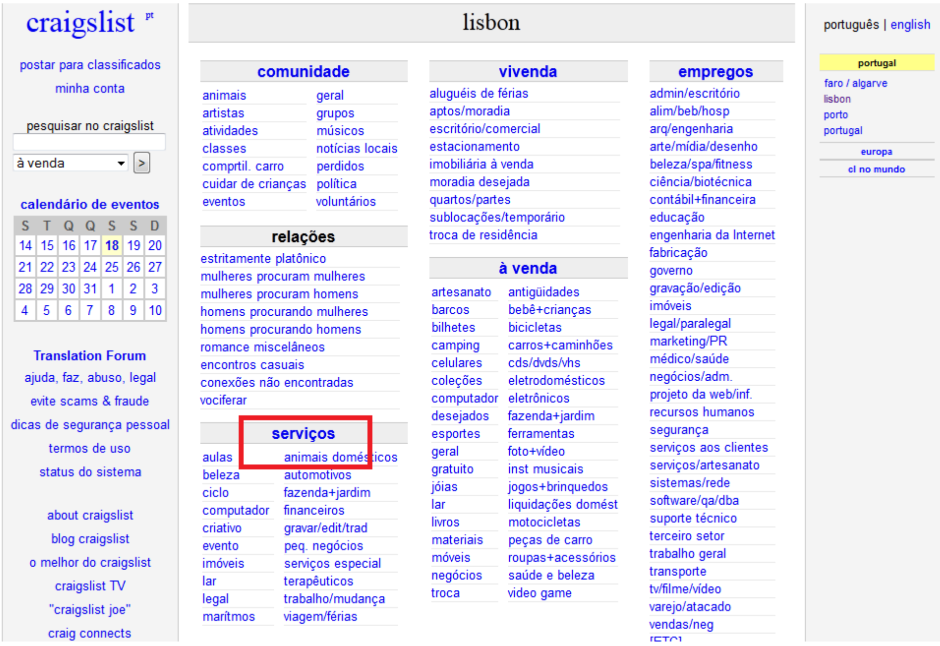

Figure 1.1: Craigslist website

1.5.3 Extracting service descriptions and relationships

Regarding the extraction of information about services and their relationships we are faced with paucity of information. Finding the right service descriptions and their relations allows us to create more complete service networks.

During the research for information about services, we focused on software services (which bounded us to only a few websites). The criteria for website selection was the available, suitable and structured description of information, and the explicit description of service relationships.

For information extraction we can consider *screen scraping*. The technique recur to a computer program that extracts data coming from another system. In this particular case, *screen scraping*[6] is the most appropriate method to extract structured information from websites. However, we face with lack of structured information so that, we also consider the manual extraction. To proceed with the extraction it is crucial to locate useful sources for that information on websites. We are interested in information regarding *services* and *relationships*. Service descriptions can be found in websites like *Find-*

[6]Screen Scrapping is a computer software technique of extracting information from websites. Such software programs simulate human exploration of the World Wide Web (WWW).

Figure 1.2: PortalDoCidadao website

TheBest[7], *VentureBeatProfiles*[8], *CrunchBase*[9], and *CloudReviews*[10] as showed in figures 1.4, 1.5, 1.6, and 1.7.

Relationships can be found in websites like *FindTheBest* and *VentureBeat-Profiles* showed (figures 1.8 and 1.9) are examples of websites where we can find information about possible relationships between services.

Relating these two types of information it becomes possible for us to represent service networks in a proper way.

1.5.4 Network Representation

The usage of network representation is crucial to the success of modelling engineered networks. It influences the computational efficiency of search, clustering and network optimization. In network analysis, the graphical representation of the network is excellent for visual pattern recognition. Cui, Kumara and Albert [11] point out four techniques for representing networks:

Node-arc incident matrix: Where rows correspond to nodes, and columns correspond to arcs. This is an intuitive scheme, but wastes memory space and, in general, leads to sparse matrices.

[7] http://www.findthebest.com/
[8] http://venturebeatprofiles.com/
[9] http://www.crunchbase.com/
[10] http://www.cloudreviews.com/

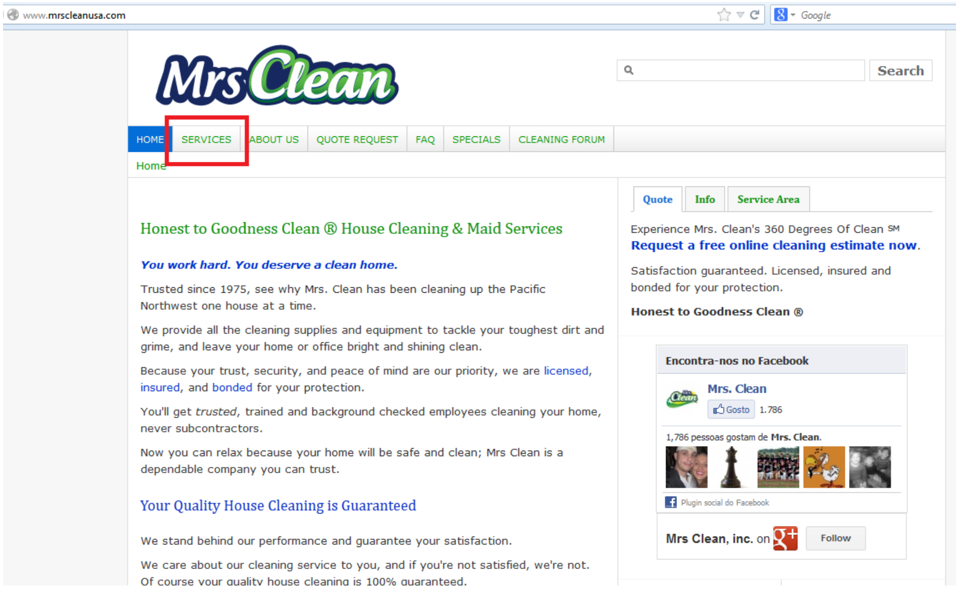

Figure 1.3: MrsClean website

Node-node adjacency matrix: Where rows and columns both correspond to nodes, and in the position (i,j), 1 indicates an arc going from node i to j. This representation is space and time efficient only if the network is dense.

Adjacency lists: Where the arc adjacency list $A(i)$ is stored as a linked list for each node i, and each record in the linked list corresponds to an arc (i,j). This type of representation ensures storage efficiency.

Forward star representation: Stores the same information as an adjacency list does, but using arrays instead of linked lists. This method has the disadvantage that makes it difficult to add or delete arcs and the time taken for adding and removing operations is proportional to the length. This is contrary to adjacency lists, where adding or deleting arcs instantaneous.

Tsvetovat and Kouznetsov [27] use *adjacency lists* to represent *social networks*, which they prove to be the most effective method. In our case, it is also advantageous to use adjacency lists in the graphical representation of the network.

1.5.5 Construct service networks

A service network is a joint of several instances which together represent and describe the network. For that, it is necessary to use models such as Linked-USDL, OSSR and OSSN. **Services** can be represented with Linked-USDL.

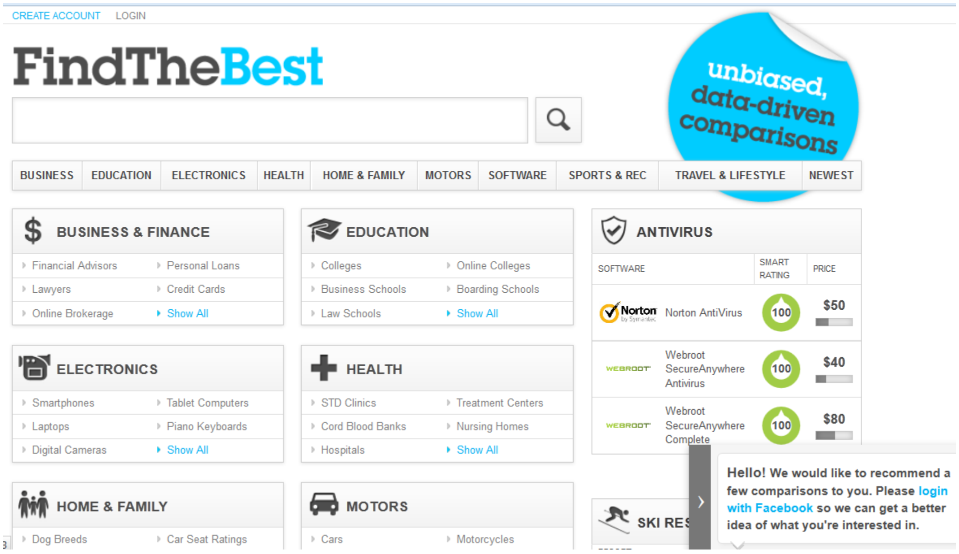

Figure 1.4: FindTheBest website

Relationships can be modelled by the Open Semantic Service Relationship (OSSR) model. **Service Networks** can be modelled by Open Semantic Service Networks (OSSN);

USDL is described by Cardoso et al. [6] as a "specification language to describe services from a business, operational and technical perspective", that "(...) has been created to capture the business and operational nature of services and align them with technical perspective", the author also refers that "USDL can be seen as the first step to better understand and describe the fundamental characteristics and peculiarities of business services". USDL also presents the service's technical interface, legal aspects, pricing and service legal agreement.

Linked-USDL aims to better promote and support the use of the Unified Service Description Language (USDL) on the Web. IT is a remodelled version of USDL that builds upon the Linked Data principles and the Web of Data. This change reduced the complexity of the data model, making use of namespaces that have been on the market for a long time. It also describes services, aiming to be applicable to all sectors of service industry[11], and offers a comprehensive approach to describe services of all sorts and sizes in a machine and human readable way. Linked-USDL was developed to provide the means for publishing and interlinking distributed services for an automatic and computer based-processing.

[11] http://www.linked-usdl.org/

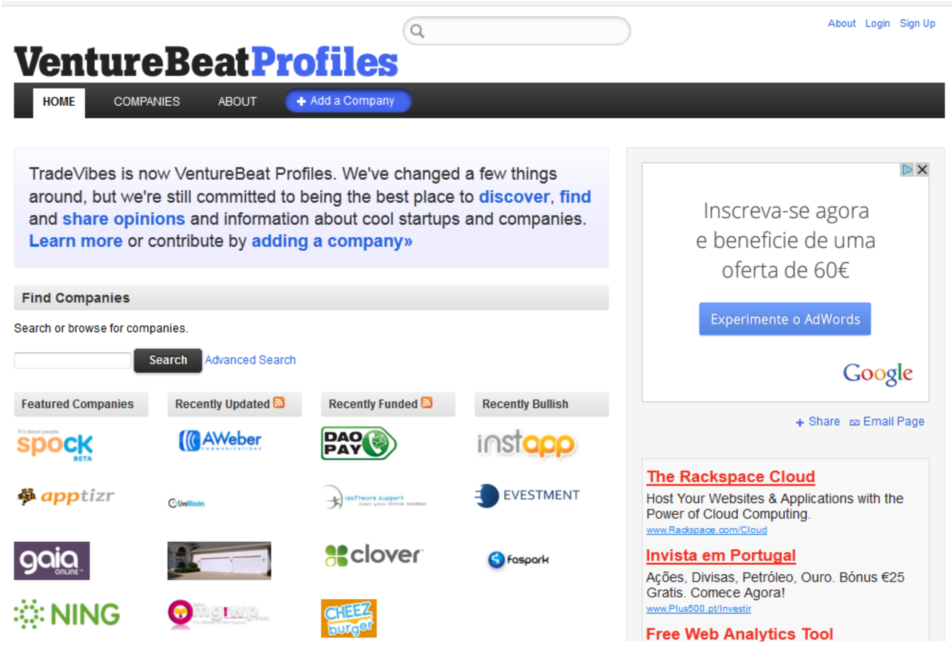

Figure 1.5: VentureBeatProfiles website

OSSR is a computer-understandable model. It is represented with Semantic Web languages, and defines the main concepts and properties required to establish rich semantic relationships between service models [?]. It was implemented using the Resource Description Framework (RDF) which allows semantic information to be expressed as a graph. The model establishes links with various existing ontologies, such as Linked-USDL, in order to reuse concepts. The OSSR Ontology is available online[12].

OSSN is a new concept concerned with the establishment of rich relationships between services. The current research on OSSN is presented by Cardoso, *et al.* [9] [8]. OSSN are structures aiming at sustaining and empowering the digital representation, modelling and reasoning of business service networks.

OSSN brings three innovative and challenging aspects to explore:

1. Service descriptions go beyond simple descriptions of technical interfaces specified with operations and data types. They are more complex, domain dependent and aggregate, structure and configure people, resources and information creating new value for consumers.

2. Service architectures are open and large-scale. Is not possible to assume that all existing services are known before designing the architecture.

[12]http://rdfs.genssiz.org/ossr.rdf

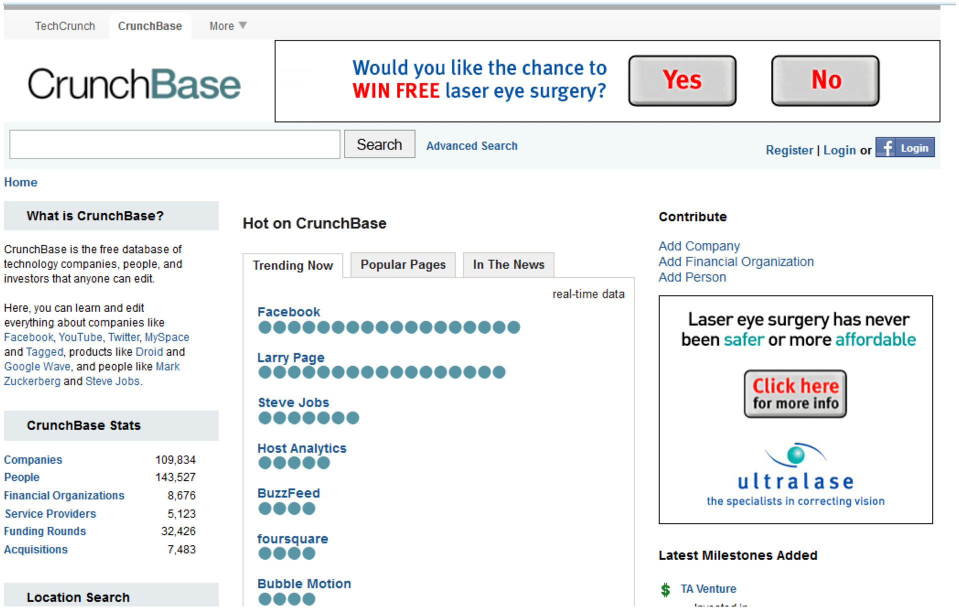

Figure 1.6: CrunchBase website

3. Do not use flow-control elements and temporal dependencies to articulate the execution of services.

OSSN enables consumers to better perceive the nature of the services they subscribe by understanding how they interact and relate with other services in the network. OSSN is particularly focused in the challenging task of constructing *open semantic service networks* by accessing, retrieving, and combining information from globally distributed *service* and *relationship models*. OSSN is a valuable concept which provides a new dimension to analyse, control and innovate business models out of existing services and their relationships.

1.5.6 Network Analysis

1.5.6.1 Topological Metrics

For the characterization of the network we can consider the work done by Cui, Kumara and Albert [11]. They define some important topological metrics for the structure of complex networks, which can be applied in service networks. The table 1.1 presents the considered metrics and their brief description.

We can, for instance, extrapolate from service networks the following metrics *order*, the total number of services in the network; *size*, the total number of relationships in the network; *degree* of a node, the number of relationships of a service;

Metric	Description
Order	Total of number of nodes (vertices).
Size	Total number of links (edges) in a network.
Degree	Number of links connecting the node to its neighbours.
Density	Ratio between network size and the maximum possible number of links.
Distance	Distance between two nodes is the length of the shortest path between them.
Diameter	Longest distance between any pair of nodes in a network.
Clustering coefficient of a node	Number of triangles centred at the node. Consists of three nodes that are connected by either two or three undirected ties.
Betweenness	Quantifies how much a node is between other pairs of nodes.
Proximity ratio	The *CP ratio* (ratio between the clustering coefficient and the average path length) between one network and a random network.
Efficiency	The communication effectiveness of a network system (global) or of a single node (local).
Mixing coefficient	The *Pearson correlation* [13] between the degrees of neighbouring nodes.
Modularity index	Measures the topological similarity in the local patterns of linking.

Table 1.1: Considered topological metrics for the structure of networks

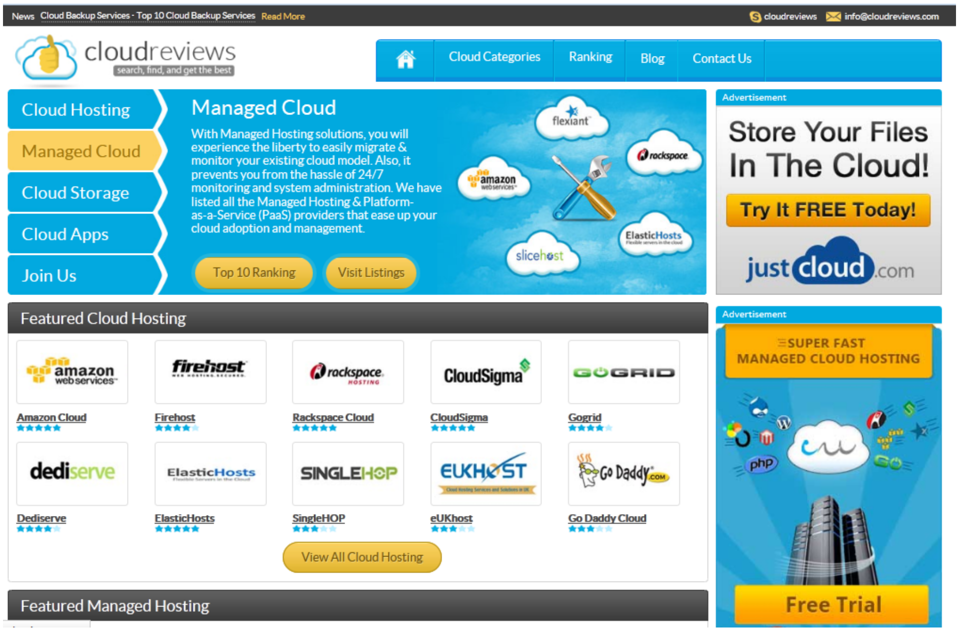

Figure 1.7: CloudReviews website

1.5.6.2 Network Models

Several models have been developed in the past few years to improve the performance of real world networks. Taking the concepts of robustness and optimization into account, future large-scale engineered networks can be designed. Some models can be analysed in complex networks such as:

Random Networks: Usually constructed randomly by adding links to a static set of nodes. A random network is obtained by starting with a set of n nodes and adding relationships links between them randomly (figure 1.11).

Power-Law Networks: Adamic, et al. [1] mentions that "This distribution reflects the existence of a few nodes with very high degree and many with low degree, a feature not found in standard random graphs.". In service networks it means that we can identify many relationships in diversified services, but there are also services where we can not identify any type of relationship or just a few types (figure 1.12).

Scale-Free Networks: A class of *power-law* networks where the high degree nodes trend to be connected to other hight degree nodes. In other words, in service networks services with many relationships usually are related with services that also possess a high number of connections (figure 1.12).

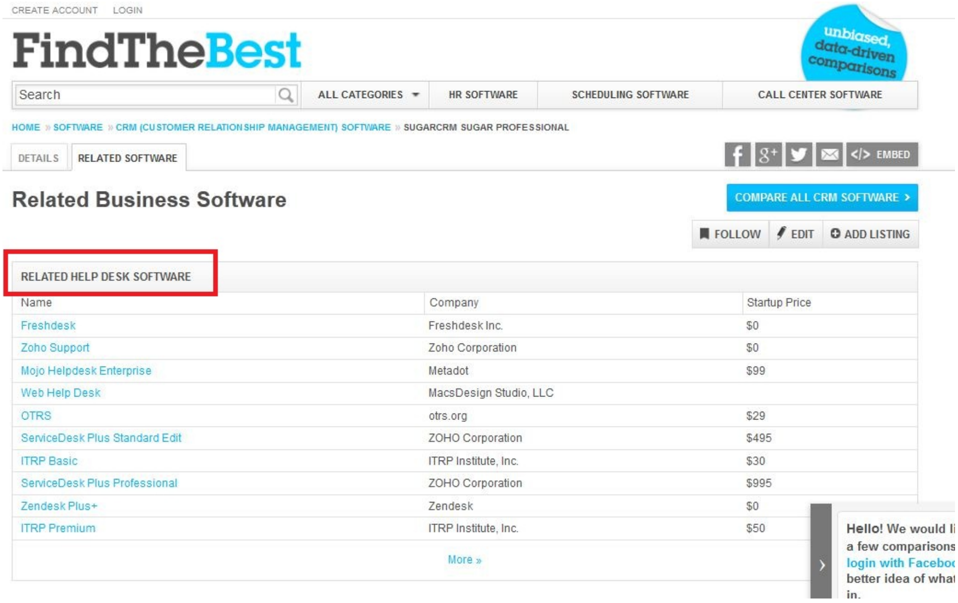

Figure 1.8: FindTheBest related services

Small-World Networks: A *small-world* network is a type of mathematical graph in which most nodes are not neighbours of one another, but most nodes can be reached by a small number of steps. Milgram [20] presents studies about the small-world theory, where he concluded that there are “Six degrees of separation between us and everyone else on this planet”. In service networks, if applicable, the small-world model could state that, from one service, we can achieve any other service by at most of six steps (figure 1.13).

We can observe the behaviour of service networks and link it to the models such as *random network*: if the services are spread in the network randomly, and the relations they create are also random; *power-law network*: if services with many relationships exist, contrasting with others, that have few relationships; *scale-free network*: if services which have a high number of relationships are connected to other services that also have a high number of relationships; *small-world network*: if we can achieve any service on the network, from any another service, using a maximum of six hops.

To perform the analysis to the service network we

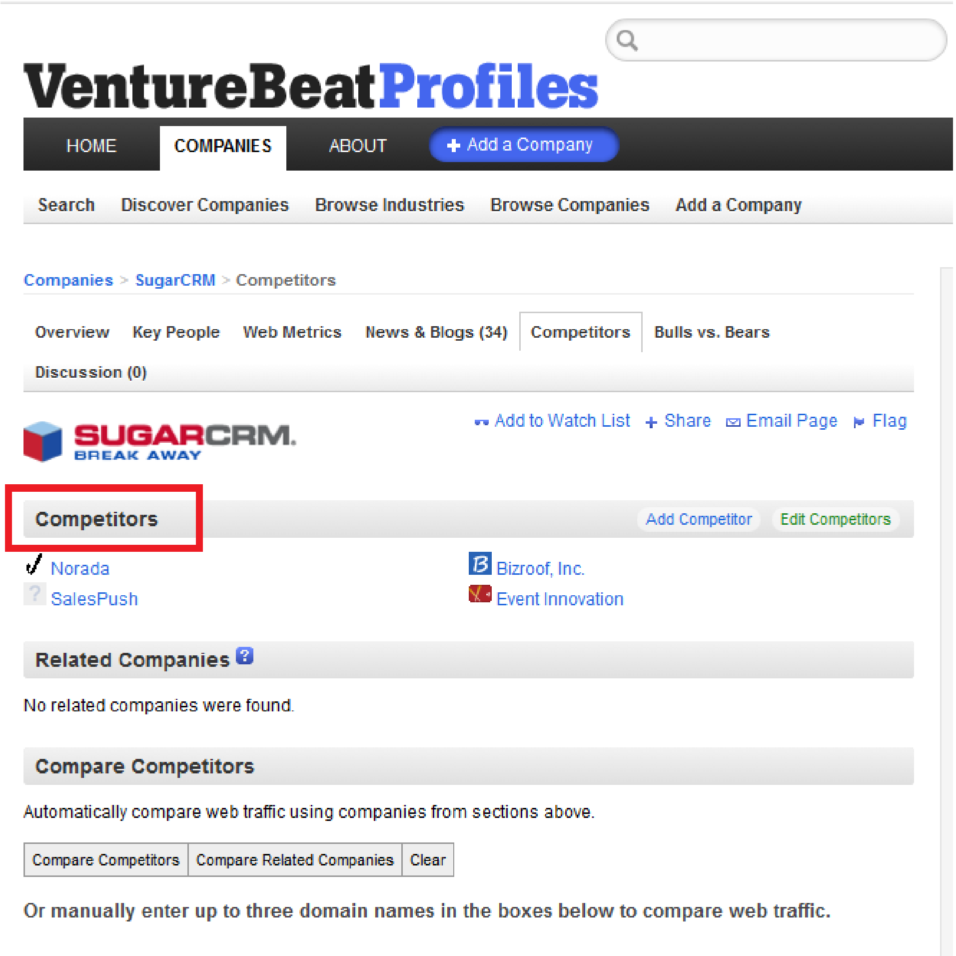

Figure 1.9: VentureBeatProfiles related services

1.5.7 Network Visualization

Tsvetovat and Kouznetsov [27] use nodes to represent people, and links to represent their friendships in the social networks. In service networks nodes can represent services, but we have different types of services and we have to distinguish them. To represent relationships between services we need colourful (different types) links because there are also different types of relationships. The analysis to service networks must be different from the other networks, acquiring specific characteristic.

For the graphic visualization of service networks we can use *NetworkX*[14]. It is a *Python* package for the creation, manipulation, and study of the structure, dynamics, and functions of complex networks. This tool was used by Tsvetovat and Kouznetsov [27] for the visualization of social networks and could be modelled and adapted to service networks.

[14] http://networkx.github.com/

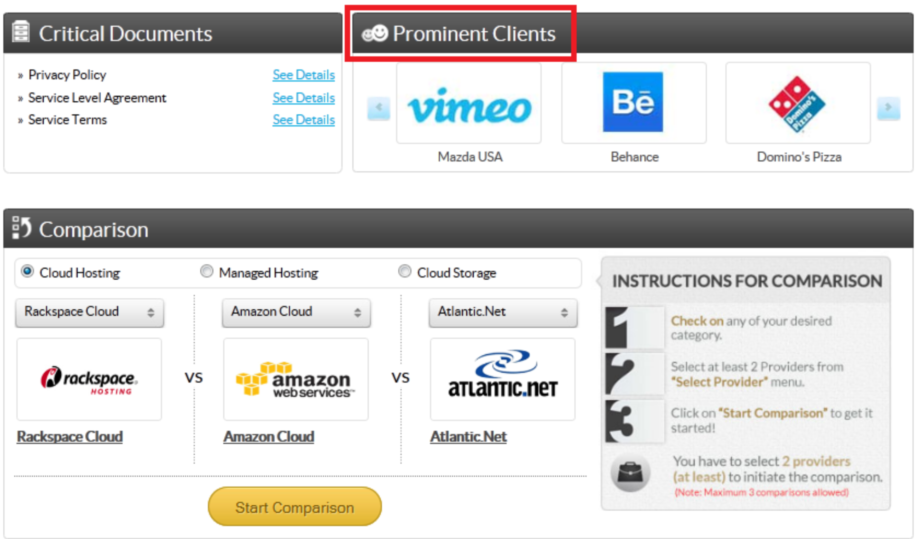

Figure 1.10: CloudReviews prominent clients

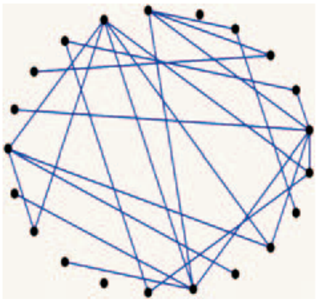

Figure 1.11: Random network representation [11]

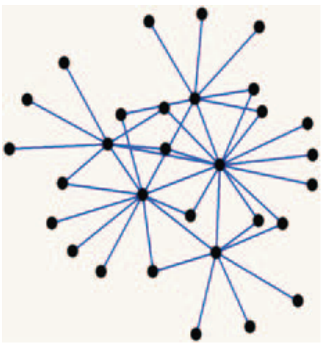

Figure 1.12: Power Law or Scale-free network representation [11]

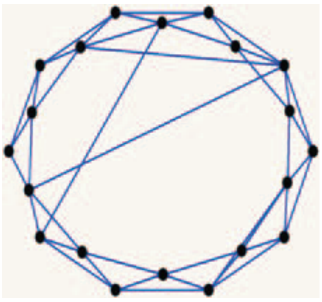

Figure 1.13: Small-world network representation [11]

1.6 Thesis Scheduling

1.6.1 First Semester

Figure 1.14 has the Gantt Diagram with the schedule for the first semester.

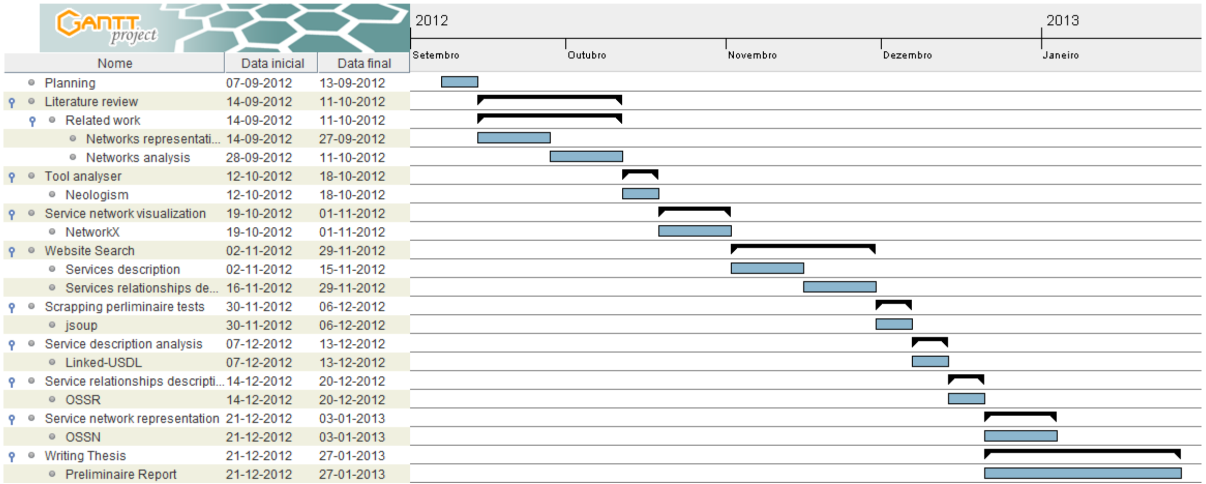

Figure 1.14: Scheduling of the first semester

1.6.2 Second Semester

Figure 1.15 has the Gantt Diagram with the schedule for the second semester.

Website information collection: Research web sites with content about services.

Service description: Create Linked-USDL instances.

Service relationships: Create OSSR instances.

NetworkX Algorithms: Development of algorithms to represent service networks.

Network representation: Represent the service network with NetworkX algoritms using RDF files.

Service network visualization: Graphical representation of services and relationships with NetworkX.

Service network analysis: Analyse topological metrics and models in service network using root developed algorithms and NetworkX algorithms.

Results analysis: Analyse the results from the analysis, and representation of the network.

Writing thesis: Continuation of the first semester report.

Nome	Data inicial	Data final
Website information collection	07-02-2013	15-05-2013
Service description	01-04-2013	15-04-2013
Create Linked USDL insta...	01-04-2013	15-04-2013
Service relationships	16-04-2013	15-05-2013
Create OSSR instances	16-04-2013	15-05-2013
NetworkX Algorithms	16-05-2013	30-05-2013
Network representation	25-05-2013	10-06-2013
Create OSSN model	25-05-2013	10-06-2013
Service network visualization	11-06-2013	25-07-2013
Generate graphs	11-06-2013	15-07-2013
Develop algorithms	10-07-2013	25-07-2013
Service networks analysis	26-07-2013	15-08-2013
Analyse topological metrics	26-07-2013	05-08-2013
Analyse network models	01-08-2013	10-08-2013
Analyse graphs	01-08-2013	15-08-2013
Results analysis	20-07-2013	15-08-2013
Writing Thesis	01-05-2013	01-09-2013

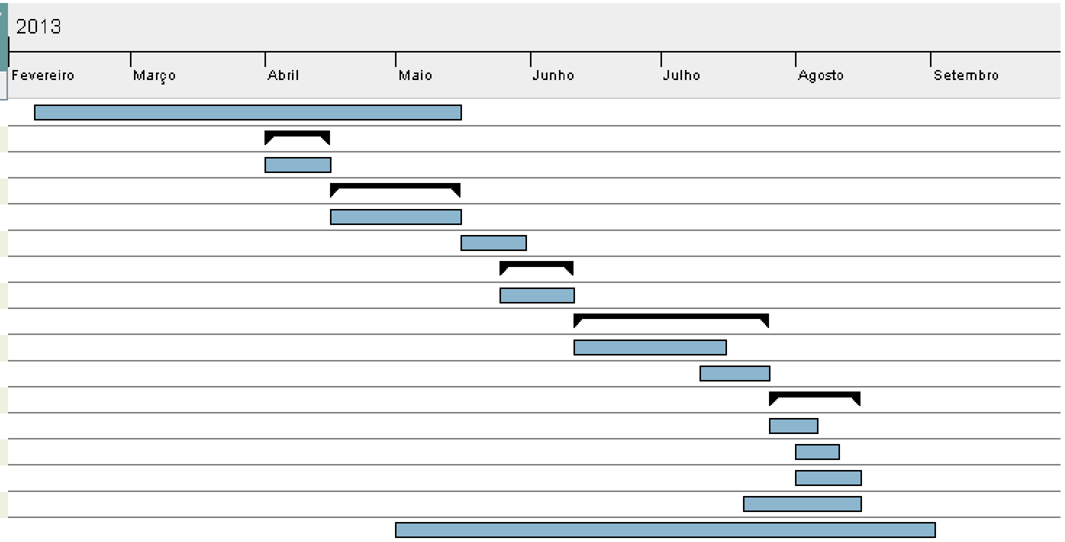

Figure 1.15: Scheduling of the second semester

2
Related Work

With the widespread interest in networks in general, the area of relationships in service networks is an important area that has not been yet properly studied. Although some important research has been developed, the analysis and representation of several networks could help us to define some goals to achieve, and critical points to avoid.

In this chapter we describe the work that has been done related to the network representation in section 1 and analysis of networks in section 2.

2.1 Networks Representation

Graph-Based Notation is proposed Allee [3] to model flows inside a network of business entities. The value flows from an entity to other through the exchange of *Goods, Services and Revenue* (GSR), *Knowledge* or *Intangible Benefits*. The author calls them currencies since they serve as a medium of exchange in a network.

GSR includes all the transactions involving contracts and invoices, return of receipt orders, request for proposals, confirmations, payment and knowledge products or services that generate revenue.

Knowledge includes exchanges of strategic information, planning and process knowledge, technical know-how, collaborative design or policy development.

Intangible Benefits are the exchanges of value and benefits that go beyond the actual service, which are not accounted for in traditional financial measures. Some examples of intangible benefits are customer loyalty, image enhancement or sense of community.

Figure 2.1 shows how the values are exchanged in Graph-Based Notation between Product or Service Providers and Customer or End Users. This nota-

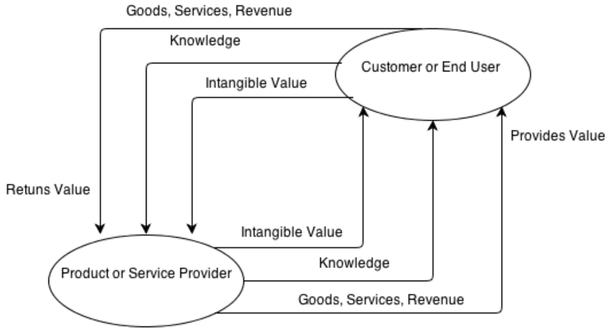

Figure 2.1: Value Exchanges in Graph-Based Notation

tion allows us to know exactly who initiates the exchange, what specific value or product is being conveyed, and who receives it. The value creation can be analysed from multiple perspectives such as time, goals, resources, results, costs and value added linking the diagram to analysis tables.

Graph-Based Notation only takes into account the value flows among the business entities, and does not consider other types of business or relationships that can be established between agents, therefore limiting the synergies with the technology stack and the related practices. The automatic machine-processing of services and flows was not a concern, hence limiting the applicability of the approach to the analysis of distributed large-scale networks.

This method to analysis service networks is mostly focused on the value flows among participants.

e^{3}value is a graphical approach, part of the e^{3}family of business ontologies and provides an ontology[1] to represent e-business models, services, and the value exchanged within companies [2].

Has been developed to be tractable and lightweight. e^{3}value explicitly recognizes that most e-businesses are networks of enterprises.

It emphasizes wants, benefits, need and demand. Like most modelling approaches, it fails to adhere to service-dominant logic and to focus too much inward the company, instead of the network key they belong to.

e^{3}service is also part of the e^3family of business ontologies and provides an ontology to model e-business models and services [16].

Kinderen and Gordijn [13] write that "The ontology represents needs, wants, demands, benefits, and related constructs, to build a customer-oriented catalogue of customer needs for e-services, which in turn can be used during the need-elicitation process for a specific customer".

[1] `http://e3value.com`

The model represents simple relations between services from an internal perspective. The external perspective does not capture the service networks between agents explicitly and does not analyse the effect of relationships quantitatively.

Service Network Notation (SNN) is described by Danylevych et al. [12] and propose a formalism to describe service networks from a Business Process Management (BPM) and Service Oriented Architecture (SOA) perspective. The formalism that authors present is to model service networks with the emphasis on software services and the interplay of service requests, offerings and providing among the participants. SNN describes a service as a combination of several elements:

Participants: In a service network, there are of two types of participants: *individuals* and *business entities*.

Business Relationships: Participants in a service network can be connected by business relationships.

Service Requests: Consumers are participants that need services, therefore they make service requests to advertise their needs.

Service Offerings: Providers make their services available to other participants thought service offerings.

Service Providing: Is a particular type of relationship that occur between a provider and a consumer. It consists of a delivery of provider services to the consumers.

This approach to service networks modelling adopts an *instance* point of view with the goal of enabling the modelling of *concrete* service networks. It means that service networks are made of actual participants in contrast with the roles they play.

SNN is to be used to describe how a service can be composed from a network of existing services. Only capture offerings and rewards which occur between service systems. Focusing on composition, processes and how new services can be created using BPM to describe the interactions of existing SOA-based services.

This approach, to analysing and configuring service networks, does not take into account the role of knowledge and intangible value exchanges.

2.2 Networks Analysis

Studies on social networks are a starting point for the study of service networks.

The growth popularity of on-line communities brings to researchers an amount of useful information that can be used to study the characteristics of *social networks*, contrarily to what happens in *service networks*.

Social Networks are built around users. Users join a network, publish their profile or some other content, and create links to any other users with whom they interact. The result network provides a basis for maintaining social relationships.

Mislove et al. [21] made such a research, which confirms the presence of *power-law*, *small-world* and *scale-free* properties on on-line social networks, by examining data from four on-line social communities such as *Flickr*[2], a photo-sharing site based on a social network, *YouTube*[3], a popular video-sharing site that includes a social network, *LiveJournal*[4], a popular blogging site whose users form a social network, and *Orkut*[5], a social networking site runned by *Google*.

All of the data sets considered in the research are available for the community and have a detailed description of the data format and downloading instructions available[6].The authors developed some important work which can be used to analyse service networks:

Link Symmetry directed links can be useful for locating content in information networks. In three of the studied social networks (Flickr, LiveJournal and YouTube), links are directed and users may link to any other user they wish. These networks have a significant degree of symmetry, which affects the network structure, increases the overall connectivity of the networks and reduces the diameter and can also make it harder to identify reputable sources of information.

Power-Law all the four studied networks show behaviour consistent with power-law networks. The majority of the nodes have a small degree, and a few nodes have significantly a hight degree.

Correlation of indegree and outdegree Indegree and outdegree distributions in the Web graph helped researchers to find better ways to discover

[2] http://www.flickr.com/
[3] https://www.youtube.com/
[4] http://www.livejournal.com/
[5] http://www.orkut.com/
[6] http://socialnetworks.mpi-sws.org/

relevant information in the Web. Pages that are *active* have high outdegree, and pages that are *popular* have high indegree. In social networks, active users also tend to be popular. The high correlation between indegree and outdegree in social networks can be explained by the high number of symmetric links, as showed before.

Path lengths and diameter The path lengths and diameters of all four social networks presented on study are remarkably short. This property results from the high degree of reciprocity within the social networks.

Link degree correlations examine which users tend to connect to each other.

Joint degree distribution: provides structural properties of networks such as, networks with high-degree nodes tend to connect to other high-degree nodes and networks with low-degree nodes tend to connect to other low-degree nodes. In three social networks (except YouTube) high-degree nodes tend to connect high degree-nodes.

Scale-free behavior: the scale-free metric s is a value calculated directly from the joint degree distribution of a graph and ranges between 0 and 1, measuring the extent to which the graph has a hub-like core. A high scale-free metric means that high-degree nodes tend to connect to other high-degree nodes, while a low scale-free metric means that high-degree nodes tend to connect to low-degree nodes. The social networks with the exception of YouTube show a significant s, which indicates that high-degree nodes tend to connect to other high-degree nodes, and low-degree nodes tend to connect to low-degree nodes.

Assortativity: The assortativity coefficient r is a measure of the likelihood for nodes to connect to other nodes with similar degrees, and ranges between -1 and 1. A high assortativity coefficient means that nodes tend to connect to nodes of similar degree, and a negative coefficient means that nodes likely connect to nodes with very different degree from their own. Again, only YouTube shows a negative assortativity coefficient.

Densely connected core a *core* of a network is any set of nodes that satisfies two properties: the core must be necessary for the connectivity of the network; and the core must be strongly connected with a relatively small diameter. In this sense, a *core* is a small group of well-connected group of nodes that is necessary to keep the remainder of the network connected. The high-degree core nodes in these social networks are all within roughly four hops of each other, while the rest of the nodes, the majority of the network, are at most a few hops away from the core nodes. This high dependence on few highly connected nodes, may have implications for information flows, trust relationships and vulnerability of these networks.

Tightly clustered fringe The *clustering coefficient* of a node with N neighbours is defined as the number of directed links that exist between the node's N neighbours, divided by the number of possible directed links that could exist between the node's neighbours. The *clustering coefficient* of a graph is the average clustering coefficient of all its nodes. In social networks, the *clustering coefficients* are between three and five orders of magnitude larger than their corresponding random graphs, and about one order of magnitude larger than random power-law graphs, which is unusually high and suggests the presence of strong local clustering. In social networks this is explained by the fact that, people tend to be introduced to other people via mutual friends, which increases the probability of two friends of someone, become also friends.

Limitations of the models: The available techniques nowadays fall short on providing workable solutions and are unable to deal with the establishment of open and rich relationships between services. To model networks we need a more detailed description of services. These descriptions should include aspects like pricing, quality levels and legal constraints.

3
Service Networks

This chapter is divided in six sections. The first shows an overview of service-based economy. The second section explains how the economy can be organized in networks. The third section describes service networks. In the fourth section we enumerate some types of possible service networks. In the fifth section several types of relationships are described. The last section presents the usefulness of service networks analysis.

3.1 Service-Based Economy

Nowadays, we face two recent economic developments:

1. The increased importance of the service sector in industrialized economies;
2. The importance of service in a product offering.

Presently, services offerings are nearly at the same level as products offerings. This happens because products have now a higher service component than in previous decades.

Many products are being transformed into services. IBM[1], for example, treats its business as a service business, despite the fact that they still manufacture computers. Several companies that started with products are now offering services. For example, Microsoft[2] offers products such as software (e.g. Microsoft Office, Windows 8, etc.), but also offers services (e.g. Windows Azure, Bing, Skype, Dynamics CRM, etc.).

The growing demand for software services by industry, to perform activities previously developed by humans, is also increasing the service economy and

[1] http://www.ibm.com/
[2] http://www.microsoft.com/

leads companies to focus much more in this type of offers. OECD [22] points out the following regarding the importance of services in economy: "Their growth has exceeded overall economic performance for decades, which has resulted in the share of services in total economic activity increasing over time. The rising trend can be expected to continue, or even accelerate, in light of the increasing prominence of knowledge-based, service-oriented activities (...)".

3.2 Network Economy

We live in a information society, where a network economy is emerging. The products and services created generate value, which spreads by the network. These networks operate on a global scale and, in a network economy, the value created is shared by all members of the network rather than by individuals. Companies can provide 24-hour service. Customer requests are passed from one time zone to another, through the network economy, without customers being aware that the work is being done on the other side of the world.

Figure 3.1 illustrates a real example of the today's service offerings. As it can be observed, services of different companies are related forming networks of services. Microsoft and Sapo[3] are both service providers, and Sapo is also a consumer of Microsoft services. Sapo complements it offerings using technology from Microsoft gaining with this relationship a wide range of consumers and stability in the market, Microsoft gets a consumer and disseminate it services.

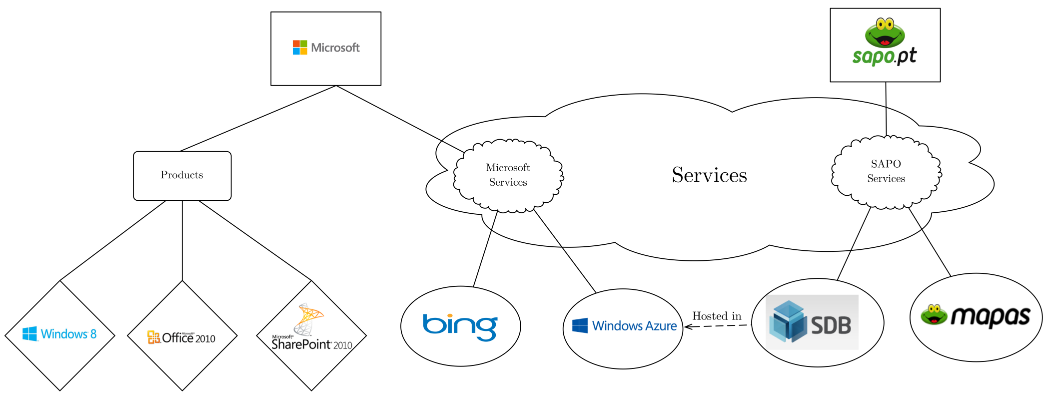

Figure 3.1: Related services

[3] http://www.sapo.pt/

3.3 What are Service Networks

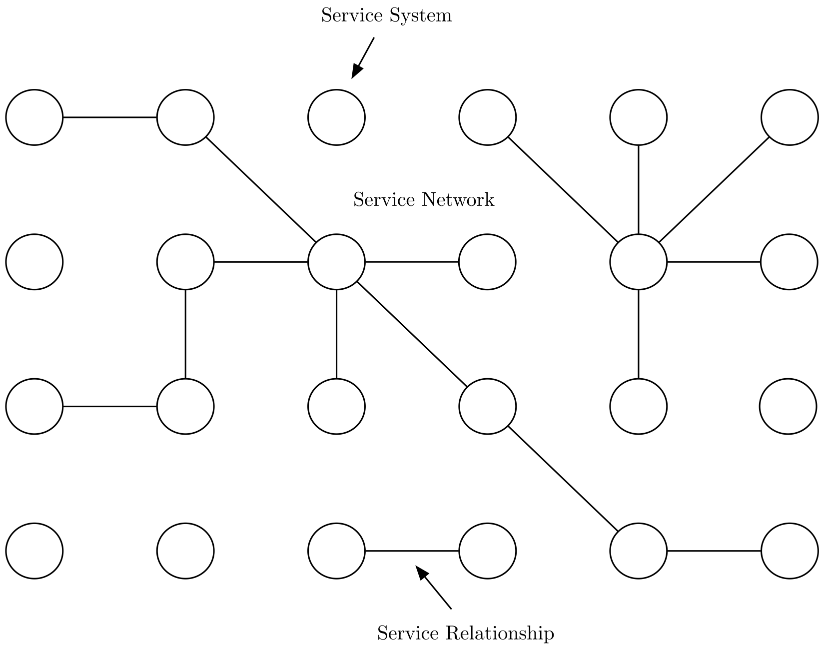

Figure 3.2: Service, service relationship and service network

In business, networks are defined by Smith-Doerr and Powell [23] as "(...) formal exchanges, either in the form of asset pooling or resource provision, between two or more parties that entail ongoing interaction in order to derive value from the exchange".

Service networks are described by European Research Center for Information System [14] as: "a collaboration amongst two or more organisations that decide to cooperate as a group in order to provide services regionally, nationally, or globally, that no member of the group could independently provide. (...) Service networks are Internet business communities where companies collaborate through loosely coupled business services".

The figure 3.2 shows the elements of a service network. Services are illustrated by nodes and relationships by edges, which represent the transfer of goods, revenue, knowledge, or intangible benefits.

A *service network* is defined by Cardoso et al. [9] as "a business structure made up of services which are nodes connected by one or more specific types of relationships". Danylevych et al. [12] describe service networks as "The interconnections in terms of services offered and required by enterprises shape complex webs".

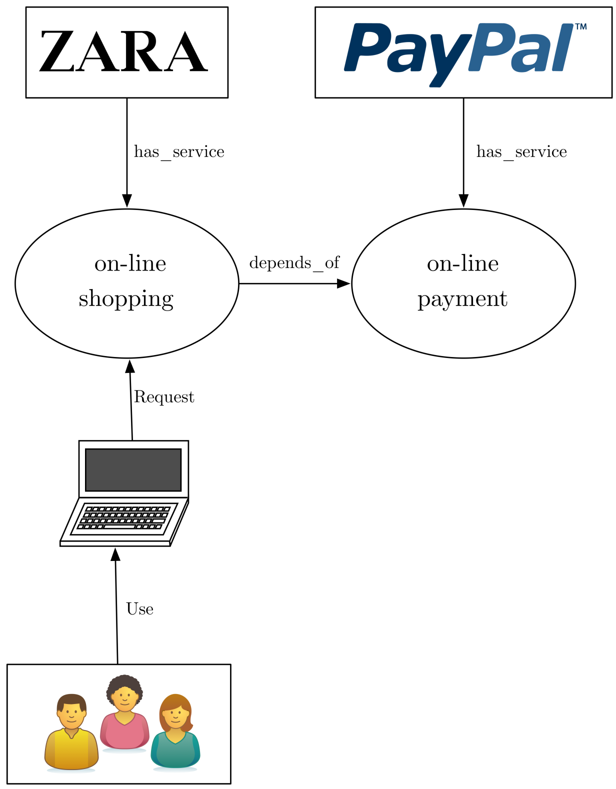

Figure 3.3: Relationship between an On-line shopping service and e-Bank service

In this work, we consider *Service Networks* as

> Services interconnected by relationships established between them.

An example of a service network is the on-line shopping services related to on-line bank services illustrated in figure 3.3. The On-Line shopping service is complemented by the e-Bank service, both services obtain profits from this relationship getting clients and generating value.

3.4 Usefulness of Service Networks

Inferring links between the different types of services and studying how they are related provides relevant insights that make the available information on the internet more valuable.

Two related services create more value than one service alone, living in a silo. In some cases, like the one illustrated by figure 3.3, a service can not exist without the other, since they depend on each other. Service networks appear in a natural way, when defining interactions between services.

There are several benefits in service networks, the European Research Center for Information System [14] pointed a couple advantages of service networks:

1. Provide options for making services available across unreachable markets till now, both nationally and globally;
2. Help to achieve economies of scale, providing impetus to enhance their competitiveness in both national and international markets;
3. Service networks stimulate new business opportunities, for example, to innovate and commercialize new products and services offerings;
4. Improve the responsiveness of service delivery;
5. Help reduce costs of operation;
6. Enhance the scope to form new capital bases;
7. Create new businesses;
8. Increase exports, and provide means to explore new sources of competitive advantage;
9. Allow better negotiation positions for all parties (suppliers, customers and/or regulatory organisms).

3.5 Types of Service Networks

3.5.1 Inter-Organizational

Services create relationships between different organizations. As figure 3.3 shows, two distinct companies share services.

We can highlight the advantages of inter-organizational networks described by Smith-Doerr and Powell [23], for business networks: "Inter-organizational networks can contribute to greater productivity in manufacturing, as well as facilitate the introduction of new production methods. (...) At the organizational level, the performance of firms can benefit from network ties in the form of access to information and resources, more rapid product development, and enhanced innovation. (...) Connections to other organizations can also improve the likelihood of a firm's survival and ability to garner financing". We can also assign these advantages to service networks. Services could have better performance combined with other services and informations regarding service features can be easily spread within the network, improving other services.

3.5.2 Intra-Organizational

Service networks exist as well inside enterprises since there is interaction tacking place, in form of service offering, business units, divisions and departments. Therefore, service networks do not occur exclusively among distinct business.

3.5.3 Financial

Financial service networks are a specific set of service networks. The world economies are highly interrelated and interdependent, creating networks with enormous value. The occurrence of a disturbance in a service can create consequences in others services of the network.

Cardoso et al. [9] give the example of the economic collapse in 2008 that started in USA and propagated to Europe. It could probably be have an avoided if the information of financial institutions services was available to be used to anticipate such catastrophe. Using description models, like UDSL, all the services could have been accessible to regulatory entities allowing them to access and retrieve service and relationships models to construct financial service networks. The vulnerabilities would have been identified. The concept of OSSN will allow to better perceive the nature of services and how they interact with each other within the network economy.

3.5.4 SaaS networks

One other type of services networks are networks made of *Software as a Service* (SaaS), a software delivery model. In this work, we focus in these type of service networks because nowadays these type of services are in significant growth and become one of the major generators of economic value for companies.

Sommerville [25] says that the "notion of SaaS involves hosting the software remotely and providing access to it over the Internet" and presents some key elements of SaaS:

1. Software is deployed on a server and is accessed through a web browser.
2. The software is owned and managed by a software provider.
3. Users may pay for this kind of software. Sometimes it may be free, but users must have to accept advertisement.

Service users benefit from SaaS since the costs of software management are transferred to the service provider, who is responsible for the overall management of the system.

On other hand, Mell and Grance [19] define cloud SaaS as "The capability provided to the consumer is to use the provider's applications running on a cloud infrastructure. The applications are accessible from various client devices through a thin client interface such as a web browser (e.g., web-based email). The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user-specific application configuration settings".

3.6 Types of Relationships

There exist several types of relationships, for example, in nature, physic, economy and in humanity. Some are not explored yet, others have some studies started and someone's have already interesting results, such as social networks [17]

3.6.1 Explicit

Relationships can be expressed by models, developed by humans to make them easier to understand. Two examples of these type of models are: Friend of a Friend (FoaF) and Semantically-Interlinked Online Communities (SIOC).

FoaF [4] Friend of a Friend[5] is a RDF/XML Semantic Web vocabulary for representing social interactions and people, and therefore can represent social networks. This method is specified in OWL and contains terms for describing personal information, membership in groups, and social connections [15]. Some social networking websites like LiveJournal[6], Twitter[7] or MyOpera[8] use it to produce Semantic Web profiles for their users[9].

SIOC [10] Semantically-Interlinked Online Communities[11] combines terms from vocabularies that already exist with new terms needed to describe the relationships between concepts within online communities scope. The goal of SIOC is to interconnect online communities [4]. It aims to promote the integration of online community information and provides a *document-centric* view. SIOC uses Semantic Web technologies to describe the information that communities have regarding their structure and contents. It also finds related information and new connections between content items and other community objects. It is normally used in combination with FoaF vocabulary for expressing personal profile and social networking information.

3.6.2 Implicit

Other types of relationships are not modelled. By means of tacit knowledge[12], we know that a molecule consists of connections between atoms of chemical elements. In nature we found several examples of relationships that are not modelled, for instance, a bee and a flower have a cooperation relationship.

3.7 Usefulness of Service Networks Analysis

As the technology evolutes, people begin to make an extensive usage of Internet. Service providers start to provide additional services that result in more, and more on-line services. As *social networks* became an important factor in the personal on-line interaction, *service networks* play an important role in on-line commerce, economy growth and providing of knowledge.

[4] http://xmlns.com/foaf/spec/index.rdf
[5] http://www.foaf-project.org/
[6] http://www.livejournal.com/
[7] https://twitter.com/
[8] http://my.opera.com/community/
[9] http://www.w3.org/wiki/FoafSites
[10] http://rdfs.org/sioc/ns
[11] http://sioc-project.org/
[12] Knowledge, that is difficult to transfer to another person by means of writing it down or verbalising it.

1. Understanding the structure of service networks benefits the design of new systems, and helps to understand the impact of on-line service networks on the future of Internet. On-line service networks became popular and bandwidth-intensive, therefore they can have a significant impact on Internet traffic;

2. A deeper understanding of the underlying topology is an essential first step in the design and analysis of robustness trust and reputation metrics for these systems;

3. The critical nature of service networks raises concerns about the risk and impacts of system failures, and makes better understanding of the essence of such networks imperative. Providing better analysis and prediction of various potential issues could maximize the service networks' potentials, which can benefit our society;

4. The analysis of service networks is particularly important for our service-based economies, since it brings us new scientific discoveries on how they operate at a global scale;

5. Value networks can help explain the dynamics of non-profits, economic clusters and economies. The huge amount of real data has stimulated great interest in trying to uncover the generic properties of service networks.

4

The USDL Model

Chapter four is divided in four sections. The first describes de USDL model, giving emphasis to services and Linked-USDL model, and discusses where services descriptions can be found. The second section explains how to model services by creating instances. In the fourth section we explain how to create instances of service descriptions. The last section evaluates de performance of the USDL model.

4.1 USDL Model for service description

The need to describe services comes with the emergence of Internet marketplaces for business services. Not only a description from a technical level is needed, but also from a business and operational perspective as said in [6] by Cardoso.

The USDL Model allows a computer-understandable description for services. There are available three versions of USDL: $\alpha - USDL$[1], USDL[2] and Linked-USDL[3]. They vary in completeness and in expressiveness. These languages will in the future allow entities to formalize services that they can be used effectively to dynamic service outsourcing, efficient SaaS trading and automatic service contract negotiation as Cardoso said in [9].

Unified Service Description Language (USDL) is also described by Cardoso in [6] as a "specification language to describe services from a business, operational and technical perspective.", that "(...) has been created to capture the business and operational nature of services and align them with technical perspective.", and Cardoso also refers that "USDL can be seen as the fist

[1] http://www.genssiz.org/research/service-modeling/alpha-usdl/
[2] http://www.w3.org/2005/Incubator/usdl/
[3] http://www.linked-usdl.org/

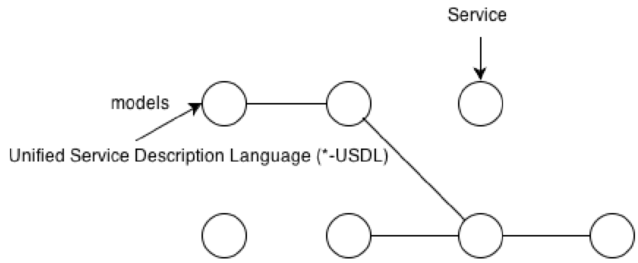

Figure 4.1: USDL

step to better understand and describe the fundamental characteristics and peculiarities of business services.". USDL considers the description of the service's technical interface and also legal aspects, pricing, service level agreement, bundling, operations, interfaces, distribution channels, resources and participants. This makes USDL too complex to implement. To solve these problems Linked-USDL was developed, changing the paradigm of USDL to the domain of semantic web, having computer-readable descriptions of the services. It uses Semantic Web technologies and each user can implement new elements which inherit from the standard model. Extensions of the model are also allowed, for example, for specific domains.

Figure 4.1 graphically represents services, possible relations between services, and where the model *-USDL acts in services and describes them.

Linked-USDL aims to better promote and support the use of the Unified Service Description Language (USDL) on the Web. It is a remodelled version of USDL that builds upon the Linked Data principles and the Web of Data. This change reduced the complexity of the data model, making possible the use of namespaces that have been on the market for a long time. It describes services and aims to be applicable to all sectors of service industry[4]. The model offers a comprehensive approach to describe services of all sorts and sizes in a machine and human readable way. Linked-USDL was developed to provide the means for publishing and interlinking distributed services for an automatic and computer based-processing.

[4] `http://www.linked-usdl.org/`

4.2 Modelling Services

Linked-USDL is a master data model for services. It describes various types of services from professional to electronic, describes business aspects such as ownership and provisioning, pricing and legal aspects, in addition to technical aspects. Linked-USDL is composed by some models, such as:

USDL Core provides the core module of Linked USDL. It covers the main concepts and relationships characterising services, leaving more specific aspects regarding some particular dimensions such as technical interfaces, licensing or security aside.

USDL-Pricing a pricing model vocabulary for USDL.

USDL-SLA describes service level agreements. Service Level Agreements (SLAs) are a common way to formally specify such functional and non-functional conditions under which services are to be delivered.

Linked-USDL core is demonstrated in figure 4.2[5] and has ten main classes: *usdl:BusinessRole*, *usdl:InteractionRole*, *usdl:InteractingEntity*, *usdl:InteractionPoint*, *usdl:InvolvedEntity*, *usdl:Role*, *usdl:Service*, *usdl:ServiceModel*, *usdl:ServiceOffering* and*usdl:TimeSpanningEntity*.

The properties associated to these classes allow a description of the functional properties of the service, describing the interaction protocol as well as non-functional properties.

[5] https://github.com/linked-usdl/usdl-core

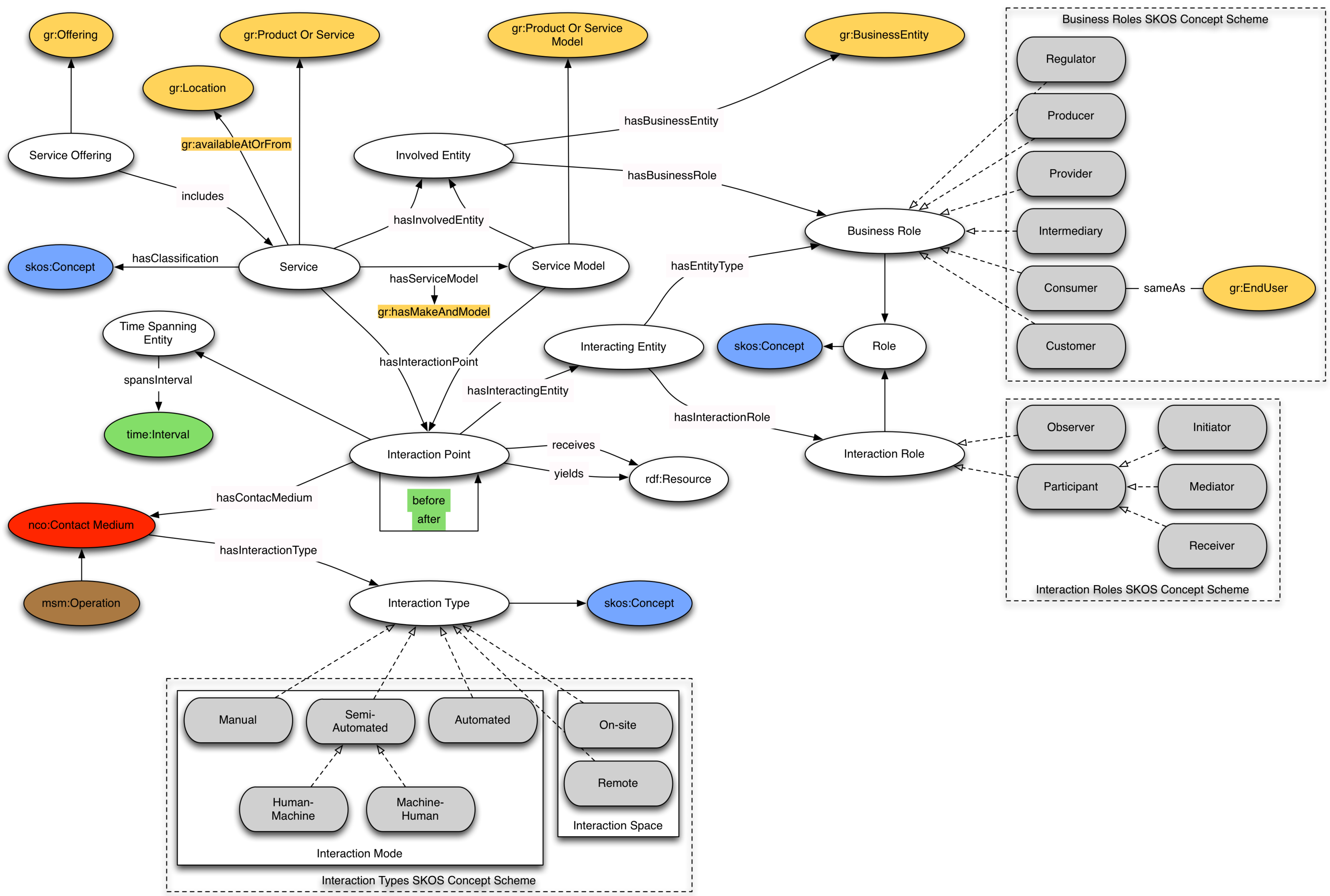

Figure 4.2: Linked-USDL core

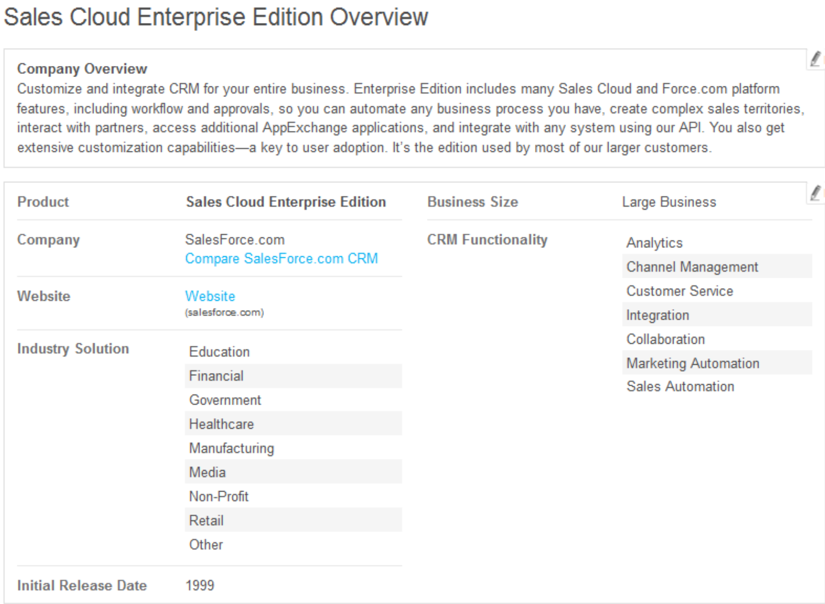

Figure 4.3: Sales Cloud in FindTheBest.com

Services and their descriptions can be found in websites such as *FindTheBest.com*[6], *VentureBeatProfiles.com*[7] , *CRMsearch.com*[8] for customer relationship management (CRM), or even in the websites of the services.

Salesforce.com, Inc.[9], for instance, is a provider of enterprise software applications delivered via the software-as-a-service (SaaS) cloud computing model and *Sales Cloud* is the company's flagship product is a CRM system designed for businesses of all sizes and industries. In *FindTheBest.com* we found information which describes Sales Cloud service, the company overview, their functionalities, pricing and industry solutions, as shown in figure 4.3, and is with this type of information that we can populate the Linked-USDL model.

4.3 Create Instances

Figure 4.4 demonstrates the creation of instances of Sales Cloud software service using the Linked-USDL model. The figure describe the Sales Cloud service, a Customer Relationship Management service (CRM) used to manage company's interactions with current and future customers. It involves software to organize, automate, and synchronize sales, marketing, customer service, and technical support.

[6] http://www.findthebest.com/
[7] http://venturebeatprofiles.com/
[8] http://www.crmsearch.com/
[9] http://www.salesforce.com/

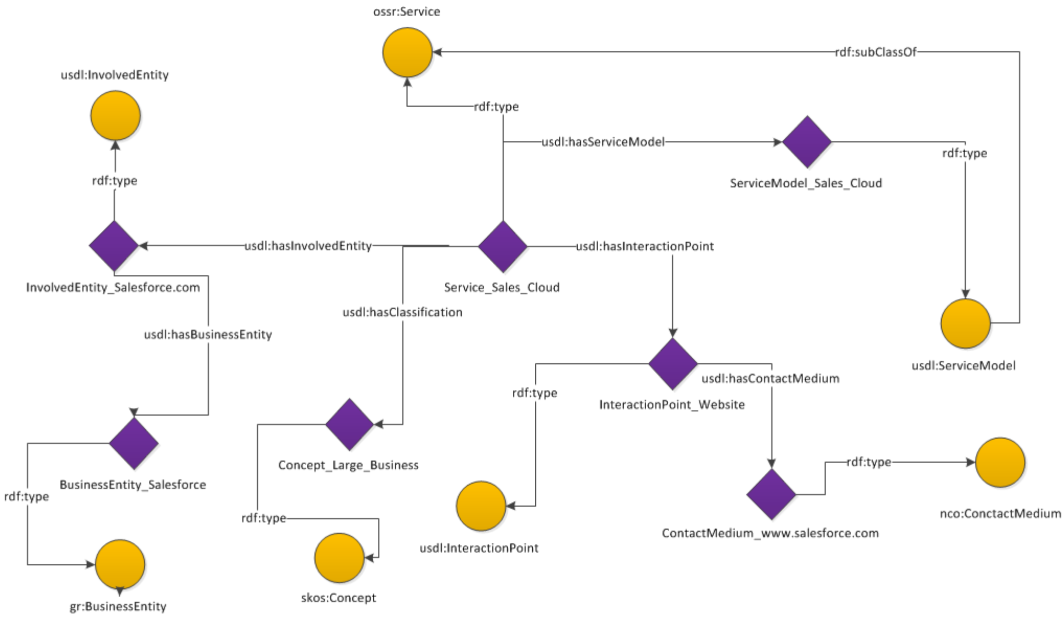

Figure 4.4: Linked-usdl instances of Sales Cloud

The model used, *Linked-USDL Core*[10], addresses the description of the participants, interactions, resources, access to technical and some more information. The price, SLA, security and legal aspects are defined in other models auxiliary, *Linked-USDL Price* and *Linked-USDL SLA*. As the figure 4.4 shows, the model of the service is Sales Cloud and its interaction point is a website with a contact medium www.salesforce.com. It is used in large business, its entity is Salesforce.com and the business entity is Salesforce.

4.4 Evaluation of the USDL Model

As Cardoso et al. said in [7], USDL is not limited to technical and implementation aspects of services. The model also enables organizations to describe and publish their business services by describing their characteristics, enabling consumers to discover and select services. It builds on the usage of models for describing business and technical services, and creates a unified description of related research efforts. USDL also provides an extension mechanism that allows users to make new properties part of the service description. The class *usdl:Service* is the central element in a description of a service with the purpose of describing it in a way that serves as an interface between the provider and the consumer. The service descriptions contains functional properties of the service (e.g. interaction points or service model) and non-functional prop-

[10]`https://github.com/linked-usdl/usdl-core`

erties (e.g. qualitative and quantitative values), allowing an almost complete description of the service.

USDL model was developed to be possible to integrate with other models. In our case, the Linked-USDL model will be linked to the Open Semantic Service Relationships (OSSR) model. In the next chapters we describe how to link the models and how it will be an advantage to service business.

5

The OSSR Model

Chapter five is divided in four sections. The first section describes service relationships and where and in what manner they can be found. The second section explains in detail the OSSR model for describing service relationships. Third section illustrates the creation of service relationships instances using the OSSR model. In the last section we evaluate the OSSR model pointing out some interesting aspects of its use.

5.1 Service Relationships

The development of models which describe relationships between services came with the growth to service marketplaces and the need of understand how they can be related to improve its performance for both clients and service providers. Knowing how services are related with others could help us to describe the service and know how they behave in case of a disruption in that service, like the failure of the headquarters. Some services are related to others in a relationship of dependence, other services improve their performance with relationships of complementarity, and there are some services related to others just because of their nature. Figure 5 represents a graph composed of services (nodes) connected to other services by way of relationships (edges) between them.

Populate information into models needs services data, describing the service and possible relations with other services.

Relationships between services can be found in many sites such as `http://venturebeatprofiles.com/`, `http://www.crmsearch.com/` or `http://www.findthebest.com/` with the purpose of characterizing a wide range of services and comparing them. They can also be found on specific websites of each services, for example, `http://www.salesforce.com/` or

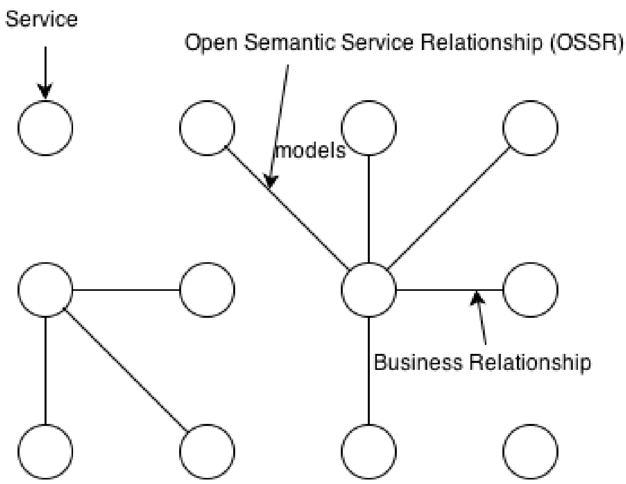

Figure 5.1: OSSR

Figure 5.2: Relationships between services found in *Salesforce* website.

http://www.zoho.com/. In websites, relationships can be represented by texts or images.

In figure 5.2 there is a snapshot of a website[1] where relationships between Salesforce.com and services like Facebook, Twitter or even Oracle databases are represented. In these cases the extraction of information is made difficult, because it cannot be done using scrappy techniques and it has to be performed manually, although this type of representation is visually more perceptible for humans.

Figure 5.3 is also a snapshot of a website[2] where relationships between services can be found. Service relationships are described in text form, in

[1] http://www.salesforce.com/platform/cloud-infrastructure/integration.jsp

[2] http://www.crmsearch.com/salesforce-competitors.php

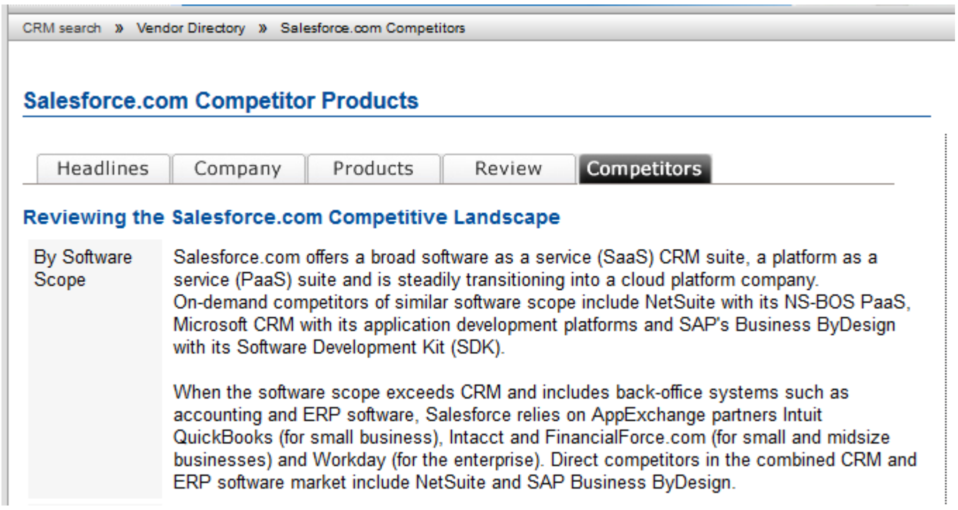

Figure 5.3: Relationships between services found in *crmsearch* website.

websites with the intention of comparing similar types of CRM services. To perform the information extraction it is more appropriated find descriptions in text because allows the use of scrappy techniques. However, the information is not structured which difficult the collection of it.

Therefore, no one of these types of descriptions is adequate to our need. The information is not structured so it has to be performed manually and can lead to padding error. The time expended during the extraction is increased due to the impossibility use of technology.

5.2 The OSSR Model

Open Semantic Service Relationships (OSSR) Cardoso in [5] said that the OSSR model is computer- understandable, is represented with Semantic Web languages, and define by the main concepts and properties required to establish rich semantic relationships between service models. It was implemented using the Resource Description Framework (RDF), which allows semantic information to be expressed as a graph. The model establishes links with various existing ontologies, such as Linked-USDL, to reuse concepts. The OSSR Ontology is available online[3].

The OSSR model includes 15 top level concepts: *Relationship*, *Service*, *Source*, *Target*, *Role*, *Level*, *Involvement*, *Comparison*, *Association*, *Causality*, *Cause*, *Link*, *Effect*, *Category* and *Key Performance Evaluation (KPI)*. All these concepts are related, as shown in figure 5.4.

[3] `https://github.com/Genssiz/OSSR`

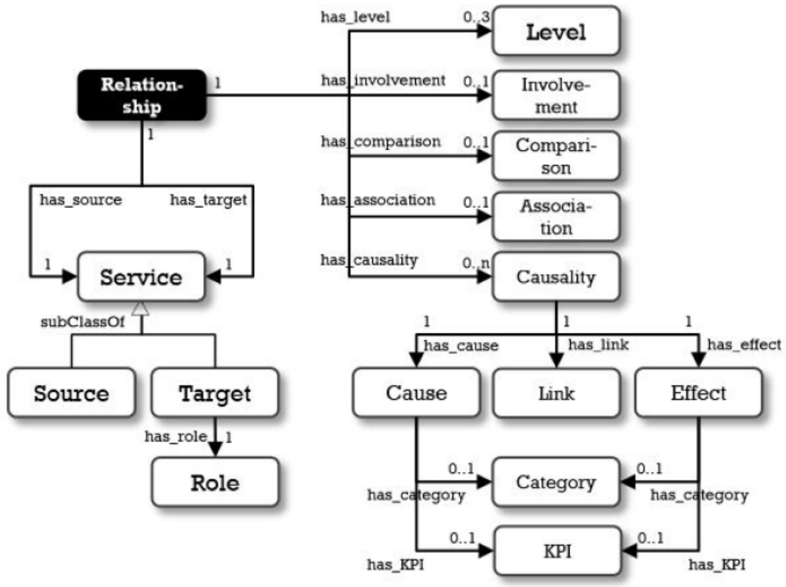

Figure 5.4: Layers of OSSR model[5]

The *ossr:Source* and the *ossr:Target* are subclasses of *ossr:Service* which can be modelled by a language like Linked-USDL, adding value and content to the OSSR model.

The OSSR model was designed to be used for all types of services such as human-based services or software services. In this work we focus in *software services*. Different types of services establish different types of relationships, and not all services of the same type have the same types of relationships. Therefore, the model is designed to adapt to different types of services by not placing restrictions that prevent the adjustment of the service in the model.

Below we describe the concepts of the OSSR model, in table 5.1 we summarize the layers and concepts of the model.

Participating roles: **Customer** focuses on a good working model with customers. **Supplier** focuses often on a durable stream of competitive advantage which may be hard for others to imitate or break. **Competitor** belongs to a group of competing firms. **Complementor** enables a service source to increase its value by adding external operations to it.

Interconnection level: **Activity links** refer to the integration of activities, tasks, or operations excluded under control of two services. **Actor bonds** are the integrations among participants belonging to the human resource structure of distinct services. **Resource ties** are the exchange of resource types.

Layer	Description
Role	Position and participation of a service in the network
Level	To streamline integration to other firms' services It is associated to the concept *relationship*
Involvement	The stakeholder willingness to establish a partnership
Comparison	Identification of similarities and differences between services
Association	Enables the combination of simpler services into more complex service systems
Causality	Also refered to as *cause-effect*, describes how a *cause* event occurring in a service has an *effect* in another service

Table 5.1: Layers of OSSR model

Involvement strength: **Low-involvement** suggests that both parties opt for a more simplified relationship. In **High-involvement** both parties are more interested to establish a long-term partnership.

Functional comparison: **Equivalent** suggests that two services are identical in their functionalities and characteristics (full equivalence). **Generalization** shows that a service has a closer set of functionalities than another (partial equivalence). **Specialization** expresses that a service has a wider set of functionalities than another (partial equivalence). **Similar** if services are similar (inexact equivalence). **Different** when two services do not have any functionalities in common.

Service association: **Aggregation** expresses *a part of* or *has a* relationship between services. *AggregationBy* indicates that the service source has the role of assembly and the service target has the role of component. *AggregationOf* is the inverse relation of association, the service source has the role of component and the service target has the role of assembly. **Composition** is a specialized form of strong aggregation where component services cease to exist, or are not needed, if the assembly service ceases to exist. *CompositionBy* is the inverse of *CompositionOf* is the inverse relation of composition, where the service source has the role of component and the service target has the role of assembly.

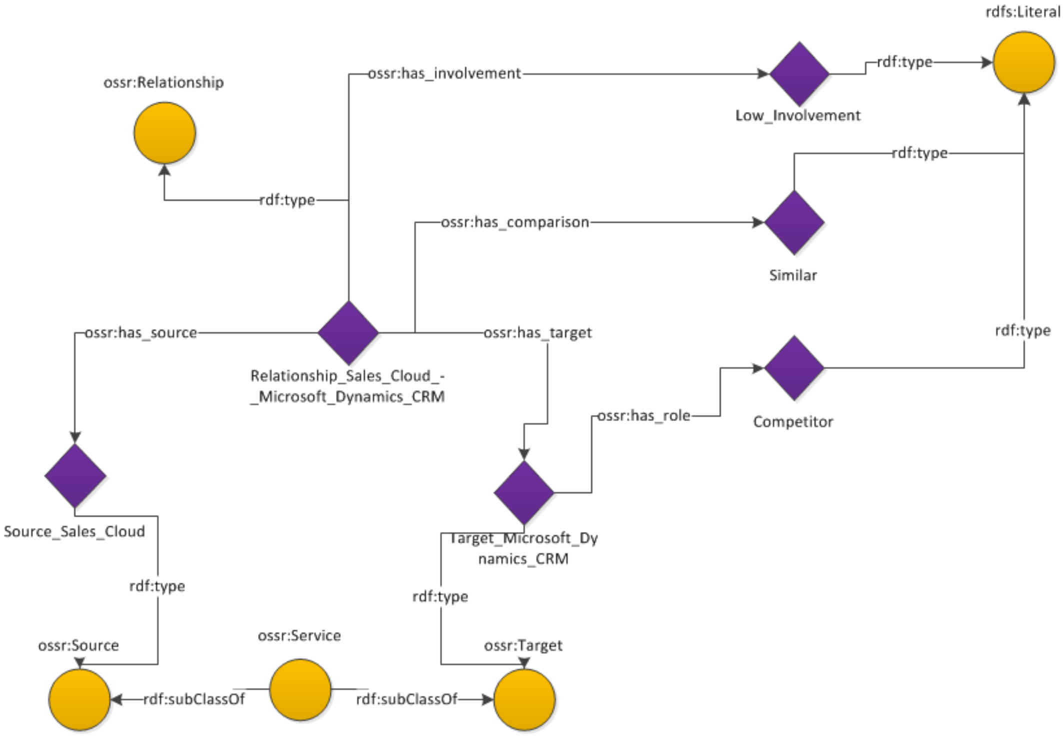

Figure 5.5: Relationships between Sales Cloud and Microsoft Dynamics CRM modelled using OSSR

Causality between services: expressed using key performance indicators (KPI) of service systems, that they connect. This five elements compose a schema to classify the measure of cause-effect performance. **Quality**, **Time**, **Cost**, **Flexibility** and **Other**.

5.3 Creation of Instances

After the information extraction it is possible to populate the model with data and create service relationships instances.

Figure 5.5 demonstrates the creation of relationships between Sales Cloud and the Microsoft Dynamics CRM software services using the OSSR model. In this relationship the service source is Sales Cloud and the service target is the Microsoft Dynamics CRM, therefore the role of the Microsoft Dynamics CRM is *"Competitor"*. Sales Cloud and Microsoft Dynamics CRM are *"Similar"*, some functionalities intersect while others are disjoint. The services have *"Low Involvement"* because both parties choose a more simplified relationship.

Figure 5.6 demonstrates the creation of instances of relationship between Sales Cloud and the Oracle database software services using the OSSR model. In this case, Sales Cloud is the service source and the Oracle database is

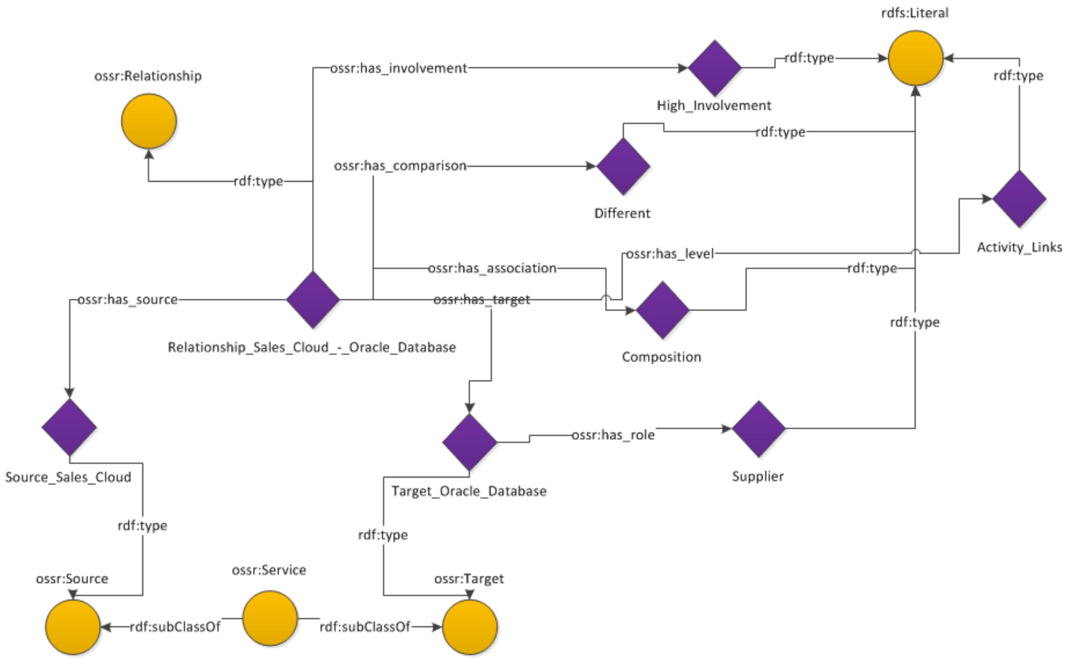

Figure 5.6: Relationships between Sales Cloud and Oracle database modelled using OSSR

the target source. The role of the Oracle database is *"Supplier"*. These services are *"Different"* and have an *"High Involvement"* because both parties are interested in establishing long-term partnership. The association of these services is a *"Composition"* ,because if the component role ceases to exist, or to be needed, the assembly role ceases to exist. Sales Cloud and the Oracle database integrate their services, so their level is an *"Activity Link"*.

The dataset created covers a wide range of interactions between services. As we can see in images 5.5 and 5.6, Sales Cloud is related to two other services in different ways. Depending on the service target it is related to, and the type of characteristics of the relationships it establishes, the OSSR model is filled with different parameters.

Using the OSSR model, relevant data about service relationships can be grouped and easily accessed. Information about the association, the involvement strength, the interconnection level, and comparison between services are some examples of data that are gathered in OSSR. The model allows this information to be easily exported and used for service analysis. With the creation of these dataset it is possible to understand the position of a service in a network. Defining its role will give an overview of the types of relationships it will create with other services.

5.4 Evaluation of the OSSR model

As Cardoso said in [5], the model verifies several aspects: *Consistency:* no circular definitions found and syntactically correct; *Completeness:* the model is not complete, additional relations types can be added in the future; *Expandability:* new relations can be added without altering the set of well-defined relations that are already guaranteed; *Sensitiveness:* relatively insensitive to small changes; and *Conciseness;* it did not contain redundant or unnecessary definitions.

As regards to completeness, observe that the Open Semantic Service Relationships (OSSR) model can be modified. For example, classes like *ossr:Level*, *ossr:Involvement*, *ossr:Comparison*, *ossr:Association* and *ossr:Role* are not being used, making it possible for the user to choose how to complete the instances.

The model becomes more susceptible to human errors but more open to other possible solutions which can better describe the relationship, can be expanded. The model is now designed for development with a view to improving so it is not closed to new features. In a second phase, these classes that are not being used will protect the model restricting the choices of the user.

Relationships are described in OSSR model in such level that it is possible to understand which is the position of each service in the relation, and state if it has benefits or limitations for services.

The idea behind the implementation of service relationships is to create a linked global service network using machine-readable descriptions.

The OSSR model was designed to integrate with *Linked-USDL*. Services connected by a relationship described by OSSR model, can also be represented with *Linked-USDL* model using the *usdl:Service* class. Services and relations are encoded in Resource Description Framework (RDF), which allows semantic information to expressed as a graph, and becomes possible to make queries over distributed service networks using the SPARQL RDF query language[4].

[4] http://www.w3.org/TR/rdf-sparql-query/

6

Visualization of Service Networks

Chapter six is divided in four sections. The first section describes the concept of open semantic service networks (OSSN) and how to model open semantic service networks (OSSN) in combination of Linked-USDL and OSSR models. In the second section, the structure made by OSSR and Linked-USDL is defined and represented. The third section introduces the packages of NetworkX Python packages to graphically represent service networks. In the last section, the NetworkX's derived graphs are demonstrated.

6.1 Open Semantic Service Networks

Open Semantic Service Networks (OSSN) are defined by Cardoso *et al.* in [9] as *open*[1] because the models are transparently available and accessible by external entities and follow an open world assumption, and *semantic* since they can be represented using shared models, common vocabularies and semantic Web technologies.

OSSN is represented using the Unified Service Description Language (USDL) to model services (nodes) and Open Semantic Service Relationships (OSSR) to model relationships (edges) as figure 6.1 shows.

The combination of Linked-USDL and OSSR models result in an Open Semantic Service Network (OSSN). The use of these models in combination enhances the usefulness and value of OSSN definitions. When aggregated, they comprise additional and varied information making the resultant data more expressive and complete. In the OSSR model, the class *"ossr:Service"* is a subclass of *"usdl:Service"*, a Liked-USDL class. The properties of Linked-USDL are inherited by OSSR and can be used as part of the model, resulting

[1]Definition of the concept: `http://opendefinition.org/`

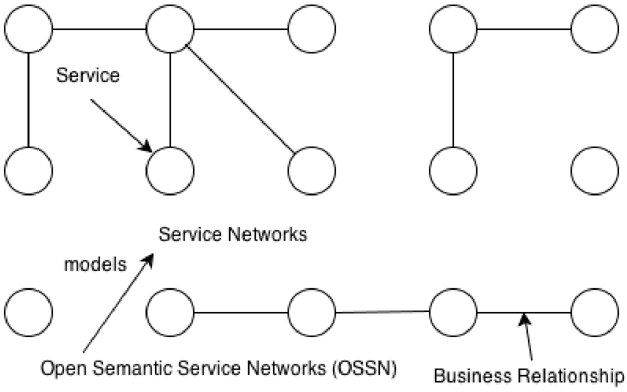

Figure 6.1: OSSN

in connected and complement models. The OSSR model gains value with this connection because some kind of relationships can be better understandable knowing the nature of the service at issue.

The OSSNs arising from this connection are the result of a combination of firms, groups and individuals which provide information about services and their relationships with other services.

6.2 OSSN structure with Linked-USDL and OSSR

Figure 6.2 demonstrates the creation of OSSR and Linked-USDL instances connected by the *usdl:Service* class. The software service source of the relationship is the *Sales Cloud* and the target is the *Oracle database*.

The services are *different* and have an *high involvement* because both parties are interested in maintain a long-term partnership. They are a *composition* because it is fundamental to source the existence of the target. It is noteworthy that the role of the Oracle database is *supplier*, defining the main type of this relationship. It is not possible to complete all the parameters of OSSR model because some relationships do not cover all of them.

The image also represents the creation of Linked-USDL instances of each service, which compose the relationship, defining parameters that describe the functional properties of each service.

The interconnection of models aggregate an amount of crucial definitions that can be advantageous for a subsequent analyse of service networks.

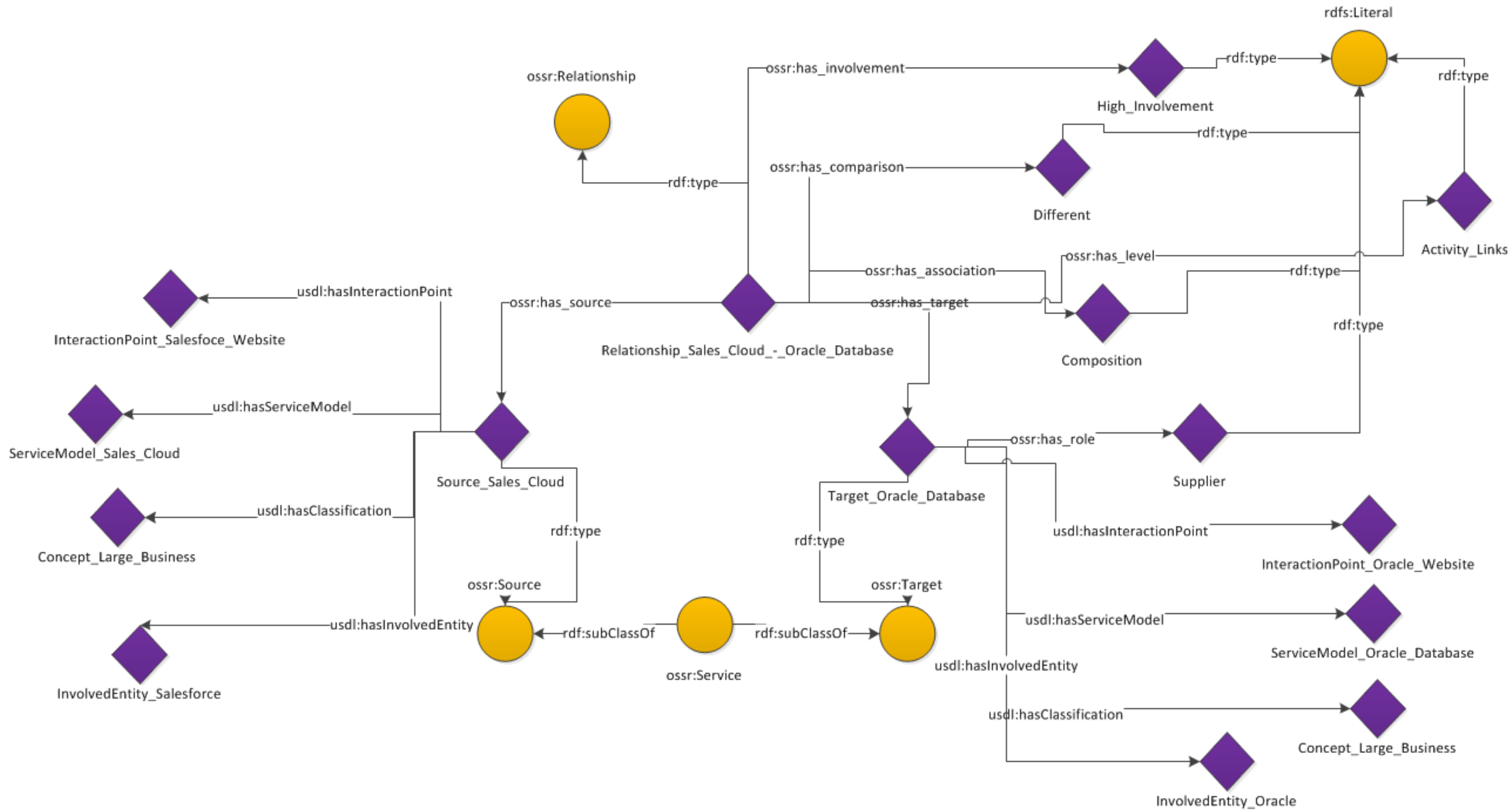

Figure 6.2: Open Semantic Service Networks (OSSN)

6.3 Evaluation of OSSN

The concept of OSSN is concerned with the establishment of rich relationships between services. The networks generated provide the valuable knowledge on the global service economy, and can be exploited with the purpose of service network analysis, management and control, as Cardoso et al. say in [9].

The construction of OSSNs brings new aspects such as: go beyond simple descriptions of technical features; is created autonomously, enabling the analysis of different types of services and relationships; and focuses essentially in services and their relationships.

With the OSSN infrastructure created, service networks can be discovered and accessed by distributed information systems enabling the development of algorithms to analyse, argue and optimize service networks.

6.4 Visualization packages/software

To represent service networks we use a Python language software package named NetworkX[2][3].

NetworkX is a software package developed in Python for the creation, manipulation, and study of the structure, dynamics, and functions of complex networks. It allows users to load and store networks in standard and nonstandard data formats and generate different types of random and classic networks.

Our network is generated from a RDF[4] file, used as a method for conceptual description or modelling of information that is implemented in web, which contains information about services (Linked-USDL) and their relationships (OSSR) with other services.

The OSSR model uses different designations for the two services that composes one relationship: the *source* and the *target*. It means that, graphically, if the same service is source in one relationship and target on another, the network will have services replicated. To graphically represent open semantic service networks (OSSNs), nodes with same name (same service) are gathered in one single node. But, even so, there are two different colours on nodes: red for sources and blue for targets (figure 6.3). If one node is the join of two

[2] `http://networkx.github.io/`

[3] `http://networkx.github.io/documentation/latest/_downloads/networkx_reference.pdf`

[4] `http://www.w3.org/RDF/`

services the colour presented is blue (figure 6.4, the Oracle CRM On Demand service).

As we can see in figures 6.3 and 6.4, the links connecting services have different colours depending on the type of the relationship. OSSNs differ from social networks, in which relationships between people are “friendship” and do not need to be differentiated, and the connections are coloured by the role of the service target. The algorithm developed to represent the service network allows the users to select how to colour the connections, depending on the type of analysis to perform. OSSR enables the creation of five different types of graphs linked by *Role*, *Strength*, *Comparison*, *Level* and by *Association*. Each graph comprehends different information about the network allowing contrasting analysis.

6.5 OSSN visualization

The NetworkX Python package is a flexible tool, enabling different types of representations of network in analysis and giving diverse perspectives of the same network.

Figure 6.3 represents a graph with connections between 11 services created by relationships between them. The colours of connections between services are defined by the *role* of the *target* service. If the role is *competitor*, the colour is red, if it is *complementor*, the colour is green, for a *consumer* role the colour is yellow, and if the role is *supplier* the colour is blue. For relationships where target services have no role, the colour of the connection is black. This network has distinct sources and targets: sources are red and targets are blue. The nodes are added and linked randomly by NetworkX acquiring different dispositions depending on the number of nodes connections they establish.

Figure 6.4 is a service network composed by 22 services. The connections between services are also coloured by service target *role* as the network in figure 6.3. In this case, we have one service that is source and target at the same time, the *Oracle CRM On Demand*, therefore the colour of the node is blue. The services (nodes) are positioned in the network randomly and take shape depending on the connections they acquire. As it is possible to observe, the network is taking in a star shape around some of the nodes.

A different type of visualization of service networks is illustrated in figure 6.5. The network is composed by 38 services, also coloured by target role. It is possible to see that services that have more relationships (higher degree) have a larger diameter, allowing a better perception of the network.

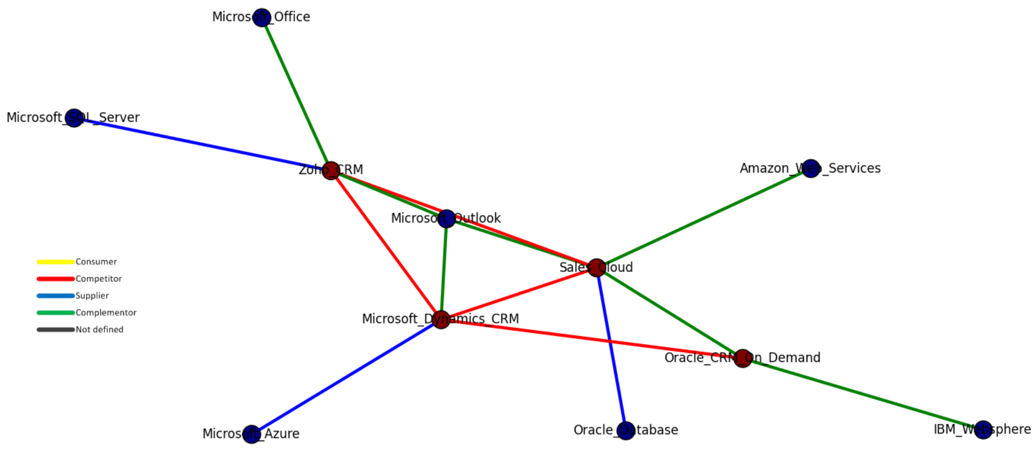

Figure 6.3: Graph of relationships between 11 services linked by service target role

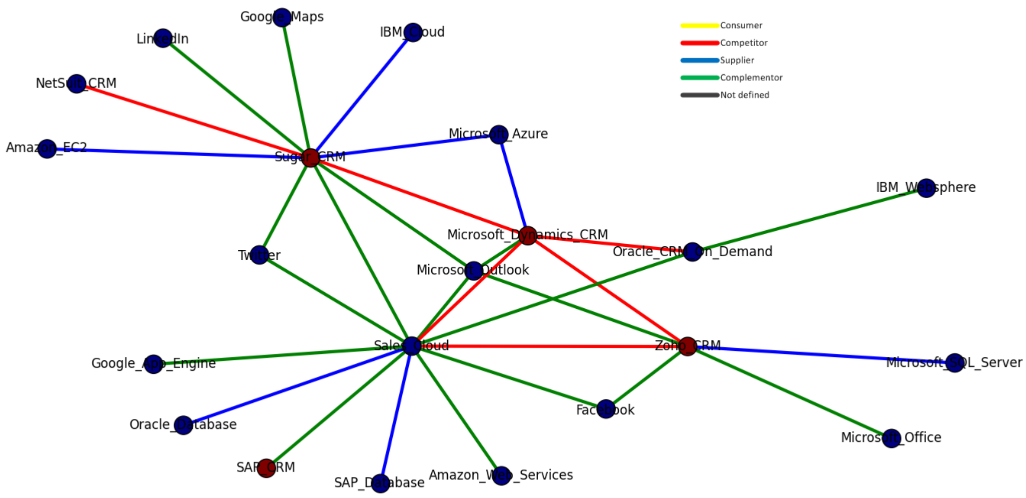

Figure 6.4: Graph of relationships between 22 services linked by service target role

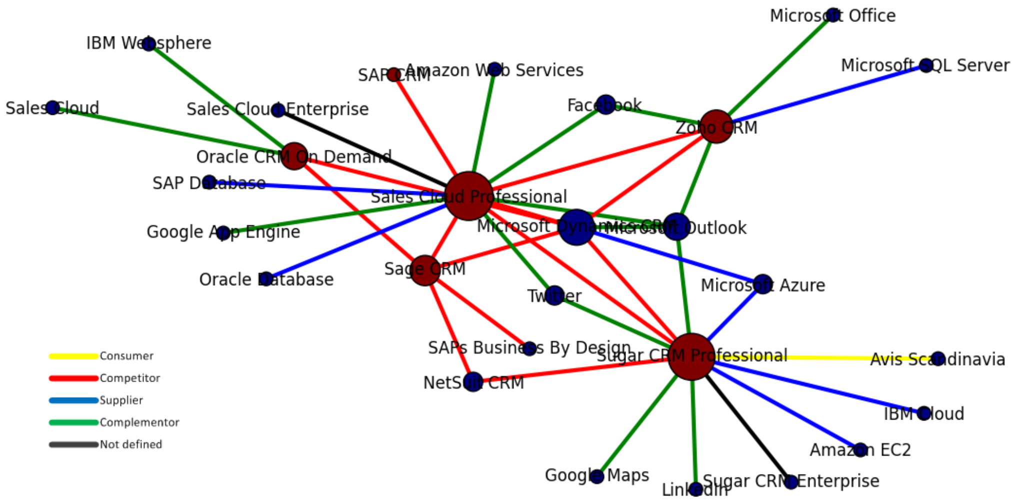

Figure 6.5: Service network with node size defined by degree.

7

Analysing Service Networks

Chapter seven is divided in five sections. The first section is an summary of the network analysis importance. The second is an overview of the NetworkX algorithms used to analyse the metrics of the network. The third section is an analysis to the OSSN, performed with NetworkX algorithms. The fourth section indicates the visualisation results from the generated OSSN graphs. In the last section we outline interesting results.

7.1 Overview

The growth and complexity of nowadays networks requires the development of technological methods to analyse and represent those networks. To optimize the analysis of networks, various network representations have to be studied since different representations serves different purposes.

The network properties have to be measured and quantified to formulate useful algorithms to optimize the study of networks. Network models need to be introduced and analysed.

Below, we present the study developed in service networks with the aid of tools, specifically the NetworkX, and models, such as Linked-USDL and OSSR, that we have mentioned in previous chapters.

7.2 Networking Algorithms /NetworkX

NetworkX enables the analysis of network structures, but also to build network models, design new network algorithms and draw networks. In this analysis, we use algorithms from the NetworkX Python package to generate service network graphs and analyse them.

An important characteristic of service networks representation is the colour of nodes and edges, which represent services and their relationships. It is fundamental, for the visual analysis of a graph, to differentiate the types of relationships and services that compose the service network. The NetworkX function for the drawing of graphs is shown in Listing 7.1 and contains parameters to define the colour of nodes and edges, and also the width of the edge.

Listing 7.1: Graph colours

```
net.draw(G, node_color = info[0], edge_color = colors,
    width = 3)
```

The NetworkX Python package enables the drawing of graphics to analyse the behaviour of graphs.

To analyse if the service network is a Power Law network, we use the algorithm in listing 7.2 that draw a graphic with all nodes degrees values.

Listing 7.2: Power Law verification

```
def degree():
  degree_sequence=sorted(net.degree(G).values(),reverse=True)
  print "Degree sequence", degree_sequence
  dmax=max(degree_sequence)
  plt.loglog(degree_sequence,'b-',marker='o')
  plt.title("Degree rank plot")
  plt.ylabel("degree")
  plt.xlabel("rank")
  plt.axes([0.45,0.30,0.45,0.55])
  Gcc=net.connected_component_subgraphs(G)[0]
  plt.axis('off')
  net.draw(G, node_color = info[0], edge_color = colors,
      width = 3)
  plt.show(net)
  return
```

The algorithm presented in listing 7.3 verifies if the the service network is a Small World network. This analysis calculates the shortest path between all nodes and verifies if the result does not exceed the number six, the maximum number of steps between nodes allowed in a network that follows the Small World property [20]. The function to calculate the shortest path length is part of the NetworkX Python package.

Listing 7.3: Small World algorithm

```
def smallWorld():
  services = G.nodes()
  spl = net.shortest_path_length(G)
  for s in services:
    print 'Service source: ', s
    for t in services:
      print '\nDistance to: ', t ': ', spl[s][t]
      if spl[s][t] >= 6:
        print 'Not Small World !!'
        break
```

7.3 Analysing the OSSN

The service network created presents a set of characteristics observed in other types of networks already studied, such as *social networks*.

7.3.1 Metrics

Order of a network is the number of nodes present in that network. In this case, the *order* is the number of services that compose the service network. The volume of data presented in the service network is proportional to the *order* of the network, as more services represent more information. The NetworkX package has a function that can easily count the number of nodes, listing 7.4.

Listing 7.4: Order of a network

```
order = G.number_of_nodes()
```

Size of a network is the total number of connections between the nodes forming the network. In our case, the size equals the total number of relationships in the network. As larger is the size, bigger is the number of relationships between services. NetworkX includes an algorithm to count those connections, listing 7.5.

Listing 7.5: Size of a network

```
size = G.number_of_edges()
```

Degree of a node, which represents a service in this case, is the number of links connecting the node to its neighbours. In service networks, the degree of each service is the number of relationships that it holds with other services, listing 7.6.

Listing 7.6: Degree of a node

```
for n in range(0,len(G.nodes())):
 neighb = G.neighbors(G.nodes()[n])
 print 'Degree of ', G.nodes()[n], ': ', len(neighb)
```

Contrary to what happens in social networks, in service networks the degree of a service (node) does not always represent power to that service. In social networks more links represent more people than can be achieved from that node, translating into power to reach the masses. In service networks, depending on type of the connection, it can represent power or weakness in service.

Figure 7.1, the result of listing 7.2, shows the relationships that *Sales Cloud* establishes with other services. As we can see, *Sales Cloud* has 13 neighbours (linked services) connected with different colours, what means that each colour represents a different type of relationship that *Sales Cloud* maintains with other services. It has 5 connections with *competitors*, 5 connections with *complementors*, 2 connections with *suppliers* and 1 connection not defined. For *Sales Cloud*, the 5 connections with service competitors represent a weakness, as it means more choice for the final consumer and that the service has to become more attractive than the others if it wants to be selected. However, the 5 competitors connections represent for final consumers different options for the same service, larger range of choices, which is an advantage. On the other hand, the supplier connections allows *Sales Cloud* to select the best offer, not being restricted to one single provider. The complementor links represent for the service add-ins and features that could interest the final consumer.

Distance is the shortest path between two nodes, in this case, the distance between two services. It represents the reachability of a service from another. Services that are not directly reachable may, however, be affected indirectly through other connections. With NetworkX, the shortest path length can be easily calculated, as shown in listing 7.7.

Listing 7.7: Distance between services

```
spl = net.shortest_path_length(G)
print '\nDistance: ', spl[service_A][service_B]
```

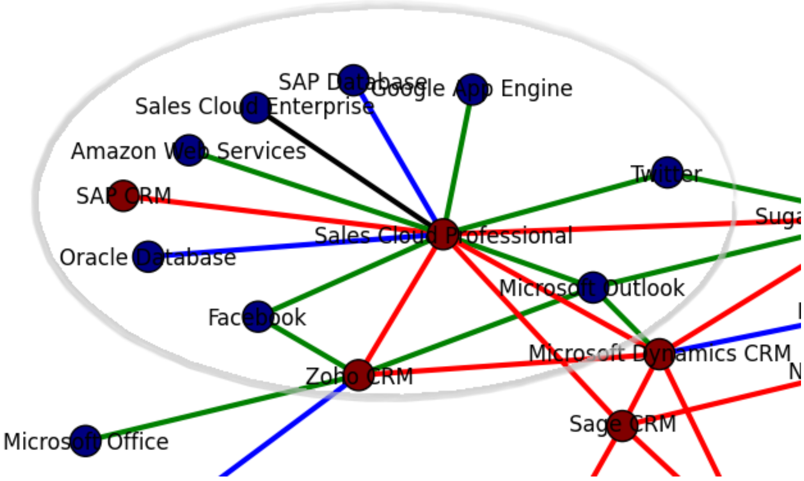

Figure 7.1: Degree of Sales Cloud

7.3.2 Network Models

Random Networks are generated by a random process. In our case, NetworkX starts the filling of services (nodes) randomly but, as they are added and linked, the network starts to take shape and the graph ceases to be random. Service networks are not random networks, their graphs are not random. Services connections have an origin (source) and destination (target) defined.

Power-Law Networks have nodes, in these case services, with high degree and nodes with low degree. Figure 7.2 shows a graphic generated by the degree of each node. As we can see, the service networks are Power-Law networks. There are services connected to many services (high degree), and other services with less connections (low degree). As a result, the degree distribution of service networks follows a Power-Law. Comparing service networks to social networks, both power-law networks, it is not possible in service networks assert that high degree services are powerful than low degree services because of the nature of the connections. Not every relationships established between services bring benefits to the services.

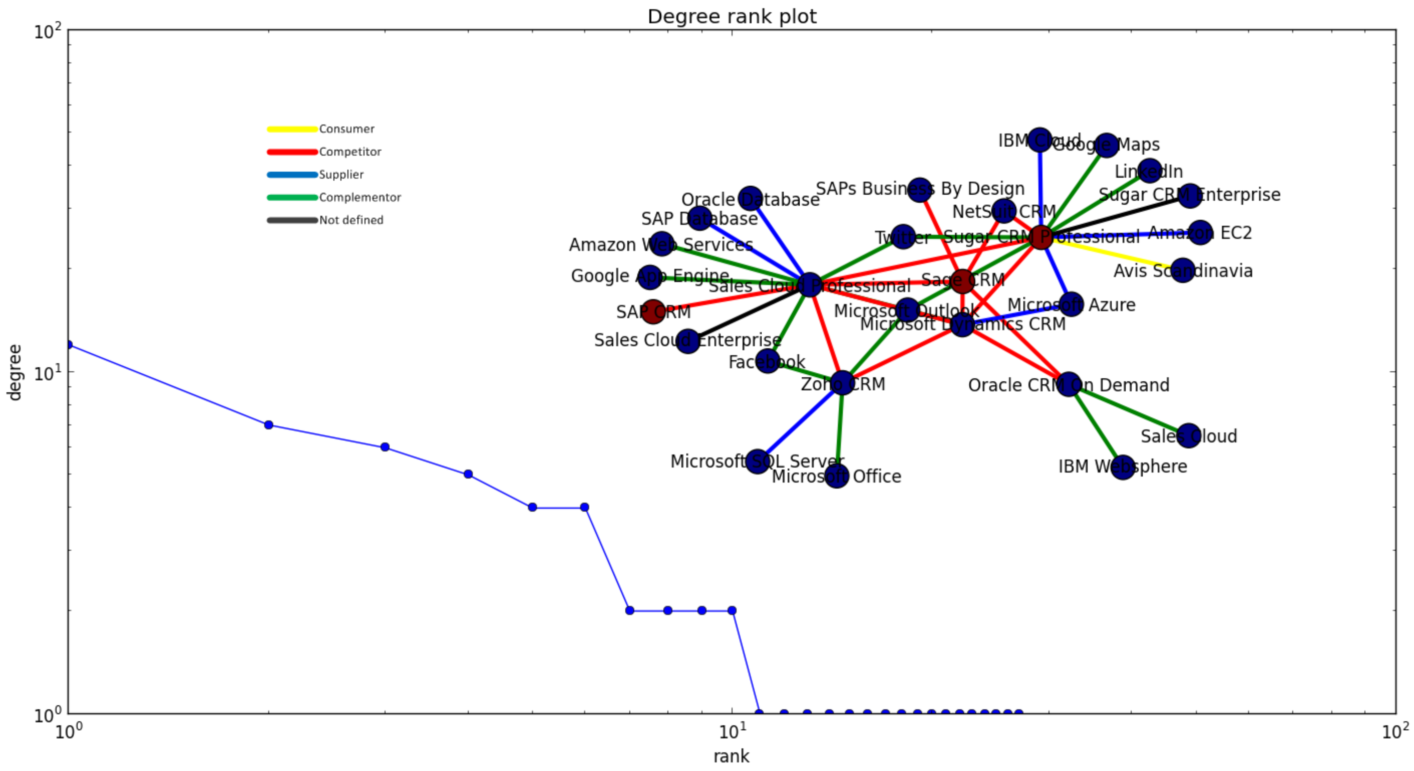

Figure 7.2: Degree of services in the network

Scale-Free Networks are networks whose degree distribution follows a Power-Law so that service networks have conditions to be a Scale-Free network. In Scale-Free networks, nodes tend to connect to nodes with similar degree. In our case, we observe (figure 7.2) that services with high degree (services with many relationships) are normally also connected to other services with high degree. The opposite, however, is not always true in our research, but the results lead to believe that service networks are scale-free networks as Cui *et al* says in [11]. This situation could just be happening because we are analysing a small set of services hence we can not conclude that service networks behave as Scale-Free networks.

Small-World Networks are those where most of nodes can be reached from every node by a small number of steps. In our case, a service network is a small world network if from every service we can reach any service in the network by a small number of relationships between services. With the aid of the developed algorithm in NetworkX listing in 7.3, we come across a network where the small path between any service in the network is never greater than 6. Based on Milgram studies in [20], we conclude that our service network is a Small World network. This experiment attempts to test the idea that the world of software services is increasingly interconnected. On one hand this is also an advantage, due to the benefit from knowledge transfers but and on the other hand it is also a disadvantage, because in case of rupture or failure of a service, the interconnected services will inevitably be affected.

7.4 Visualization Results

The graphic behaviour of service networks is demonstrated below, in a more visual way. How services are interconnected and the kind of established relationships are some of the outcomes. Different types of relationships are represented by different colours on the graph connections, being the black colour reserved for connections where the relationships type was not identified.

7.4.1 Services linked by Role

Understanding the roles of each service is an important aspect to determine the position of the service in the network. Figure 7.3 shows the graph generated with services linked by relationship Role. The classification of the role of the services involved in a relationship could be: *Customer*, *Supplier*, *Competitor* or *Complementor*. As we can see in the figure 7.3, relations of competition are represented by red links and are usually between services that are similar

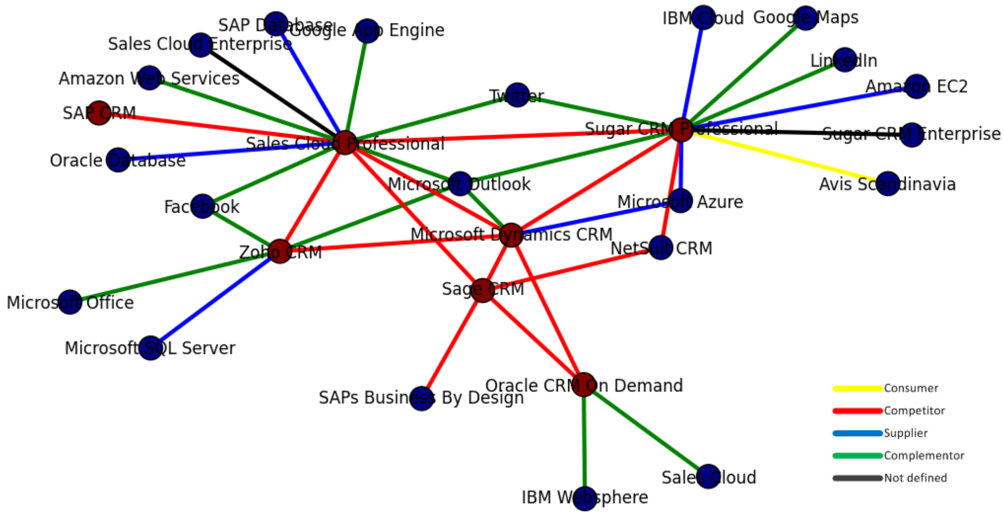

Figure 7.3: Service Network graph coloured by Role

as shown in figure 7.7 in yellow links (e.g Sage CRM and NetSuit CRM). Relationships between services that complement each other are represented by green connections. Comparing figures 7.3 and 7.7 we can observe that services that are complementors in 7.3 are normally different in 7.7 (e.g. Sales Cloud Professional and Twitter). Supplier relationships are represented by blue links (e.g. Microsoft CRM Dynamics and Microsoft Azure), and yellow links represent consumer relationships (Sugar CRM and Avis Scandinavia).

This analysis is important to understand, for instance, that services who create alliances with complementors differentiate themselves from competitors services, and attract more consumers. Service consumers, performing an analysis to the generated graph, can opt for services with those add-ins (green links) that are more attractive and improve the performance of the service. Can also view possible alternatives for the same service (red links).

7.4.2 Services linked by Interconnection Level

The consideration of various levels of relationships can lead to a better description of service relationships. The OSSR considers 3 varieties of levels: *Activity links*, *Actor bonds* and *Resource ties*. Figure 7.4 shows the graph generated with services linked by relationship Level. As we can see there are services that establish activity links (e.g. Oracle CRM On Demand and IBM Websphere) on yellow connections, which means that those services integrate their activities or tasks under the control of two services. We also have red links representing relationships of resource ties (e.g. Sugar CRM Professional and

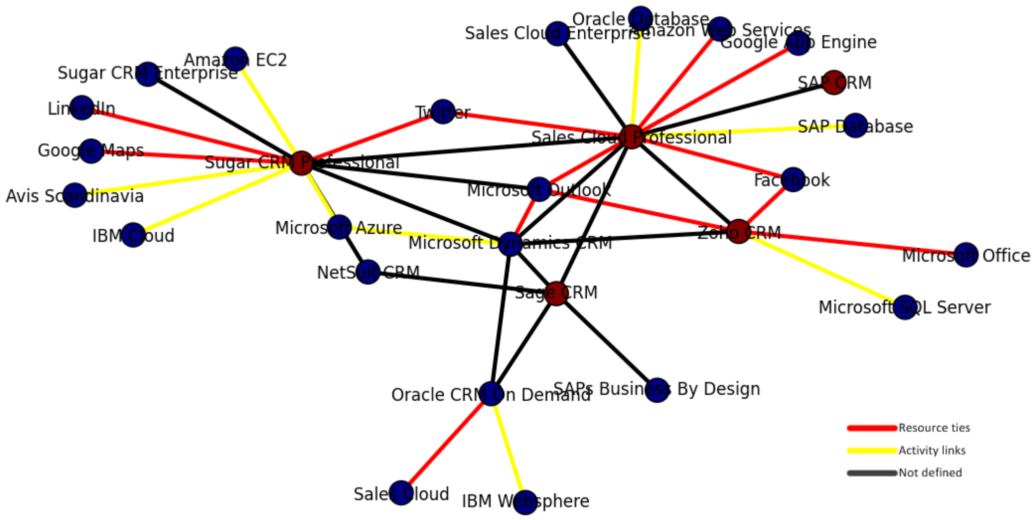

Figure 7.4: Service Network graph coloured by Level

Twitter) where services presented in that relationships exchange resources. It is a valuable type of relationship because services can increase their competitiveness by using different resources of other services. Actor bonds are a level that refers to the integration among participants belonging to the human resource structure of distinct services, so that any of our services could fit in this relationship level. Black links refers to services that we did not found a level to fit in the relationship.

The Microsoft Dynamics CRM and Microsoft Azure for instance establish activity links, this integration provides a secure channel for communicating Microsoft Dynamics CRM run-time data to external cloud based line of business applications[1]. Zoho CRM and Microsoft Outlook perform resource ties because Zoho CRM has a Plug-In for Microsoft Outlook to integrate contacts, calendar, tasks and e-mails[2].

7.4.3 Services linked by Involvement Strength

The involvement strength in a service relationship quantifies the involvement of one service with another with which it is related to. It can acquire two forms: *High-involvement* and *Low-involvement*. The high-involvement is associated to the necessity of services to maintain the relationship because both parties are profiting from it. As we can see in figure 7.5, red links represent high-involvements and they connect services having relationships of mutual

[1] http://msdn.microsoft.com/en-us/library/gg334766.aspx
[2] http://www.zoho.com/crm/outlook-edition.html

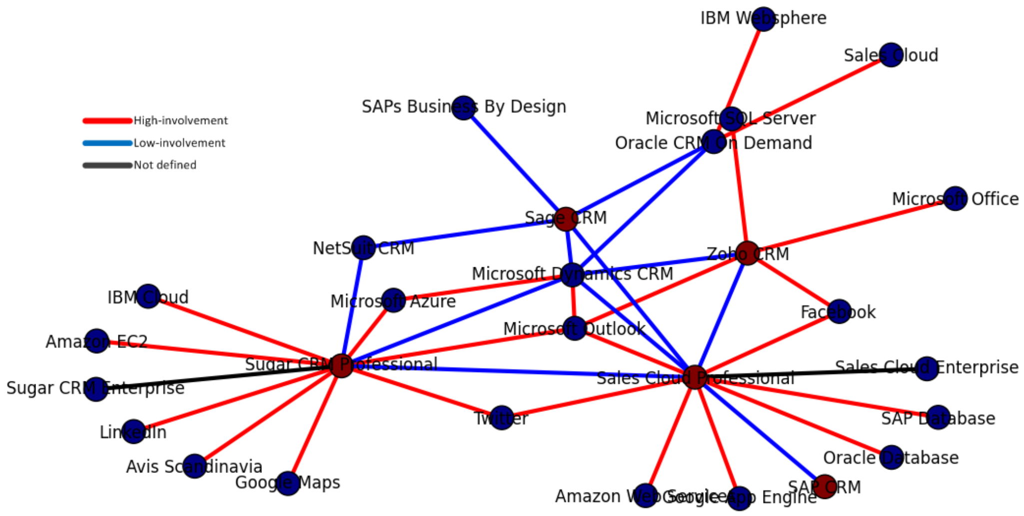

Figure 7.5: Service Network graph coloured by Involvement Strength

benefits (e.g. Zoho CRM and Microsoft Office, complementors in image 7.3). Low-involvement occurs in service relationships where both parties choose for a more simplified relationship because it is not propitious. In figure 7.5 low-involvement is represented by blue links (e.g. Zoho CRM and Microsoft Dynamics CRM are competitors in figure 7.3 and have low-involvement).

Services with several blue links (low-involvement) have relationships that do not represent creation of value instead, it represent critical connections of the service. Usually, low-involvement relationships are between services that are also linked by competition so that, it is important for services the disruption of the relationship. In contrast, red links represent relationships that service should maintain because strengthens its market presence. In service relationships with high-involvement exists exchange of value, the services should keep the connections because improve its offer and the services can obtain a wider range of clients.

7.4.4 Services linked by Association

Figure 7.6 presents our service network which relationships coloured by association type. This type of relationship can take the form of *aggregation* or *composition*, where one service has the role of component and another the role of assembly. Aggregation occurs in relationships where one service is "a part of" or "has a" relationship with another. In its turn, composition is a specialized form of strong aggregation where one service (component or assembly) ceases to exist, or to be needed, if the other service ceases to exist. In figure

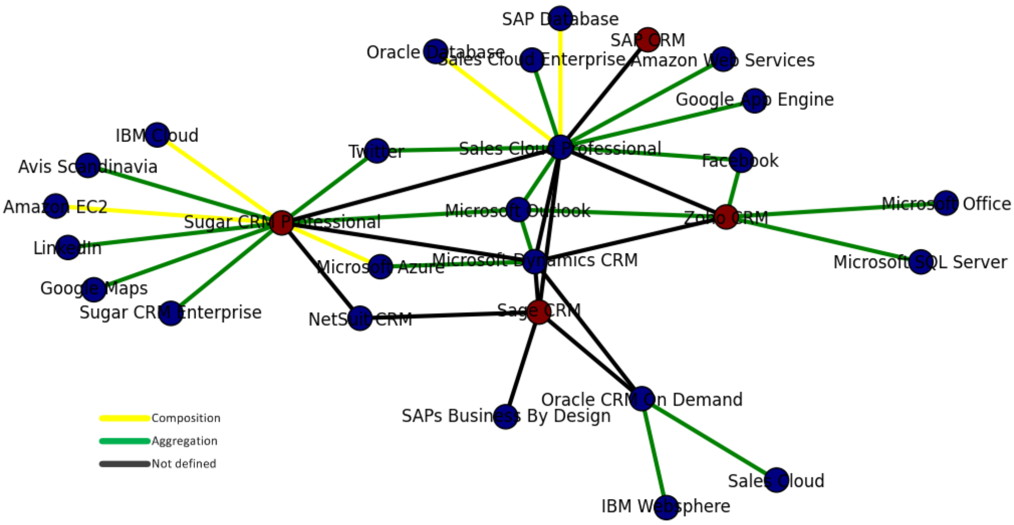

Figure 7.6: Service Network graph coloured by Association

7.6 yellow links represent relationships of composition (e.g. Oracle database and Sales Cloud Professional) and the green aggregations (e.g. Sugar CRM Professional and Twitter). Black links represent services in which relationship association is not defined, for example, in relationships of competition (e.g. Sage CRM and NetSuit CRM, 7.3) we decide not to define the association.

This graph is important to understand the dependencies between services, some services could not exist without others. The case of services that need databases represent an increase of service complexity leading the prices to raise. The Sales Cloud Professional is an aggregation by (green links) Google App Engine, Twitter, Microsoft Outlook and Facebook, these relations improve the performance of the Sales Cloud Professional service complementing it services.

7.4.5 Services linked by Comparison

Figure 7.7 shows the graph generated with services coloured by relationship comparison. Comparison can acquire the form of: *similar*, *different*, *specialization*, *generalization* or *equivalent*. In our network, blue links represent specialization (e.g. Sugar CRM Enterprise and Sugar CRM Professional), which are relationships between similar services have the same target, but with some new or different functionalities that increases the performance of the service. Relationships between similar services (e.g. Zoho CRM and Microsoft CRM Dynamics) are represented by links coloured in yellow. These services have the same target and similar features and functionalities. We also find different types of services (e.g. Zoho CRM and Facebook), represented by red links,

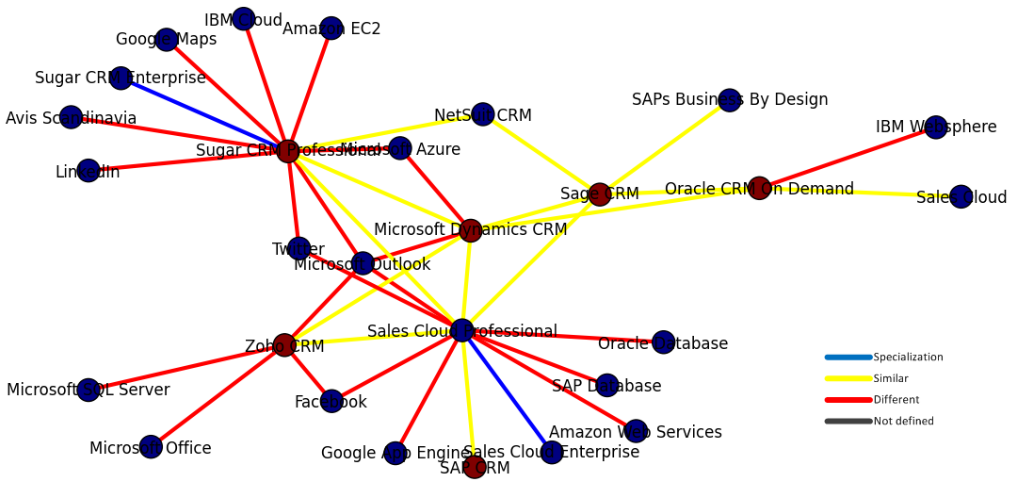

Figure 7.7: Service Network graph coloured by Comparison

in which services have similar or different targets but their functionalities are different as it is also their place in the market. In this research we did not find relationships that could be considered equivalent, because all services have some differences and generalizations of services.

The comparison between services is useful for companies, for example, to search for similar and less expensive alternatives. The service information stored covers the classification, involved entities, interaction points, service models, pricing, service offerings, etc. which allows the consumers to compare and choose the best service offer.

7.5 Interesting Results

During the analysis it was possible to observe that relationships follow some patterns with regard to properties.

Relationships that have the role *competitor* are also *similar* in the comparison, because of the nature of target users and its market, and the relationship involvement strength is *low* (figures 7.3, 7.7 and 7.5).

Relationships of service *complementors* have normally *high-involvement* strength, because both benefit from the relation (figures 7.3 and 7.5). Relationships where the target role is *supplier* also acquire an association of *composition*, since the service source ceases to exist if the target also ceases to exist (figures 7.3 and 7.6). It is therefore a relationship of dependence.

Observing the *Sales Cloud Professional* service in figure 7.3, we conclude that the service gains by having various links with the role complementors because increases its position in the market and can reach more users. An increase in the relationship links of competitors could be a weakness for the service, as consumers will have more options of choice and the market will be more competitive. Relationships of complementarity with consumers are a surplus, since the service will cover a larger area in the market by having more connections with complementor services.

Analysing the degree of each node in the network we conclude that service networks have behaviours of *power-law* networks, because we have high degree nodes (many relationships) and also low degree nodes (few relationships) (figure 7.2).

Service network appears to be *small world* networks because we can reach all nodes in the network from any node with no more than six steps.

With more services and relationships between them, the results and the graphically generated network will probably be different and more interesting, with more content to analyse.

8
Conclusions

Chapter eight is divided in three sections. The first is a summary of the dissertation. The second section exposes the interesting findings about service networks and describes positive effects of these studies for society. In the last section we outline the future work.

8.1 Summary

This dissertation focused on the study of Service Networks through the development of algorithms to represent and analyse the networks. We used the Linked-USDL model and the Open Semantic Service Relationships (OSSR) model to describe relationships. We describe the benefits of using the Linked-USDL and OSSR models in conjunction to create Open Semantic Service Networks (OSSNs). We used the NetworkX Python package to generate graphs and develop algorithms for the analysis.

8.2 Findings and Benefits for Society

The results of our implementation establish that service networks are not random networks. Services are disperse in the network, depending on the connections they establish with other services, forming patterns.

Service networks exhibit behaviours similar to social networks. It is possible to observe that some services establishing many relationships with other services, contrasting with others that only possess a reduce set of relations, it means that service networks follows Power-Law properties. Service networks shows Small World behaviours, because starting in one node from the network, it is possible to achieve any other node by the maximum of six steps. The network is strongly interconnected leading the services to be closer to each other, enabling rapid transfer of information in the network.

The many more services that compose the network, further information it contains and more valuable it is. A network composed by 10 services and 15 relationships has clearly less information than a network with the triple of size.

The service degree of each node does not represent its strength in the network due to the different nature of each connection. Services with more competition links are weaker than services with fewer. On the other hand, a large number of consumers, supplier and complementor links is a benefit and represent that the service is better placed in the market.

OSSNs provide a rich knowledge base to derive information for service discovery and matching supply and demand. It improves service recommendations, ratings and price calculations, and combines services providers and consumers in the same network. This information can be extrapolated from the OSSN and analysed depending on the goal. Services are connected to other services and business elements via OSSNs so that marketplaces can use this information to achieve a more effective matchmaking. Comparing services, observing their dependences and the position of the service to other services are purposes in service network analysis which can be used by consumers and suppliers.

8.3 Future Work

The application of these models to other types of services, with some adaptations, could bring different and interesting results to a wider range of services. An analysis with more data will bring new interesting results to service networks. A non-manual collection of information about services descriptions and their relationships from the web, would also facilitate the gathering of information and generate more complete service networks. A platform with structured information populated by service owners to maintain the credibility, will add value to web scraping activities. The structured nature of information repositories would also allow a systematic approach to avoid errors in the fill the models.

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Appendices

A
Data collection

The appendix A contains the websites in which we found the information about service relationships.

A.1 Data collection

Collecting social network data is a hard work insofar it has to be done manually. The data used are not always an indicator of trust relationships between services because of the nature of website sources.

Table A.1 contains the relationships between two services and the corresponding source website.

Table A.1: Relationships and source websites

Relationship	**Site**
Microsoft Dynamics CRM - Microsoft Azure	http://msdn.microsoft.com/
Microsoft Dynamics CRM - Microsoft Outlook	http://www.microsoft.com/
Microsoft Dynamics CRM - Oracle CRM On Demand	http://www.crmsearch.com/
Oracle CRM On Demand - IBM Websphere	http://www.oracle.com/
Oracle CRM On Demand - Microsoft Dynamics CRM	http://www.crmsearch.com/
Oracle CRM On Demand - Sales Cloud	http://www.oracle.com/
Sage CRM - Microsoft Dynamics CRM	http://www.crmsearch.com/
Sage CRM - NetSuit CRM	http://www.crmsearch.com/
Sage CRM - Oracle CRM On Demand	http://www.crmsearch.com/
Sage CRM - SAPs Business By Design	http://www.crmsearch.com/
Sales Cloud Professional - Sales Cloud Enterprise	http://crm-software.findthebest.com/
Sales Cloud - Amazon Web Services	http://aws.amazon.com/
Sales Cloud - Facebook	http://www.salesforce.com/
Sales Cloud - Google App Engine	http://www.salesforce.com/
Sales Cloud - Microsoft Dynamics CRM	http://www.crmsearch.com/
Sales Cloud - Microsoft Outlook	http://www.salesforce.com/
Sales Cloud - Oracle Database	http://www.zdnet.com/
Sales Cloud - SAP database	http://www.salesforce.com/
Sales Cloud - Twitter	http://www.salesforce.com/
Sales Cloud - Zoho CRM	http://www.crmsearch.com/
SAP CRM - Sales Cloud	http://www.crmsearch.com/

Continued on next page

Table A.1 – *Continued from previous page*

Relationship	**Site**
Sugar CRM - Amazon EC2	http://bitnami.com/
Sugar CRM - Avis Scandinavia	http://crmworks.asia/
Sugar CRM - Google Maps	http://www.cr38.co/
Sugar CRM - IBM Cloud	http://www.sugarcrm.com/
Sugar CRM - LinkedIn	http://www.accentgold.com/
Sugar CRM - Microsoft Azure	http://www.sugarcrm.com/
Sugar CRM - Microsoft Dynamics CRM	http://www.crmsearch.com/
Sugar CRM - Microsoft Outlook	http://www.sugarcrm.com/
Sugar CRM - NetSuit CRM	http://www.crmsearch.com/
Sugar CRM - Sales Cloud	http://www.crmsearch.com/
Sugar CRM - Twitter	http://www.accentgold.com/
Sugar CRM Professional - Sugar CRM Enterprise	http://crm-software.findthebest.com/
Zoho CRM - Facebook	http://www.zoho.com/
Zoho CRM - Microsoft Dynamics CRM	http://www.crmsearch.com/
Zoho CRM - Microsoft Office	http://www.zoho.com/
Zoho CRM - Microsoft Outlook	http://www.zoho.com/
Zoho CRM - Microsoft SQL Server	https://reports.wiki.zoho.com/

B
Installing and Running Software

B.1 Installing Software

This appendix covers the software libraries used and installation instructions. The websites of each package have tutorials for its installation and execution.

B.1.1 Python

If the operating system is Linux or Mac OS X, probably it already has Python 2.6. If not, there are the websites for the download and installation:
http://www.python.org/
http://wiki.python.org/

B.1.2 matplotlib

matplotlib depends on *numpy* and can be an involved install. Linux package managers provide matplotlib and numpy prebuilt. Alternatively, it can be downloaded and either installed a prebuilt package and matplotlib also provides a comprehensive set of instructions:
http://sourceforge.net/
http://sourceforge.net/
http://matplotlib.sourceforge.net/

B.1.3 NetworkX

NetworkX is a Python package for the creation, manipulation, and study of the structure, dynamics, and functions of complex networks. NetworkX depends on the previous packages. To download the package:
https://pypi.python.org/

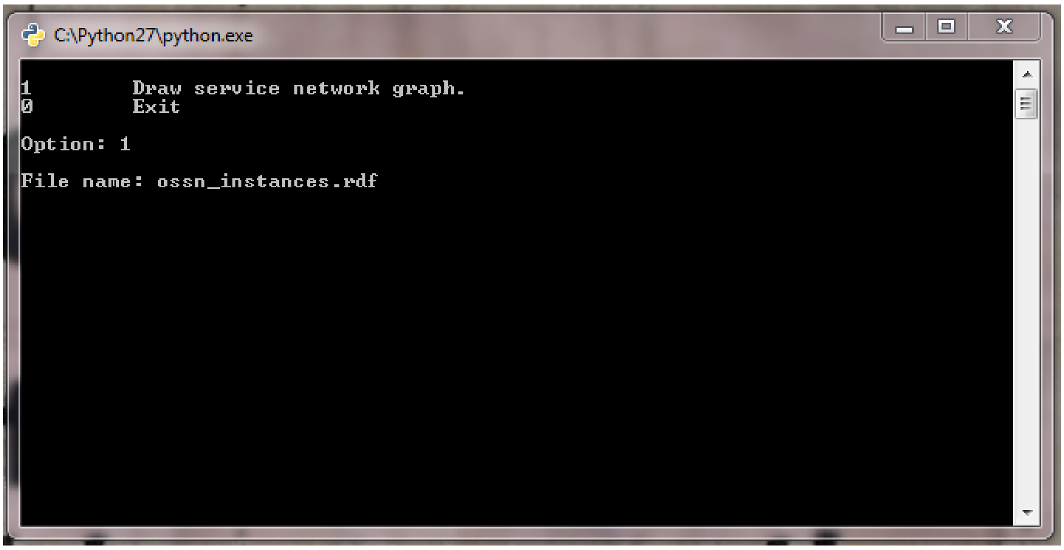

Figure B.1: OSSN executable

B.2 Running Software

To execute the software, run the executable with the name `OSSN.py`. In order to proceed with the execution, the RDF files for analysis must be in the same folder as the executable file. Figure B.1 is a snapshot of the executable.

Snapshot B.2 is an example of the execution of OSSN.py file to draw graphs depending on the type selected. In B.3 is presented an example oh the information about services stored in text files. It is also possible to save the information about the relationships between services. In example B.4 the functionalities that return the size and the order of the network are demonstrated.

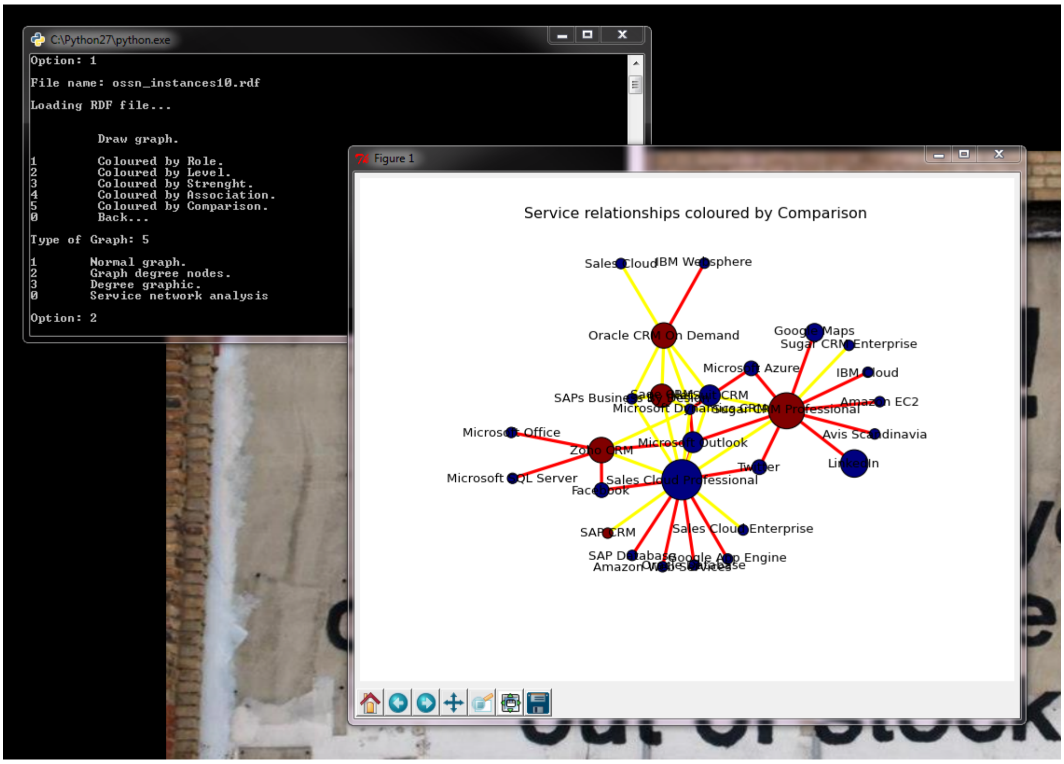

Figure B.2: OSSN graph

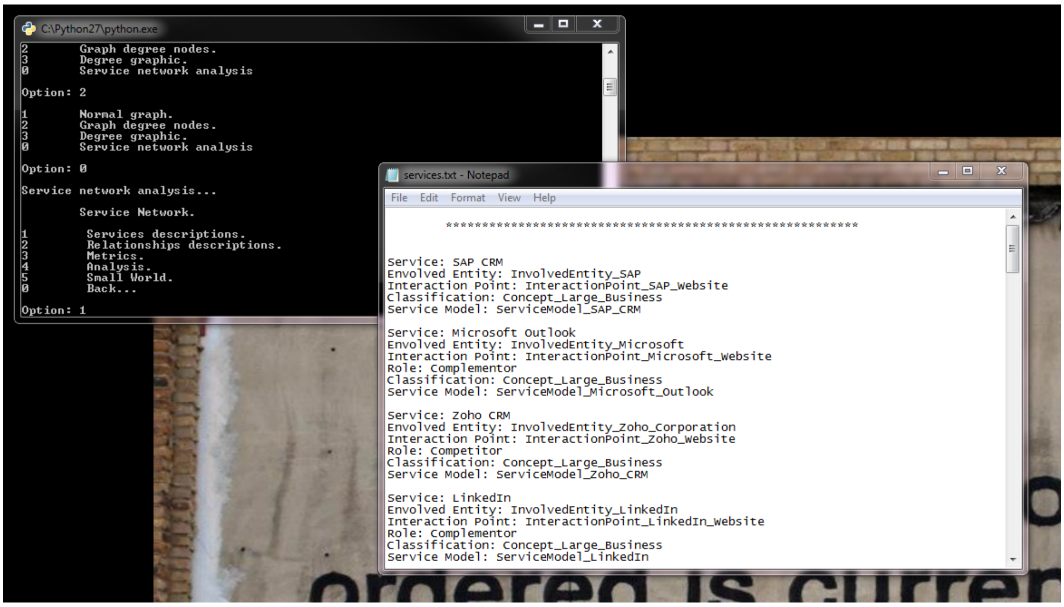

Figure B.3: OSSN text file of services descriptions

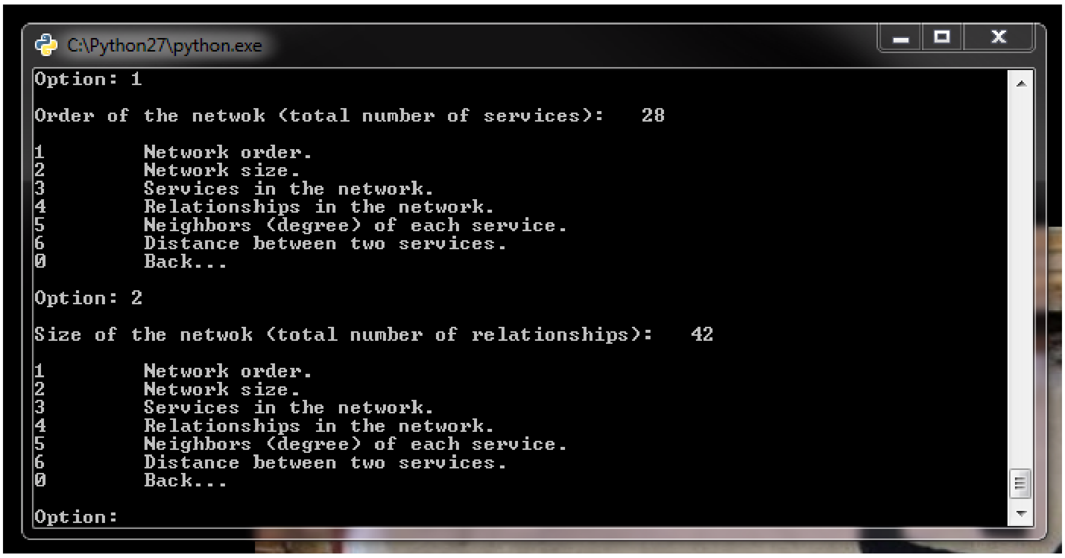

Figure B.4: OSSN order and size