Service Ecosystems:

Theory, Technologies and Use Cases

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Declaration of Academic Honesty

"I hereby, the undersigned, declare that this thesis is my wholly genuine work. The information from another author has been acknowledged by citing the source in the text of my work and providing the source of citation in reference list. This thesis is never submitted in every kind of form to any examination authority."

Frankfurt am Main, 30th March 2012

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Abstract

The service's industrialization hatched many researches. It even calls for new disciplines, namely, product-service system, service engineering, service enterprise and service science. These extensive research spectrums use the term *Service Ecosystem* in different contexts, though there is barely any literature addressing this notion. Further, the emerging Internet technology provides extra facets to the Service Ecosystem. It enables a complex online collaboration that hosts new possibilities and challenges. The recent Internet technology allows the effortless selling and consuming of digital goods. Ironically, in the era of service dominance, we are still not able to do the same with a service product, even though services account for 63.2% of economic value on average of the world GDP. It is anticipated that soon services will become digitally commercialized.

The Internet will enable service agents to collaborate in producing value-added services and innovation, i.e., The Internet of Services (IoS). The ecosystem's diversity raises a communication issue, thus increasing the transaction cost, at a time when the industry needs to compensate for such cost. Therefore, one cannot overlook the advent of a Service Ecosystem in the current fast-paced service economy. How well the actors can adapt and co-evolve in the information-intense service economy will determine their performance in the ecosystem. Subsequently, there are two preliminary issues demanding an answer. First, the notion of Service Ecosystem needs to be understood objectively and uniformly. Second, the current approaches used to overcome the challenges need to be supported. Therefore, an extensive literature research and qualitative analysis as well as study cases were conducted in this thesis.

The results of the work are the proposal of a Service Ecosystem theory, validation of the Unified Service Description Language (USDL), and five scenarios applying USDL in the Smart City vision. The substantial notion of Service Ecosystem provides an objective understanding and clarity that can be used in the lateral researches. Subsequently, the positive result of USDL validation as a dialectal mean for IoS will ripen the enabling technologies. Lastly, the five concepts concerning traffic and education problems in Jakarta encourage the broader public to create innovative or practicable use cases. Thus, it may help to amplify the network effect of USDL, expedite its standardization process and accelerate the maturity of the Service Ecosystem.

Zusammenfassung

Die Industrialisierung der Dienstleistung hat einige Erforschungen erschaffen. Sie hat sogar neues wissenschaftliches Gebiet hervorgerufen, nämlich: hybrides Leistungsbündel, Dienstleistungsbau, Integration der Unternehmensdienstleistung und Dienstleistungswesen. Diese umfangreichen Forschungsaktivitäten verwenden den Begriff *Dienstleistung Ökosystem* in verschiedenartigen Kontexten, dennoch wird diese Auffassung kaum in der Literatur adressiert. Darüber hinaus bereichert die Internettechnologie die Facette von der Dienstleistung Ökosystem. Es ermöglicht eine komplexe online Kollaboration, die neue Chancen und Herausforderungen beherbergt. Die heutige Internettechnologie gestattet ein reibungsloses Anbieten und Konsum von digitalen Gütern. In der Zeit der Überlegenheit der Dienstleistung gegenüber Gütern, in welcher der 63,2% Anteil vom durchschnittlichen Bruttoinlandsprodukt der Welt ist, ist eine solche Kommerzialisierung bedauerlicherweise für Dienstleistung noch nicht durchführbar. Folglich wird in naher Zukunft der digitale Handel der Dienstleistung erwartet, d.h. das Internet der Dienste *(IoS)*.

Dieses Internet der Dienste wird die Kollaboration von Dienstleistungsagenten ermöglichen, um innovative und mehrwertige Dienstleistung erzeugen zu können. Die Heterogenität des Ökosystems steigert das Kommunikationsproblem und die Transaktionskosten, dementsprechend wird die Industrie das dynamische Verhalten von Ökosystem adaptieren. Aus den genannten Gründen, darf der Eintritt von Dienstleistung Ökosystem nicht übersehen, und dessen Bedeutung unterschätzet werden. Wie die Akteure sich in der informationsintensiven Dienstleistung Ökonomie anpassen und koevoluiren können, wird seine Performanz in dem Ökosystem bestimmen. Hieraus resultieren zwei Bedingungen, die erstmals zu erfüllen sind. Erstens muss das Dienstleistung Ökosystem objektiv und einheitlich verstanden werden. Zweitens muss die jetzige Ansatz und Forschungsaktivität unterstützt werden. Eine ausführliche Literatur Recherche, qualitative Analyse, und Fallstudien sind daher in dieser Thesis ausgeführt.

Die Ergebnisse dieser Studie sind die Theorie über Dienstleistung Ökosystem, die Validierung vom *Unified Service Description Language* (USDL), und fünf Szenarien, in denen USDL in die *Smart City* Vision eingesetzt wird. Die substanzielle Idee von Dienstleistung Ökosystem ergibt ein sachliches Verständnis, dem verwandte Forschung herangezogen werden kann. Das positive Ergebnis der USDL Validierung ließ die Basistechnologie für die Ökosystem weiter ausreifen. Die fünf Konzepte, die sich auf Verkehrs- und Bildungsprobleme in Jakarta beziehen, inspirierten so, dass man durch die neuen Möglichkeiten und Einsatzgebiete von USDL innovative Konzept und Geschäftsmodelle entwickeln kann. Dies hat der Zweck, die Netzeffekte von USDL zu verstärken, und dadurch den Standardisierungsprozess beschleunigt, wobei es ein Kriterium für die Entstehung einer nachhaltigen Dienstleistung Ökosystem ist.

Table of Contents

List of Figures

List of Tables

List of Abbreviations

4G LTE	fourth generation long-term evolution
ACTA	Anti-Counterfeiting Trade Agreement
BPM	Business Process Management
CCTV	Closed Circuit Television
CD	Compact Disc
CERN	Conseil Européen pour la Recherche Nucléaire ("European Council for Nuclear Research)
cf.	confer ("compare")
CIO	Chief Information Officer
CMS	Content management system
COBIT	Control Objectives for Information and Related Technology
e.g.	exemplī grātiā ("for example")
EC2	Amazon Elastic Compute Cloud
EDI	Electronic Data Interchange
ERP	Enterprise Resource Planning
esp.	especially
et al.	et ("and") and alii ("others")
etc.	et cetera ("and the rest")
EU	European Union
FI	Future Internet
FMIS	Flood Management Information System
GDP	Gross Domestic Product
GPS	Global Positioning System
HR	Human Resources
i.e.	id est ("that is")
IaaS	Infrastructure as a Service
ibid.	ibidem ("in the same place")
IDR	Indonesian Rupiah
IoS	Internet of Services
ISDT	Information System Design Theory
IST	Information Systems Technology
IT	Information Technology
ITIL	IT Infrastructure Library
KPI	key performance indicator
NGO	Non-Governmental Organization
NTMC	National Traffic Management Center
OASIS	Advancing open standards for the information society

OCW	Open Course Ware
OECD	The Organisation for Economic Co-operation and Development
OGF	Open Grid Forum
P2P	peer-to-peer
PaaS	Platform as a Service
PIPA	Preventing Real Online Threats to Economic Creativity and Theft of Intellectual Property Act
RDF	Resource Description Framework
REST	Representational state transfer
RFC	Remote Function Call
RIM	Research in Motion
S&T	Science and Technology
SaaS	Software as a Service
SLA	Service Level Agreement
SME	Small and Medium-sized Enterprise
SNIA	Advancing storage & information technology
SOA	Service-oriented Architecture
SOAP	Simple Object Access Protocol
SOPA	Stop Online Piracy Act
TCAS	Traffic Congestion Avoidance Service
UK	United Kingdom
UML	Unified Modeling Language
UNESCO	United Nations Educational, Scientific and Cultural Organization
USA	United State of America
USB	Universal Serial Bus
USD	United States Dollar
USDL	the Unified Service Description Language
USP	Unique selling proposition
UST	Unified Service Theory
viz.	videlicet (“that is to say, namely”)
W3C	World Wide Web Consortium
WSDL	Web Services Description Language

1 Introduction

1.1 Background

Economies are divided into three different sectors of activity: primary (extraction of raw material), secondary (manufacturing), and tertiary (service). Fourastié [68] followed by Clark [44] proposed this three-sector hypothesis. They said that the focus of economy activity shifts from the primary, through the secondary and finally to the service sector. Nowadays, service sector is gaining more importance in world economy development [39, 116]. The recent growth of that sector in global economies is incomparable in civilization history, by scale and rapidity of the labor migration [72, 196]. The following logic explains the growth of the service sector: the main purpose of a business is to gain profit by striving product to dominate the market and satisfied lot spectrum of customer. Thus, a product can be cheaper or better in quality than other products. Here comes the role of service in play. Service gives a value-added to that product. Therefore, many businesses are today experiencing a transition from a goods-based to a service-based industry. Moreover, in their marketing and product politics most of companies use the diversification strategy, viz. service complement a physical product, service as integrated customer solutions, and service as value proposition to costumer. Such strategies are accelerating the advance of service sector in economic [223, 224].

Vandermerwe and Rada call this trend as the *servitization* of business. Servitization is business innovation to emphasize the potential, to maintain revenue streams, improve profitability [22], and to survive [191]. It is a good means for differentiation from competitors as well as for customer retention [28]. The findings of an empirical research on German companies support the effect of servitization. It says that company attains a high (38.1%) or very high (59.8%) effect on their profits in their service business. Following this further, the study [ibid.] also consistent with those finding before, 94.9% of the companies plan to enlarge their portfolio by offering customer solutions with service. Not only specific regional market but also in almost all industries on a global scale, servitization of business is happening [221]. The service sectors contribute more than double as much as the industrial sector to the average of world GDP[1].

Service Industrialization

Most of the industrialized countries had already experienced a substantial growth in the tertiary sector. Starting from the year 2003, the value added by services to the gross domestic product (GDP) touched 73% in UK and 85% in USA with an employment rate of 75% and 73%, respectively [80]. We have witnessed the rise of service industrialization from

[1] Agriculture, industry and service sector compose the average world GDP respectively 6%, 30.9% and 63.2%. [43]

servitization of business [26, 72, 105, 190, 199]. The industrialization of information-intensive service sector, technology driven, has some resemblance to the industrial revolution of manufacturing. One main issue by service production is the intangible characteristic that makes the benchmark difficult to quantify. Technology innovation can make the productivity rate (i.e. the ratio between production cost of one output and its labor costs) more efficient. For example, in textile manufacturing, the industry can produce more textiles products (e.g., yarn, fabric, clothes) by using new technology and steam-powered machine, however, with less labor and production costs [140]. In the contrary, the substitution factor between machine and labor is not trivial by service production.

Lot of service productions are man intensive process. It needs personal contact between service provider and service consumer. The individual characteristic of service is the result, as of another distinct property than good manufacturing. Moreover, the transition from manufacturing to service sector brings the consequence of the dichotomy between physical goods and services value [34]. However, we can no longer use the classic distinction between service and goods. It is not a discrete categorization. To be precise, there is no clear cut between them (service-goods continuum) [63, 63, 148]. The more a product categorized as a service the more intense is the direct contact to customer. Therefore, in contrast to good manufacturing, a complete substitution through a machine is difficult by the service production process [71]. With today technology, it is still unmanageable for machines to handle the whole production chains, but often are merely a substitution of several automated processes. In the call center for example, the first station can be replaced by computer voice recognition with standardized protocol. Subsequently, according to the problem, the system will forward the caller to corresponding staff. Nevertheless, technologies become a major factor for every production, thus emerge the industrialization in the economy and business development.

Industrialization “is a generic name for methods which save human labor input…, by an intensive investment in equipment and technology” [117]. Standardization and automatization are the requirements for increasing productivity. Increasingly those measures in the last several years conveyed to tertiary sector. This induces the business to try industrializing the service sector. However, by over dyeing the automation and standardization of services can lead to depersonalization the service itself (the characteristic of service is peculiar toward customer). Therefore, in differing to manufacturing industry, service industry has an additional pillar to support it, i.e., individualization, where the information system and technology (IST) contribute substantially. Furthermore, the progress in field information technology and its propagation catalyze the industrialization waves, in particular services [200, 200]. The following paragraphs will explain the two main factors of industrialization, viz. automation and standardization.

IST serves as the automation factor [152] and rudimentary platform to create the standard. Technology makes the work easier [81], by creating a machine that enables to replace a certain task, in order to relieve humans from heavy, dangerous, complex, boring and time-consuming tasks [154]. Thus, it called as automation [183]. IST is the key technology that supports the automation process in a service process [20, 129, 188]. Recently, the internet has brought a progressive way of service automation through the cloud technology (cf. Section 2.2.1), thus we can electronically consume or the intermediary can digitally broker a service. Beyond Web services (services available through the Web), current and disruptive models have emerged that are accelerating the ubiquity of services (e.g. Software-as-a-service, business process outsourcing, infra-structure-as-a-service, platform-as-a-service, service marketplaces, and service-centric business networks). This open a new channel, where one can commoditize, expose and access service beyond conventional boundaries. In addition to Web consumers, the reach extends to mainstream industries like transportation, logistics, banking, public sector and manufacturing, when one considers the following sorts of Web services now available: track-and-trace of shipments, tariff look-ups, health insurance comparisons, medical assistance, business formation and ERP hosting [152].

The standardization factor is a twofold, viz. the standard of service product and standard of service exchange. Stampfl [200] has said that standardization of service is negative correlated to service value. His understanding regards to the first side of standardization, which is analog to a common physical product. However, the other aspect is standard in context of producing process, as David et al. [50] have discussed that standardization is the basis and prerequisite of every further development of an industrial sector. Following this view, standards will play a significant role also in the services industry (cf. Section 3.5). Unified Service Description Language (USDL) [13] is one recently initiated approach that addresses this problem.

Besides the emergence of standardization, there is another aspect of Specialization [156, 169] i.e. services once targeted at a specific market, are rebranded and repurposed to fit new consumer needs or other markets in order to extend the reach [152]. The systematic uses of internet known as Internet of Services (IoS) facilitate the broad service spectrum (cf. Section 3.2.3) in service good continuum. This technology (automation) drives service product into broader market and across regions. Additionally it enables the individualization of service due to the service standardization, i.e., brokering manual service and accessing technical service (Chapter 5).

1.2 Motivation, Objectives and Scope

The ongoing industrialization of the service's sector spawned many research activities. It even calls for a new discipline, viz., product-service system (PSS) [46, 144, 174], service engineering [35, 212], service enterprise [14, 89], and service science, management and engineering [85, 86]. Those extensive spectrums of research activities use the term of *Service Ecosystem* in different contexts, though there is hardly any literature addressing this notion. Furthermore, the emergence of internet technology gives additional facets to Service Ecosystem, because this technology enables service industrialization and opens new possibilities to the information profound-service sector. Following this further, the key aim of this study is to take a critical view of interpreting social interaction between service actors around a core technology platform (i.e. the Internet) and analyzing the need of dialectal mean to such an ecosystem. Hence, we propose the theory of Service Ecosystem.

Apart from that, our second motivation conducting this study is the application. The theory will be useless if it cannot find a practice application in the real world. Such as the ongoing normative artifact[2] e.g. USDL, may merely stay as a theory entity without a chance to serve solving the genuine problem i.e. enabling a rich and sustainable Service Ecosystem. Currently, there is still lack of implementations of USDL [119, 185, 195]. For as in the establishment of any proposed artifact, it makes sense to show the potential and usage of such artifact in diverse concrete scenarios. At the same time, not only we can show the new possibilities that are enabled by USDL; we are able to materialize the proposed Service Ecosystem theory within such scenarios too.

In sum, the main finding of this study can be summarized in six points:

1. Service Ecosystem is a model to analyze and describe the trend in service industrialization (Section 3.1). Service Ecosystem found to be a great assists to develop several scenarios to help realizing the vision of Smart City (Chapter 5).

2. The ecosystem component's dynamic is affecting each other, thus reshaping the ecosystem. It depends on which stakeholder has more influence, will mutate the ecosystem to be open or rather proprietary. (Section 3.4.2)

3. The Internet of Services is a kind of Service Ecosystem. (Section 4.1)

4. A Service Ecosystem needs a standard dialectal mean to optimize and contribute to overall healthiness of the ecosystem. (Section 3.5)

5. USDL is a dialectal mean for the Internet of Services, as one factor that keeping the ecosystem sustainable. (Section 4.3)

6. The synthesizing of USDL can support to realize the vision of smart city and help the diversification of its service viz. in transportation and education field. (Chapter 5)

We concentrate on three main discussions about Service Ecosystem viz., the theory, its enabling technology, and the use cases. The theory is aiming to provide descriptive and analysis foundations [79] of Service Ecosystem model in application to IoS and USDL. However, due to the depth constraints of the research theory, we concern on the elementary

[2] "An artifact may be defined as an object that has been intentionally made or produced for a certain purpose." [87]. Artifact is an artificial fact.

and applicative part of design theory. There is still lot of space to validating the service in simulation study, mathematically formulating the model, or prototyping the scenarios.

1.3 Outline of the Thesis and Methods

The outline of the thesis is depicted in Figure 1.1. The initial part (Section 1.1) of this Chapter describes the emerging growth in the service sector as a background for the conducted study. Servitization and Service Industrialization are the main factors triggering the trend. Specifically, we want to examine the impact of enabling the internet as a technology platform to servitization of business or service industrialization. Therefore, we need a model as a framework to study the research problem systematically. Hence, one requirement of this study is developing the basic theory of *Service Ecosystem* (Chapter 3). Nevertheless, this also means that the problem is spreads across several different areas, and thus need to explore first.

Given its holistic approach, we observed that Service Ecosystem required multidisciplinary fundamental research (Chapter 2). There are three aspect underlying the Service Ecosystem, viz. Social and economic sciences (network economics, community buildings, diffusion of knowledge and practices, legal aspects, business and organizational models); Computer science (mainly internet technology and cloud computing) System theory, self-organization of complex systems and epistemology.

After we described the underlined aspects, we will present one of the main contributions of the study in Chapter 3. We use the framework of design theory from Gregory [79] and Jones [101] as a reference framework to develop the Service Ecosystem theory. The artifact and constructs given in the theory are designed to shape the theory for being able to analyze and to describe the research problem [23]. Besides, the theory will elaborate the dimension, characteristic, and stakeholder in Service Ecosystem thus states the corresponding structure interrelation. For this, we have conducted several rounds of in-depth interviews with experts and extensive literature research. Afterwards, Chapter 4 will discuss IoS and USDL as a concrete entity of Service Ecosystem and dialectical mean, respectively.

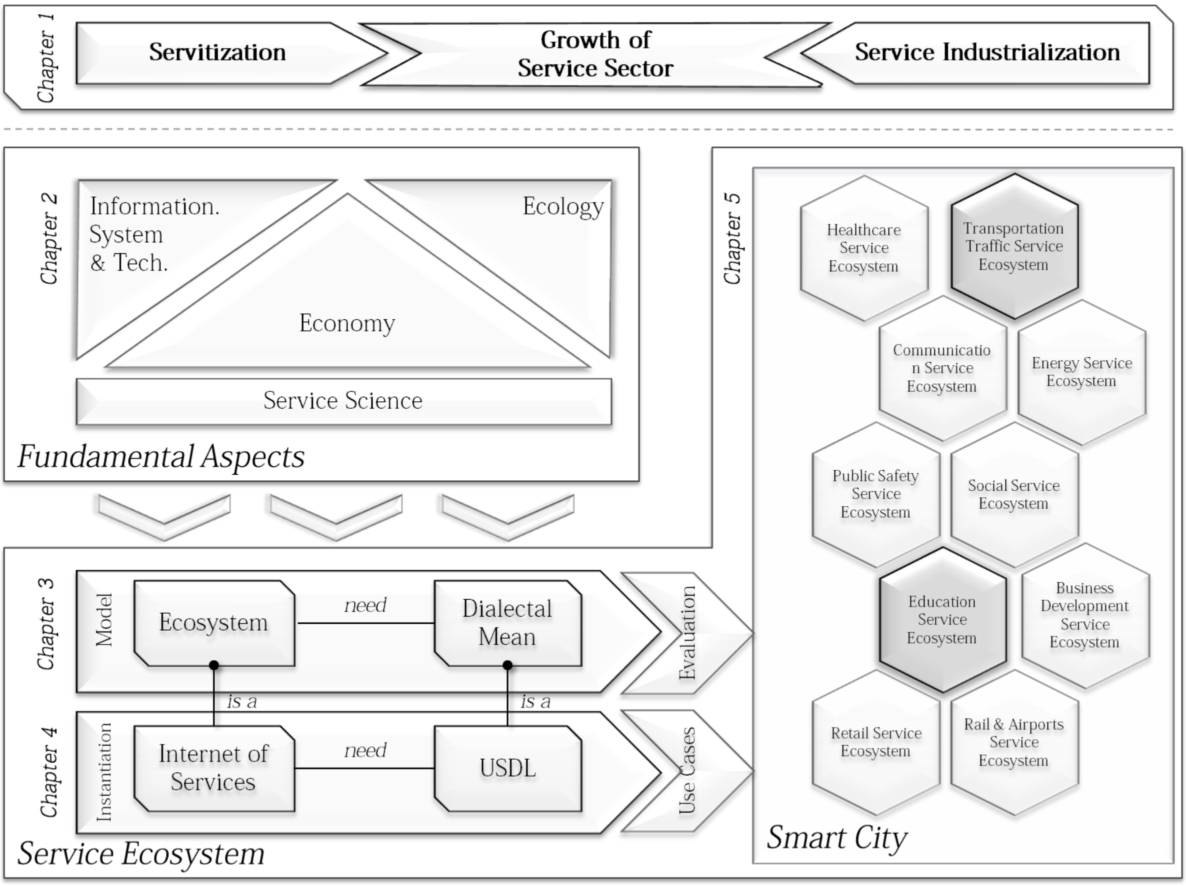

Figure 1.1: The outline of the thesis

The other main contribution of the study, and at once as an instrument to evaluate the Service Ecosystem theory and reviewing the usability of USDL in IoS will be presented in Chapter 5. In the beginning of any research attempt or newly proposed theory, it makes sense to describe and explain the universe of discourse with some case studies. Another reason we choose this method, due to pragmatic approach for evaluating concepts [23]. In this case, we choose to take the vision of Smart City [40] in general and the scenarios of transportation traffic and education Service Ecosystem in particular.

2 Fundamental Aspects

The growth in the service sector because of servitization of business and service industrialization spawned various research activities and even the request for a new discipline. Moreover, those wide-ranging bands of research activities use the term of Service Ecosystem, even though it not always had the same notion. Therefore, we want to propose a model to describe this conception. In order to construct the theory, we made an extensive literature research across lateral fields. In addition, we found that, Service Ecosystem is built above three different grounded sciences' field, viz. Social and economic sciences (network economics, community buildings, diffusion of knowledge and practices, legal aspects, business and organizational models), Computer science (mainly cloud computing and SOA), and Ecology (ecosystem, self-organization of complex systems and epistemology).

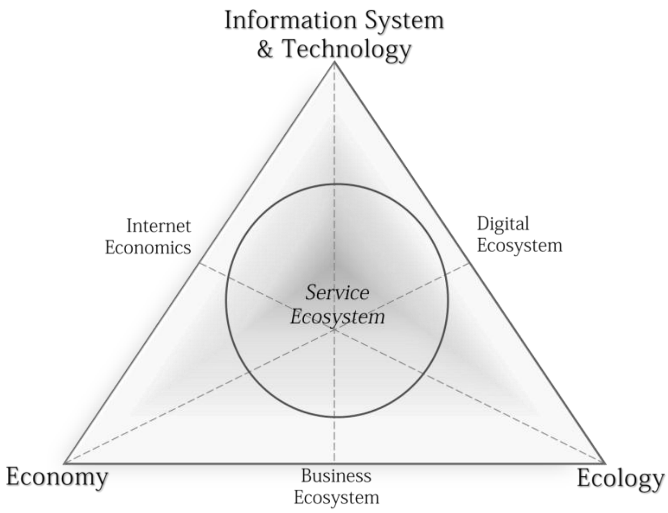

Figure 2.1: Fundamental aspects of Service Ecosystem

Following the finding further, it is helpful to be familiar with the fundamental aspects first, in order to understand the multidisciplinary context of the proposed model and positioning Service Ecosystem in it. Figure 2.1 above depicts the standpoint of Service Ecosystem within three aspects viz. economy (Section 2.1), information system and technology (Section 2.2), and ecology (Section 2.3) and the other type of ecosystem and discipline. Additionally, we also need to be clear about the connotation of service. This is important to have the consistency of understanding through the study. Section 2.4 wraps the service definition by presenting it under the term of service science.

2.1 The Aspect of Economy

Initially, we discussed the aspect of economy that alludes to Service Ecosystem. We have talked about the trends on service sector and the reason, why the trend is occurring. Thus, several interesting questions are emerged, viz., what will literally happen, if economic actors use new technology, what is the structure of the modern economy and what is the internet economics. We try to concern these issues in this Section. Moreover, these factors are significant for us to make better analyses about the impact of Service Ecosystem in society, market, and the possibility of the evolutionary ecosystem (cf. Section 3.4).

Let us start by observing the transformation progress in economy. Within civilization history, economy developed through different phases or degree of precedence. The subsistence of farming and agriculture has shaped the initial ancient economy, followed by industrial revolution at 18th and 19th centuries [88, 90]. The modern economy nowadays is driven by information technology that transforms the manufacturing based economy to informational economy [225, 226].

As the information technology rapidly developed in the recent decade, so evolved the modern economy too. The digital era of the internet is reshaping the economics model. In literature [138, 139] this new kind of economy is known as the internet economy. It is twofold. On one side, it is all about governing the household of internet in economic point of view [138]. On the other side, it is about the implication of internet technology (i.e. digital goods) to economy [103, 164]. Hence, we will use the second point of view of the notion, because in Service Ecosystem, the effect of technology development for the ecosystem is determined.

Economically, the Internet exhibits the feature of progressive network externalities. Technically, it benefits from statistical sharing of network resources [138]. In every economy region, one always has a good as a commodity, and a common way of commercial transaction within specific market structure. Internet economy resembles these characteristics, but in a different form. Respectively, we will discuss each of the characteristics in the following sections based on the significant book of [37].

2.1.1 Digital Good as a New Form of Commodity in Economy

Digital goods are immaterial goods. They are distinguished from other goods by five characteristics viz. non-rival, infinitely expansible, discrete, spatial and recombinant. Any reproduction of the good is the good itself. Quah [164] proposed the definition of digital goods as follow:

Definition 2.1

> A *digital good* is a payoff-relevant bit string, i.e., a sequence of binary digits, 0s, and 1s, that affects the utility of or payoff to some individual in the economy.

A primary character of digital good is the high manufacture cost by the first copy production. In contrary, the reproduction may have a significant low variable cost. For the first production of the digital good, company needs only to invest a major early start capital for the infrastructure, system and the expertise. Furthermore, the marginal cost is approximately gone down toward zero. Its distribution cost is significantly low due to the cheap transport cost via internet network [37].

Ideas, knowledge, computer software, e-book, visual images, music, databases, videogames, blueprints, recipes, DNA sequences, codified messages and cloud services are typically an example of the digital good. Apart from that in our context, the servitization of business and digitalization of services such as packet tracking in logistic, e-post service, ERP-system, finance transactions, booking system are another example of it.

2.1.2 Economic Impact of Digital Goods

The digital goods are changing the traditional economic model, starting from the disintermediation in supply-chain management. It creates a new procurement and distribution channel, i.e., online channel.

The change in supply chain structure

The technical characteristics of digital goods change the supply chain. It gives a chance for a different player to be active in market. At the same time, their presence is treating the old players in the ecosystem. Moreover, because of these innovative goods the market structure is gradually altered. Buxmann [37] identified two different types of transformations, one is *disintermediation* and the other is *re-intermediation*.

Disintermediation is a removal of the intermediaries in a supply chain, because the internet technologies create more transparency in the market and sink significantly the transport cost, in this way, a consumer can procure a digital good directly from the producer. For example, is the digitalization phenomenon of CD to MP3 and the physical USB media storage to cloud computing service IaaS (e.g. Amazon Simple Storage Service).

Re-intermediation is restoration of intermediaries in a supply chain. Re-intermediation requires disintermediation to occur first. Let us look at the tendency of the direct transaction between the consumers to a producer through online stores (i.e. E-Commerce). The supply chain and product delivery chain would be drastically shortened (disintermediation). However, due to the long tail effect[3] on the ecosystem, there are incrementally more producers, hence make the information more complex along the chain, thus the transparency slowly fades again. Therefore, an old role of intermediary reappears in digital landscapes (e.g. Amazon and EBay) [143]. This is also become a consideration in Service Ecosystem, if there is none solution to save the increasing information cost (cf. Chapter 4), so the intermediary is become necessity.

[3] In October 2004, Chris Anderson popularized the term of *Long Tail*. It describe the retailing strategy of selling a large number of unique items with relatively small quantities sold of each – usually in addition to selling fewer popular items in large quantities [17]. It also means, that the long tail effect is occurs in the ecosystem with lot of niche players, rather in contrast to the oligopoly structure of big player.

Multichannel Management

Another impact of digital goods in the internet economy is the enrichment of marketing channel to reach customer. A systematic organization is important to manage different channel. In order to avoid cannibalization between the channels the business needs multichannel management (e.g. online edition of newspaper versus paper ware, CD versus music streaming). On the other hand, the management is also essential for strategic planning of complementary channels of a product (e.g. online archive, search functions, community platform, recommender system).

According to the direction flow of the management, there are two different types of governing the channels, viz. central or decentralize management. If the business applies the central channel management that means, each of channels has only one person in command whom responsible for all. It is recommended for elude the redundant work thus sink the cost and better coordination. However if the channels need specific expertise or not interdependence, a decentralize management is endorsed. The multichannel management is important in Service Ecosystem, because in the era of internet, a service provider has the possibility to combine and cooperate with other agents. Typically this can be centrally controlled, and decentralize management come into play in such a service network.

2.2 The Aspect of Information System and Technology

In the earlier sections, we have seen how the technology can affect the economy. Henceforth, in this Section, we will talk more detail about the aspect of information system and technology (IST) itself. What technologies is relevance, what possibilities are offered by the current technology and how all this can support the dynamic in Service Ecosystem. IST has various branches (e.g. Microelectronic, computing, telecommunication, bioinformatics, distributed system, etc.). It is out of the scope of the thesis to concern the entire pallets of IST. The discussion is only concerning the relevance fields' viz. *cloud computing* (Section 2.2.1) and *internet* (Section 2.2.2). We set these boundaries, because latter we will show how those technologies can be concerned as the enabling technology of Service Ecosystem (Internet of Services as an Instantiation of Service Ecosystem, cf. Section 4.1).

The Internet is a remarkable catalyst for collaboration and innovation. It provides us today with amazing possibilities that just two decades ago[4] it would have been impossible to imagine. The current internet is the most important information, service, and networking infrastructure. This infrastructure is evolving rapidly with the transition from "sharing" in Web 1.0 (Web) to "contributing" in Web 2.0 (user-generated content) to "co-creating" in web 3.0 (collaborative production, semantic Web) [73]. As a result, the internet is changing at a fast pace and is called to evolve into the Future Internet (FI). It is a federation of service- and self-aware networks that provide built in and integrated capabilities such as: service support, contextualization, mobility, security, reliability, robustness, and self-management of communication resources and services [73, 216].

FI has become the focus of several research and development initiatives all over the world including initiatives in the EU[5], USA[6], China[7], Korea[8], and Japan[9]. In Mai 2009, the European Union published a study about the visions from the industry experts about Future Internet in 2020 [64]. This study depicts the fundamental and new approaches for upcoming situation. Apart from that, the basic notion of the future internet as proposed on [49] is as follows.

Definition 2.2

> *Future Internet* is the seamless fabric of classic networks and networked objects that connect to one another dynamically.

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[4] In 1989 proposed Tim Berners-Lee a new information management architecture (which will be known as Web) and two years later, CERN publicized the new World Wide Web project.[5]

[5] http://www.future-internet.eu

[6] http://www.nets-find.net

[7] http://www.cstnet.net.cn/english/cngi/cngi.htm

[8] http://fif.kr

[9] http://akari-project.nict.go.jp/eng/overview.htm

These elements will be ubiquitous, always standby, and unleash a deluge of real-time information. The Internet is going to become the societal operating system that underlies every aspect of our lives, including business, government, and social interactions. The Future Internet will open a host of different opportunities and challenges, many of which are one aim of this study (Chapter 5). The current internet in the way it is now was conceived from the very beginning: a as network of networks. But in 2020 [64] these networks will be both laid out as public infrastructures and dynamically created by the objects connecting to one another (*Internet of Things*[10]) [217, 220]. The content and services (*Internet of Services*[11]) [194] they facilitate will be all around us, always on, everywhere, all the time (*Cloud Computing*).

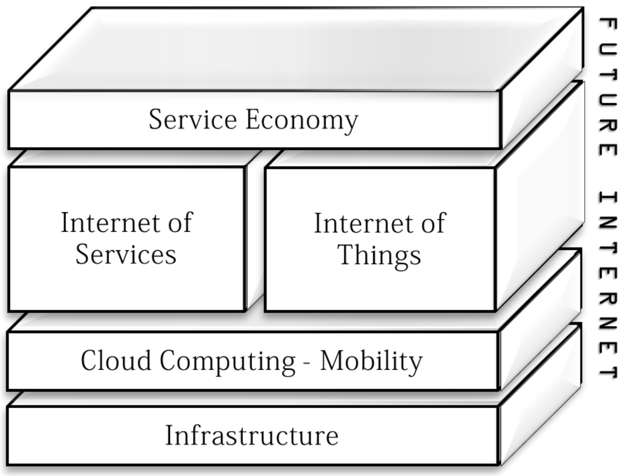

Figure 2.2: The core components of Future Internet based on [49]

At the top of the abstraction level, FI emphasizes the impact of next-generation service on economy and society (cf. Section 2.1). Product morphs into services, with profound implications for traditional organizations and value chains. Relying closely on the Internet of Things, the new *Web-Based Service Economy* will merge the digital and physical worlds opening up a multitude of niches and value propositions. The Internet of Services (IoS) relies largely on service-oriented architecture (SOA)[12] that underlying cloud-computing technology. It uses also semantic technologies that understand the meaning of information and facilitate the accessibility and interconnection of content. Thus, users can combine data from various sources though different formats. This conveys toward a wealth of innovative web-based services [27].

[10] http://www.theinternetofthings.eu/

[11] http://www.internet-of-services.com

[12] A flexible, standardized architecture, that allows various applications to be combined into interoperable services [228].

2.2.1 Cloud Computing

Cloud computing is the fundamental technology to realize the future internet, because it is associated with a new paradigm for the provision of computing infrastructure. The reasons why this paradigm shift is widely adopted is because significantly cost reduction that associated with the management of hardware and software resources [84]. There are many definitions of Cloud computing, but they all merely focus on the technology aspects. Vaquero et al., [222] has discussed those various concepts in their work and defined the cloud computing as follows:

Definition 2.3

> *Clouds* are a large pool of easily usable and accessible virtualized resources (such as hardware, development platforms and/or services). These resources can be dynamically configured to adjust to a variable load (scale), allowing also for an optimum resource utilization. A pay-per-use model in which the infrastructure provider by customized SLAs offers guarantees typically exploits this pool of resources.

There are three actors in the cloud computing. S*ervice provider* produces a (web) service and makes services accessible to the *service users* through Internet-based interfaces. Service providers can use own infrastructure or using third party asset that is offered by *infrastructure provider*. Therefore, depending on the type of provided capability in cloud computing, there are three settings [222]:

Infrastructure as a Service (IaaS)
Infrastructure providers manage a big set of computing resources, such as storing and processing volume. Through virtualization, they are able to split, assign and dynamically resize these resources to build ad-hoc systems as demanded by customers, the service providers. They deploy the software stacks that run their services. Examples of this scenario are Amazon Elastic Compute Cloud (EC2)[13], Microsoft Live Mesh[14] and Sun Network.com (Sun Grid Engine)[15].

Platform as a Service (PaaS)
Cloud systems can offer an additional abstraction level: instead of supplying a virtualized infrastructure, they can provide the software platform where systems run on. Service providers should make transparent about the sizing of the hardware resources demanded by the execution of the services. This is denoted as Platform as a Service (PaaS). A well-known

[13] http://aws.amazon.com/ec2/

[14] http://www.mesh.com/

[15] http://www.oracle.com/technetwork/oem/grid-engine-166852.html

example is the Google Apps Engine[16] and a business cloud platform by force.com from Salesforce[17].

Software as a Service (Saas)
Finally, there are services of potential interest to a wide variety of users hosted in Cloud systems. This is an alternative to run premise applications. An example of this is the SaaS-ERP Software by SAP marketed as SAP business by Design[18]. Another example is the online alternatives of typical office applications (e.g. word processors, spreadsheet, calendar, etc.) by Microsoft Office 365[19] or Google Apps for Business[20].

2.2.2 Internet of Services

The cloud computing technology is growing, and it will be even more developed [141]. The elasticity of resources, the simplicity of installation and the insignificant costs of maintenance attract more business that wants to concentrate on their own competence. It shifts the "high touch, margin, and commitment" provisioning of service to "low touch, margin, and commitment" of self-service [141]. That means this service provided by cloud computing (i.e. Web service) is now in reach of individual actor, thus emphasizes the innovation of application. The growth of cloud computing connotes the maturity rate of web service infrastructure. This movement emerges the use of internet in a service-oriented marketplace.

Barros and Dumas observed this trend, and said that "web service providers are interconnecting their offerings in unforeseen ways, giving rise to Web Service Ecosystems A Web Service Ecosystem is a logical collection of Web services whose exposure and access are subject to constraints characteristic of business service delivery." [12]. However, this kind of ecosystem is concerning merely Web service, and not the broad spectrum of service (cf. Section 3.2.3). Following this further, we want to see the usage of internet technology as a platform for facilitating the service industrialization (in extensive interpretation). Hence, we proposed the global notion of Service Ecosystem (cf. Chapter 3).

The central idea of The Internet of Services (IoS) suggests that existed and future service become tangible entities. By using the internet, service agents can offers or may also compose their own service with other services in a specific marketplace. The trading and exchange of service need a declarative description in order to facilitate the creation of a value chain [194]. The commercialization of service in the internet brings professional challenges, such as reliability, fairness, quality assurance, security, obligation and fulfillment of described service commitment [171]. In private domain, the usage of existed services (e.g. webmail services,

[16] http://code.google.com/intl/appengine/appengine/

[17] http://www.salesforce.com/platform/

[18] http://www.sap.com/germany/solutions/products/sap-bydesign/index.epx

[19] http://www.microsoft.com/en-us/office365/online-software.aspx

[20] http://www.google.com/apps/intl/en/business/index.html

social network, search, web-application, weather services, etc.) can have a big tolerance regarding with the quality of online services or the information included. However, in vital environment (e.g. professional workplace, public sector, medical domain, etc.) the risks for consuming service product and trusting the commitments should be minimalized, “how well a service is connected with others will be a measure of its success” [12].

2.3 The Aspect of Ecology

The third corner as the foundation of Service Ecosystem is the aspect of ecology. We have seen how internet as technology shifting the economy from previous sections. Likewise, the advancement of internet technology literally raises the notion of Web Service Ecosystem [12]. Consequently, we need to go toward one level higher to view an ecosystem from ecologic point of view, and thus make acquaintance with lateral type of ecosystem. In 1993, James F. Moore [145] used several ecologic metaphors, he said that the "economic community produces goods and services of value to customers, who are themselves members of the ecosystem." From here on, the literature start using the ecological metaphors to describe business structure and operations, and is understood under the term of *Business Ecology* [1, 78, 193, 215].

Business ecology is about generating a new model for technology-enabled business one that eliminates waste while creating a more resilient and responsive business operating model [130]. It requires a more holistic approach to planning, understanding and managing the business. Moreover, business ecology addresses business process flows, data design and the mechanisms (from governance to incentives to event processing) [136]. The definition of business ecology according to Townsend [214, 215]:

Definition 2.4

> *Business ecology* is the study of the reciprocal relationship between business and organisms and their environments.

The goal of it is sustainability through the complete ecological synchronization and integration of a business with the sites that it inhabits, uses, and affects [215]. Here is important to recognize that everything is interconnected, so nothing can be managed in isolation [76]. Lending a term from nature science, the relation between business's actors should like a nature *ecosystem*. Therefore, ecosystem is the main issues in business ecology. There are two different type of ecosystem, thus we will describe it further viz. *Digital Ecosystem* (Section 2.3.1) and *Business Ecosystem* (Section 2.3.2). Apart from that there is also cross type hybrid ecosystem (Digital Business Ecosystem). It depicts the socio-economic development catalyzed by IST [112].

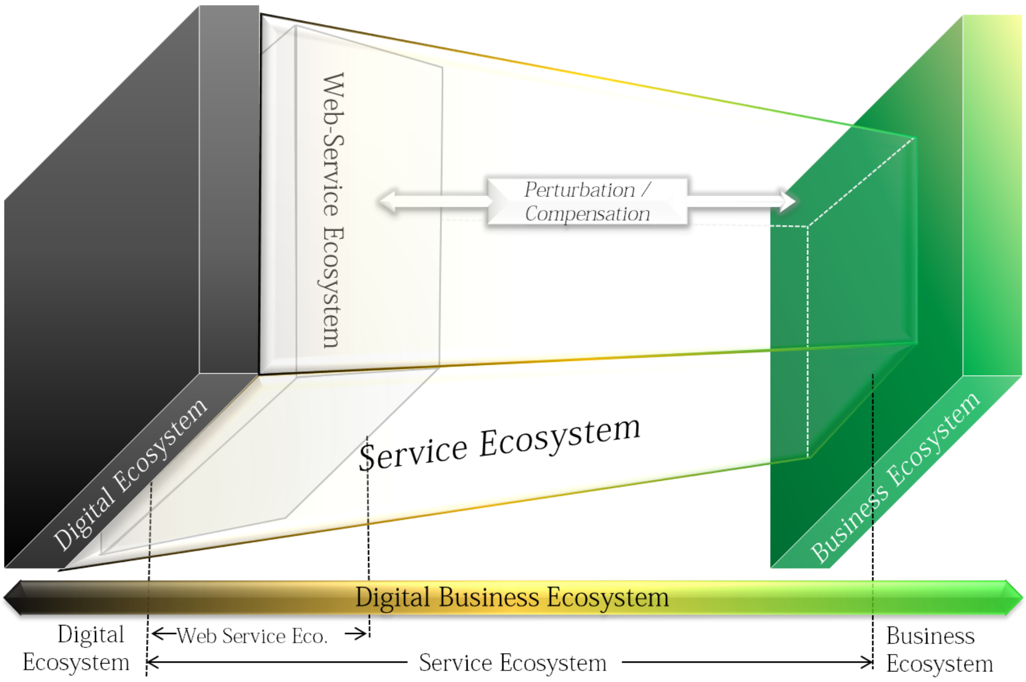

Figure 2.3: The Structural Coupling of Digital Business Ecosystem [112], Web Service Ecosystem [12], and Service Ecosystem

A Digital Business Ecosystem results from the structurally coupled (Figure 2.3) and co-evolving Digital Ecosystem and Business Ecosystem. A network of Digital Ecosystems, will offer opportunities to SMEs (Small Medium Enterprise) to participate in the global economy or in remote areas. These new forms of dynamic business interactions and co-operation among organizations and business communities, enabled by Digital Ecosystem technologies, are deemed to foster local economy growth. This will preserve local knowledge, culture and identity and contribute to overcome the digital divide [112]. As shown, there is an intersection with Service Ecosystem, which is as a subset of Digital Business Ecosystem. To be specific, Service Ecosystem concentrates on the service sector of the economy, with the enabling of IST to support the service industrialization and the servitization of business. In order to be able sorting the Service Ecosystem within the ecological aspects, we need to explore each of the lateral ecosystems. Subsequently, Digital Ecosystem and Business Ecosystem will briefly describe in the following sections.

2.3.1 Digital Ecosystem

One pole in the ecological aspect of Service Ecosystem is the Digital Ecosystem. Figure 4 shows how Service Ecosystem scope closes the entire Digital Ecosystem surface. This connotes that Service Ecosystem inheriting all the characteristics of Digital Ecosystem, which will be discussed in the following paragraphs further. Furthermore, the background why the Digital Ecosystem arise and the nutshell of the concept will also be provided.

It is a fact that SME gain more importance in the advanced economies country esp. in EU. Furthermore, it is still consistently growth[21]. It means that this progress is succeeded by the adoption of information technology [126]. The greater adoptions of IST offer the increasing competitiveness to SMEs in operative business [55]. Hence, the Digital Ecosystem concept emerged worldwide as an innovative approach to support the adoption and development of IST [18, 74, 121]. The Digital Ecosystem research area aims at developing the IST and paradigms that are needed to support the emergence and sustainability of knowledge-based networked Business Ecosystems (cf. Section 2.3.2): geographic (or virtual) areas where specific policy initiatives will foster growth, improve innovation, productivity and social inclusion, through the optimal use of local assets and the global interaction empowered by IST. The support to the knowledge sharing, the establishment of worldwide value chains and transitory business networking promotes global cooperation and alternative ways of developing software and conducting business. [112]

The key enabling technologies developed within the Digital Ecosystem aim at providing a knowledge- and service-oriented infrastructure that supports the spontaneous composition, distribution, evolution, and adaptation of IST-based services (i.e. Web Service Ecosystem) [12, 159]. This platform should allow the SME software industry to self-reliantly develop (and disseminate on the network) services and software components, which will be composed forming complex, evolutionary and adopted solutions. These technologies allow the spontaneous development and the cooperative provision of services and solutions, without the need for any keystone player (cf. Section 3.2.1), central coordination or central point of control/failure. [112]. The technical infrastructure, based on a P2P distributed software technology that transports, finds and connects services and information over internet links enabling networked transactions. In addition, the distribution of all digital goods present within the infrastructure (cf. Section 2.1.1).

Digital Ecosystems cross business domains and different value chains, for the reason they are characterized by not having a single reference model [112]. As an example is a software ecosystem. A software ecosystem consists of the set of software solutions that enable, support and automate the activities and transaction by the actors in the Business Ecosystem [31]. In such ecosystem, software developer can trade or commercialize their digital good i.e. Software, in a certain online market platform (e.g. Android marketplace[22], Google play[23], Chrome Web store[24], Samsung Smart TV apps Store[25], etc.). The offering phases in each market place have different flows and description logic. Service Ecosystem inheriting this

[21] SMEs are 99 % of companies in Europe; provide around two-thirds of all employment. In Japan 81 % of employment is in SMEs. SMEs in OECD countries represent 95% of enterprise in most countries and generate over half of private sector employment [241].

[22] https://market.android.com/

[23] https://play.google.com/store

[24] https://chrome.google.com/webstore/

[25] http://samsung.de/de/microsites/smarttvapps/default.aspx

characteristic from Digital Ecosystem, however there is already a proposed solution for handling the problem that occurred by offering digital goods in diverse market places. The solution called unified language i.e. USDL that will be presented in Chapter 4.

2.3.2 Business Ecosystem

The other pole in the ecological aspect of Service Ecosystem is Business Ecosystem. Figure 2.3 shows how Service Ecosystem scope is a part of Business Ecosystem surface. On the one hand, Service Ecosystem inheriting all the characteristics of Business Ecosystem, viz. evolution process, multi sectorial network, and existential motive (strategy) of the stakeholder. On the other hand, Service Ecosystem merely handles the service sector part of the business. In following paragraphs, we will present what Business Ecosystem according to James F. Moore [145, 146] is and what the characteristics of Business Ecosystem are.

Moore coins the term “Business Ecosystem” [146] three years after he used the ecological metaphor in 1993 [145]. The intention is to show that business needs a broad perspective, and can no longer rely merely on a vertical and horizontal chain. Apart from that, he picked the term ecosystem because it “circumscribes the microeconomics of intense coevolution coalescing around innovative ideas. Business Ecosystems span a variety of industries. The companies within them coevolve capabilities around innovation and work cooperatively and competitively to support new products, satisfy customer’s needs and incorporate the next round of innovation.” [146]. Therefore, a Business Ecosystem is an economic community consists of a large number of loosely interconnected companies that are dependent on one another to gain advantages [1, 92, 113, 145].

The dynamics or evolution of the system is determined by its performance. If one of these ‘healthiness’ factors is lacking, then the ecosystem will probably not succeed [145]: The sequence of Business Ecosystem development occurs over the course of four successive, relatively predictable stages viz. *Birth*, *Expansion*, *Leadership*, and *Self Renewal*. First, through the birth and pioneering stage, the attention should be on the acquisition of critical lead customers, key suppliers and important channels. This ensures value creation while simultaneously protecting competitors from doing business within the ecosystem. Secondly, the system expands.

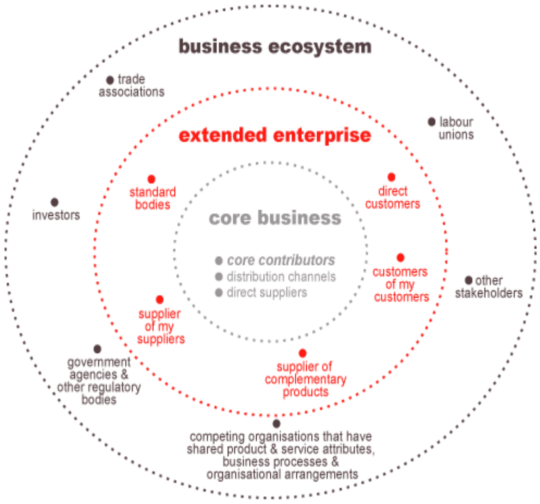

Figure 2.4: Business Ecosystem Model [98]

Business can reach the critical mass by increasing scale and scope (with vendors or partner) and by standardization in key market segments. "Leadership" or "authority" characterizes the third stage. The focus of this stage is on the '*red queen effect*[26]'; on the one hand, companies should encourage suppliers and customers to work together to continuously improve the complete offer, while on the other hand they want to maintain their strong bargaining power towards these partners. Lastly, the end stage is "self-renewal" where the implementation of new ideas stands essential. The established Business Ecosystem can delay other Business Ecosystems (with similar new ideas) by means of barriers such as consumers switching costs or competitors' entry costs [92]. The latter is critical since a non-self-renewable ecosystem will lead to the end of the evolution, meaning death [146].

The model proposed by Moore is an important foundation to develop the Service Ecosystem model. We use the stages of ecosystem development and the respectively strategy as a basis to analyse the existent motive of service agent activity (Section 3.3.2), the dependency (Section 3.3.3), and the possible mutability in the Service Ecosystem (Section 3.4).

[26] In the evolutionary system, a continuing adaption is necessity in order for a species to survive and still performance among the systems being co-evolved with [125]. In other word, Red Queen effect is "a contest of competitive moves or actions among rivalrous firms. … a firm's actions increase performance but also increase the number and speed of rivals' actions, which, in turn, negatively affect the initial firm's performance." [53]

2.4 Service Science

All three fundamental aspects of Service Ecosystem are mentioning “service” in their own field. According to the context, one may understand it differently, viz. technical sense, or broader economic sense. Moreover, the notion of *service* plays a big part in the study; therefore, it is important to clarify what we mean by that term, and several notions around it beneath the service science [86] field.

Service science is an interdisciplinary field that combines organization and human understanding with business and technological understanding to categorize and explain the many types of service systems that exist as well as how service systems interact and evolve to co-create value [15, 132]. Furthermore, it aims to improve the ability to create service innovations systematically and reliably [133]. Nevertheless, what is literally the meaning of a service? There has been a lot of dispute over what really a service is [75, 127, 128]. Traditionally, services are thought to be a homonym and there were processes that described services in three different classifications of service viz. service are *nonmanufacturing*, *intangible products*, *processes*. This common way in the end classified almost everything as service. Therefore, it was important for an integrated system of classification to specify what a service is. It gave rise to the concept, the Unified Service Theory (UST) [179, 179]. The definition of service as stated in [180] is as follows:

Definition 2.5

> *Service* is production processes in which each customer provides significant elements (assets and/or information) which are essential input for production.

Customer is the supplier to all service businesses [178]. In contrast to non-services processes, the main different is at the involvement of the customer in the production process. The production in a non-service process is customers independent. From UST point of view, service is built from an intense interaction between consumer and producer. For example, a customer provides their personal information data for ticket booking service, or one may provide their bodies and minds as input to entertainment services, apart from that they can provide their properties such as their electronic appliances to repair services, or their financial records to tax preparation services. In all scenarios, the service provider transforms customer input into an output with more value added in it, thus is consumed back by the customer [197].

The interaction between customer and provider is not the only one relation inside the whole service production chain. Moreover, there is another kind of cooperation between service agents viz. service system and service network. There is a slight difference between those terms. Raso-Zapata et al. [167] define the service network as follows:

Definition 2.6

> A *Service Network* is as a team of individuals who establish relationships among homogeneous peers to provide a specific service.

The homogeneity means that the individuals have a common business objective, i.e., provide a certain solution. However, there is also in case that a service can be providing within a heterogeneity background. Thus, Ferrario et al. propose a more general definition term as service system [65]:

Definition 2.7

> A *Service System* is the sum of all the objects anyhow involved in a service (through a participation relationship)". Service system is a complex object, consisting of all the objects participating to any of processes constituting the service.

An open issue still follows those definitions, which is, how we can optimize the heterogeneity in the service system. To this point, there are two broad approaches existing to help improve service system, namely *process-based* approach, *stakeholder-network*-based approach. Meanwhile, an ecology-based approach is also under development [131]. The process-based approach refers to variants of service blueprinting. It describes the interaction between customers and providers in time. Service blueprinting according to the context have different meaning, for example, as a use-case method, business process modeling (BPM) [177], and document engineering, respectively in the software industry [37], in business activity and in the information world [131].

The stakeholder-network-based (cf. Section 3.2.2) approaches refer to variants of network mapping. It starts by enumerating all stakeholders, identifying issues and benefits afterwards. This approaches evaluation methods are system dynamic modeling and simulations [131]. Sphorer et al. recommended the main methods for this approach are complementary methods and *blue ocean*[27] [198]. Following this view further, it initiates the last approaches viz. *ecology-based* methods. The Ecology-based approach tries to analyze the density of service interactions among all stakeholders. It becomes more important and necessary once everything is more interconnected and interdependent. Nonetheless, this is still incomplete [131]. Therefore, Service Ecosystem presented in this study (Chapter 3) will try to contribute to this barely developed approach.

[27] Blue Ocean is a business strategy that denotes all the entities not in existence today (the unknown market space, untainted by competition). Blue Ocean is an analogy to describe the wider, deeper potential of market space that the business players still need to explore. [114]

2.5 Summary

This Chapter is about the fundamental theories that constituting Service Ecosystem. We have addressed the economic impact of adapting internet technology in business, what kinds of internet technology are relevant, how those two different domains forming a heterogeneous network, and a universal discourse about service. Those are the foundations constituting the Service Ecosystem model.

Internet technology exhibits the feature of progressive network externalities as of establishing a new economy structure. This technology facilitates the origin of digital good in contrast to classic real goods. As of the traditional distribution-chain is altered, so do in the service production process. Service will become digitally commercialized and tradeable using internet in the near future. SOA, cloud computing and semantic technologies are the mainstream future internet technologies. The mobility and distributed system amplify the network externalities both in Digital Ecosystem and in Business Ecosystem; there between is the Service Ecosystem. This will lead to dense population of various service meshes. Moreover, the service agents will be interdependent and interconnected as the big player adapts the future internet technology, because it connects groups and sinks the digital service reproduction at marginal costs.

One cannot overlook the advent of Service Ecosystem while it gains more importance in such interdisciplinary research. Therefore, in order to construct a comprehensive model, we need to behold those fundamental aspects at once sights.

3 Theory of Service Ecosystem

The underlying knowledge from the aforementioned Chapter gives the basis and explanation (kernel theories) for the proposed Service Ecosystem theory in this Chapter. In order to develop the theory systematically we decided to use the suggested framework of Information System Design Theory (ISDT) from Gregor and Jones [101]. Their design theory includes components missing by previous conducted studies [59, 229], furthermore they also explicitly addressing the role of instantiations and recognizing the artifact mutability. The research starts by observing and thus subjectively understanding a Service Ecosystem. From here, we develop set of modeling constructs and theories (abstract artifacts) to guide the building and instantiations of the real-world occurrence (cf. Chapter 4) and to comprehend the material artifacts when in use (cf. Chapter 5).

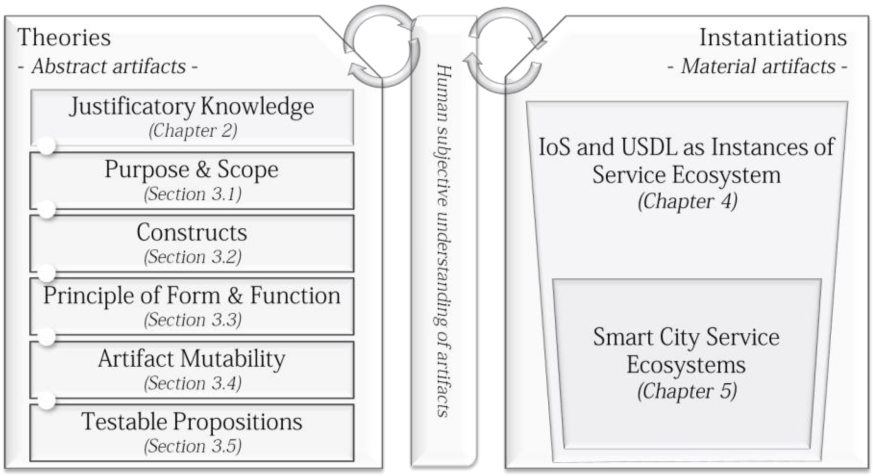

Figure 3.1: Outline of the Service Ecosystem Theory and Initiations, using the core component of Information Systems Design Theory [101].

We present a theory in the similar outline as recommended by ISDT with the focus on the core anatomy components, which are also the five mandatory components specified by Dubin [59]. The theory design starts by stating its Purpose and Scope (Section 3.1). Subsequently, the construct of Service Ecosystem describes the compound that made the ecosystem, viz., what are the characteristics of an ecosystem, who lives in it, and what kind of activities are they doing in it (Section 3.2). Thus, it followed by the design of the Principles of Form and Function, which is the norms that define the structure, organization, and functioning of the design model. It represents the important component, and the architecture of the Service Ecosystem (Section 3.3). Afterwards, we perceive the probability of the evolving artifact in the adaptation skill of Service Ecosystem actor. The special natures of this kind of Artifact Mutability (Section 3.4) are the vigorous dynamic and high possibility of alteration. To conclude, we affirm the Need of Dialectal Mean in Ecosystem as Testable Propositions (Section 3.5).

3.1 The Purpose and Scope of the Theory

In literature, the notion of Service Ecosystem is widely used. However, most of them lack a basic and uniformly comprehension about it. Although several established research initiatives try to study about the ecosystem viz., Business Ecosystem, Digital Ecosystem, Software Ecosystem and Web-Service Ecosystem, the term of Services Ecosystem itself, is not properly defined. Thus to clarify and give an objective understanding of the notion, are the purposes of the proposed theory as of to limit its scope.

Even though there are several approaches to define service network and service system, still there is a common mistake by using them analogously in the diverse contexts. Although like is stated in Section 2.4 they have a slight distinctiveness. Apart from the differences, both have a similarity, which is the lack concern of ecological vibrant in the service industry (e.g. the performance of a service provider, the dynamic of the service network, or the improvement's effect in science and technology for the service system). Therefore, we propose a definition of Service Ecosystem as follows:

Definition 3.1

> A *Service Ecosystem* is a dynamic set of symbiotic interrelations between service agents in specific markets and amid a core technology platform. A service agent may be an enterprise, a human, a machine and an automaton.

By proposing a theory of Service Ecosystem in this study, firstly we intend to clarify and sort the Service Ecosystem within the ecological aspect. Secondly, this theory can be used as an underlying model to demonstrate IoS as instantiations of Service Ecosystem. Lastly, the theory is also important to show the essential need of normative language (USDL) in such an ecosystem. Apart from that, it is necessary to explain the future challenge that may evolve in this kind of ecosystem, thus the relevant stakeholder can create appropriate measures. Nonetheless, due to the scope of the thesis (Figure 3.2), we are excluding a quantitative formalisms und mathematic model.

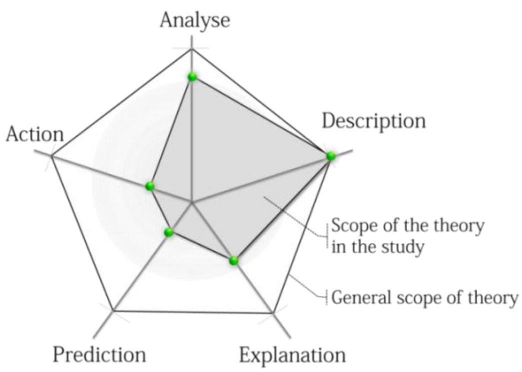

Figure 3.2: Purpose and Scope of Service Ecosystem Theory. The edges of the pentagon represent the different purpose of a theory [79], and the area illustrates the scope of proposed theory.

3.2 Construct of Service Ecosystem

The construct of Service Ecosystem describes the most basic representation entities of interest. Gregor and Jones adopt the idea from Aristotle about the *causa materialis* and use it to define the "construct" component of theory [101]. It is a material cause: "that out which, what it is made from" e.g., the bronze of a statue, or wood of a table. Assigning it to the Service Ecosystem theory, what are understood by the constructs of theory is following:

- The ecological aspect of Service Ecosystem
- Who constituted the ecosystem?
- The spectrum of the service that connoted in the theory

These entities of interest are abstract theoretical terms such as metaphor and stakeholder of ecosystem. Why we use the metaphor of ecosystem, and several terms used in nature science will be explained thoroughly in Section 3.2.1. Thus, we describe the characteristic of Service Ecosystem stakeholder in Section 3.2.2, viz. the diversity, type, its roles and interests. Following from the Definition 2.5 about *service* further, we present the spectrum of the different kind of service that belongs in Service Ecosystem (Section 3.2.3).

3.2.1 Metaphor Characteristics

Why does the attini-ant (known as fungus-growing ant [147]) collects and cut up periodically leaves, and never eats it? The ants fertilize a mushroom's culture with the leave as its nourishment. It is not that the leaves uninteresting for other species of ants. In primeval forest of Costa Rica, those species also learn to filter different type of leaves that is free from chemical stuff because this substance can damage the mushrooms. This type of ant supports the sustainability of its ecosystem with their behavior and contributes to the renewal based on their subsistence.

The symbiotically relationship is not merely existed in the nature, but also happening in the economy environment. One of the prominent examples is the observation by James F. Moore in his study [146]. He has shown the similar pattern occurred between American companies (e.g. Intel, Apple and Wal-Mart). He then explained that the success of these enterprises is the focus to build its own ecosystem and periodically enhance it. First is to create a solid ecosystem through innovation and therefore, established advantages towards the concurrent as well as maneuver flexibility to market dynamic.

Another example is the trend of open research initiatives from IT Enterprise (e.g. SAP in Theseus joint research[28] and industry consortium led and sponsored by IBM[29]). The investment on developing new technology together with another industry partner permits the

[28] http://www.theseus.joint-research.org/das-theseus-forschungsprogramm/texo/

[29] http://www.thesrii.org/

ecosystem to create new values that no company could achieve alone. Services have become commodities. Value-added and associated service levels have also become key differentiators in ensuring business sustainability [104]. They invested their assets and resource in the community to create a healthy ecosystem i.e., in their core competence to ensure vitality of the business.

This characteristic inherits also to Service Ecosystem, which consists of a large number of loosely interconnected service networks of service agents who are dependent on one another. Each of service agents has its own interest, and several agents are cooperating to provide a service (cf. Definition 2.6). These contributors lined together for a common cause even though they have different interests [145]. The heterogeneity of interest shows a proof of multiple and lead to the contribution diversity in Service Ecosystem. The service organisms want to exist in such conditions, and thus utilize it resource efficiently by forming a network of cooperation with another service organism. Galletoi [70] shows that the centrality and center-sponsorship of network formation are the most efficient network formation. The heterogeneity of the player in the service network and the cost to forming such network lead to origin of *keystone* [93]. The keystone is defined as [113]:

Definition 3.2

> A *Keystone* is the dominant platform obtaining the greatest advantage from the ecosystem member, similar to predators dominating the highest position of the natural food web.

The keystone species determines the survival of both the ecosystem and its members. "Fundamentally, they aim to improve the overall health of their ecosystems by providing a stable and predictable set of common assets … that other organizations use to build their own offering." [92] Furthermore, they can increase ecosystem productivity by simplifying the complex task of connecting network participants, and they are capable to enhance ecosystem robustness by incorporating technological innovation. The ecosystem's health is depending from such species. In many cases, its removal will lead to the catastrophic collapse of the entire system [ibid.]. For example, are the online auction platform E-Bay, or the apps stores[30]. If the keystone company disappears from such Service Ecosystem, many interrelated niche vendors associated with it, may also disappear because other companies cannot quickly replace its role and related technologies or infrastructures [113].

3.2.2 Service Ecosystem Stakeholder

The second construct of Service Ecosystem is related to the species or the actors. In prior Section, we have talked about the importance of keystone species, apart from that we also

[30] An app store is an online marketplace that offers various mobile applications, software solutions for business, entertainment, or personal use. It typically built by a keystone vendor, such as Adobe, Apple, Google, Microsoft, Salesforce.com, Samsung, etc.

learned that heterogeneity is one of the main characteristics of Service Ecosystem. It connotes the multiple interests of service organism and their activities. Thus, we want to analyze in detail the subjects, who compound this ecosystem. In corporate terminology, it defined as the *stakeholder* [91]. The Service Ecosystem's stakeholder is a party of different entities that affect the existence this ecosystem. Depending on the scope and art of the influence, the stakeholder is divided into three distinct categories: *active*, *passive* and *influencer* stakeholder (Figure 3.3). The following paragraph will described each of the stakeholders in more detail.

Active stakeholders are the main actor in the ecosystem. Their activities are hence the core existence of Service Ecosystem and invigorating. They are *service producer*, *service consumer*, and *intermediaries*. Consumer per se (Definition 2.5) always involve in the service production. Therefore, service consumer has the same aspect, likewise service producer for rolling the ecosystem cycle. Apart from that, the dynamic occurrences of disintermediation and reintermediation (as explained in Section 2.1.2) cannot be generalized for every kind of service. For example, an intern-company mail carrier can be seen as service supplier in the whole chain of a logistic company that delivers bill of material from one department to another. Still, in the global context, we can see a service producer also as an intermediary (service supplier or service distributor), if its service is being consumed or use by another service producer. This characteristic of intermediary endorses different pallets of the service spectrum (see Section 3.2.3).

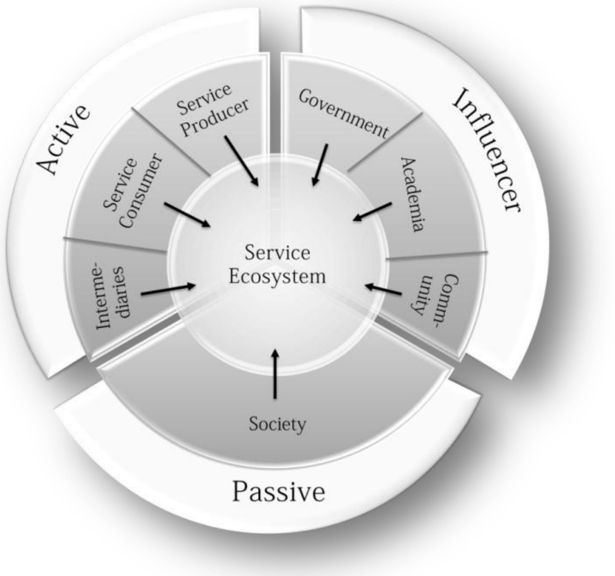

Figure 3.3: Three categories of Service Ecosystem Stakeholder viz., Active, Influencer and Passive

In addition, there is another stakeholder, whose action may reshape the ecosystem. We termed it as an *influencer stakeholder*. It comprises from three different institutions namely, *government*, *academia*, and *community*. The actor from this kind of Stakeholder is typically an engineer keystone[31]. Because of their influence, we should concern this stakeholder deeply by the investigation of analyzing the possibility of ecosystem mutability and evolution (described further in Section 3.4). For example, the government and its legalization power (political products) can significantly support, balancing or even destroying the ecosystem. This is also applying for academia and community. Academia is group of students, scholars and researcher that are the motor of science and technology development. The community is a social group of people with same interest, intent and preferences (e.g. open source community, NGOs, etc.). The recent headlines about the multi-government standards known as ACTA[32], or a US bill known as SOPA[33] / PIPA[34] show the interplay in this stakeholder. These issues initiate from government are creating a massive dynamic in the ecosystem. Hence, the other influencer actor viz., academia and community group also make their movement for balancing the ecosystem [45]. This example shows the scope and impact of the action of this stakeholder for the ecosystem.

The last stakeholder is the *passive stakeholder*, which is the *society* where the Service Ecosystem exists. It does not have any direct influence nor actively turn the cycle of Service Ecosystem. However, this stakeholder is important to identify the health (performance) of an ecosystem. The performance can be measured by identifying following parameter, namely: *value* (niche creation in the society), *robustness* (towards dynamic in Service Ecosystem) thus *flexibility* (adapting ability to different value proportions of diverse society), and *continuous performance enhancement*. Such parameters will determine whether an ecosystem can adjust to the diverse society condition and economic value or not. Subsequently, it connotes the existence and sustainability of the ecosystem in a certain society. For an example, let us look at the new model of an online commerce system. Until now, it is still difficult to penetrate the mature market i.e. senior society, or why the Digital Divide [173] still exists. Nonetheless, it is also possible that the Service Ecosystem will completely evolve into a different structure, if it has good performance.

3.2.3 The Diversity inside the Service Spectrum

Lastly, the third construct of Service Ecosystem, is the service spectrum. Clear-cut classification of services and non-services is vital requirement for a better organizing which service is mean in the Service Ecosystem. Table 3.1 below present the spectrum of a different kind of service based on the characteristic given by Kayastha [110]. Furthermore, our work

[31] Engineer keystone is a keystone species, that their main activity can affect transforming the whole habitat where they exists. [41]

[32] Anti-Counterfeiting Trade Agreement (ACTA) is a multi-national agreement for establishing international standards for intellectual property rights enforcement. [234]

[33] The Stop Online Piracy Act (SOPA) is a United States bill to expand the ability of U.S. law enforcement to fight online trafficking in copyrighted intellectual property and counterfeit goods. [236]

[34] PROTECT IP Act (Preventing Real Online Threats to Economic Creativity and Theft of Intellectual Property Act, or PIPA) is a proposed US law. With this law US government and copyright holders have additional tools to curb access to websites dedicated to infringing or counterfeit goods. [235]

extends the table by proposing another two distinction (*manual* and *technical service*) to make the spectrum more specific. We state manual service, as a human-provided service and technical service as a machine-provided service. Though Service Ecosystem theory can be used to general defined service, this study refers service in the ecosystem as a service in the real world under legal jurisdiction of their respective location (examples are also given in the Table 3.1).

The dichotomy between physical goods and intangible service is slowly losing it credence. These are not discrete categories [168]. The service continuum getting more concise because the servitization of business and digitalization of service that create a new hybrid service, which is the combination between human-provided services with machine-enabled service [100, 231]. Commonly, this is called as *IT-enabled service*, that remotely executable by exploiting the information technology. This service is having the same ontology of normal service [170], however, with a new dimension i.e., Service offering through IST (e.g. Taxi booking via mobile apps). Apart from that, for a consistence use term of service and clearance, in this context such labeled of *meta-services* (e.g. service matchmaking, bus service, transaction protocol service, thread service, etc.) are latent in the evaluation of Service Ecosystem. We mean a manual and technical service and IT-enabled service (hybrid), if we mentioned a service in this study.

Characteristic	Categories	
	Manual Service	**Technical Service**
Giving access to performance	▪ Education ▪ Theatre performance	▪ TV or Radio Program ▪ Video Streaming
Performing acts		
▪ on the goods of buyers	▪ Haircuts ▪ Repairs service	▪ Online customer support ▪ Helpdesk
▪ Transferring ownership		
▪ of physical goods	▪ Made-to-order sculpture ▪ custom made Tailor	▪ 3D-Printer ▪ E-Post
▪ of non-physical goods	▪ Architectural drawing ▪ Made-to-order movie scripts	▪ Website builder ▪ ERP Customizing
Not to perform certain acts	Concealment agreement	SLA
Insurance	Health insurance	Automated data Backup Service
Resource lending	Money credit	▪ PaaS ▪ IaaS
Licensing		
▪ of physical goods	▪ Access to art galleries ▪ Leasing of cars	Access of sound recording service
▪ of non-physical goods	▪ Patents ▪ Electromagnetic spectrum	Access to online game account
Forward contracts in which sellers,		
▪ perform acts	Finance product (derivative) sale	BPM
▪ do not perform acts	Delivery of grains from stocks	Automated factory track

Table 3.1: Diversity of Service Spectrum

3.3 Design Principles of Form and Function

The next component of theory building is the principles of form and function. This component refers to the norms that define the structure, organization, and functioning of the design model. It represents the important component, and the architecture of the model [101]. Therefore, in this Section we want to examine this aspect further. We will describe the structure, organization and dependency of Service Ecosystem model. In order to construct the wireframe of Service Ecosystem, we need to know the essence of a Service Ecosystem, which are dynamic systems of service networks. It is also necessary to consider the stakeholder, its influence and the interests by the analyzing, because these factors have the potential to shape the ecosystem. We proposed the model of Service Ecosystem as depicts in Figure 3.4 below.

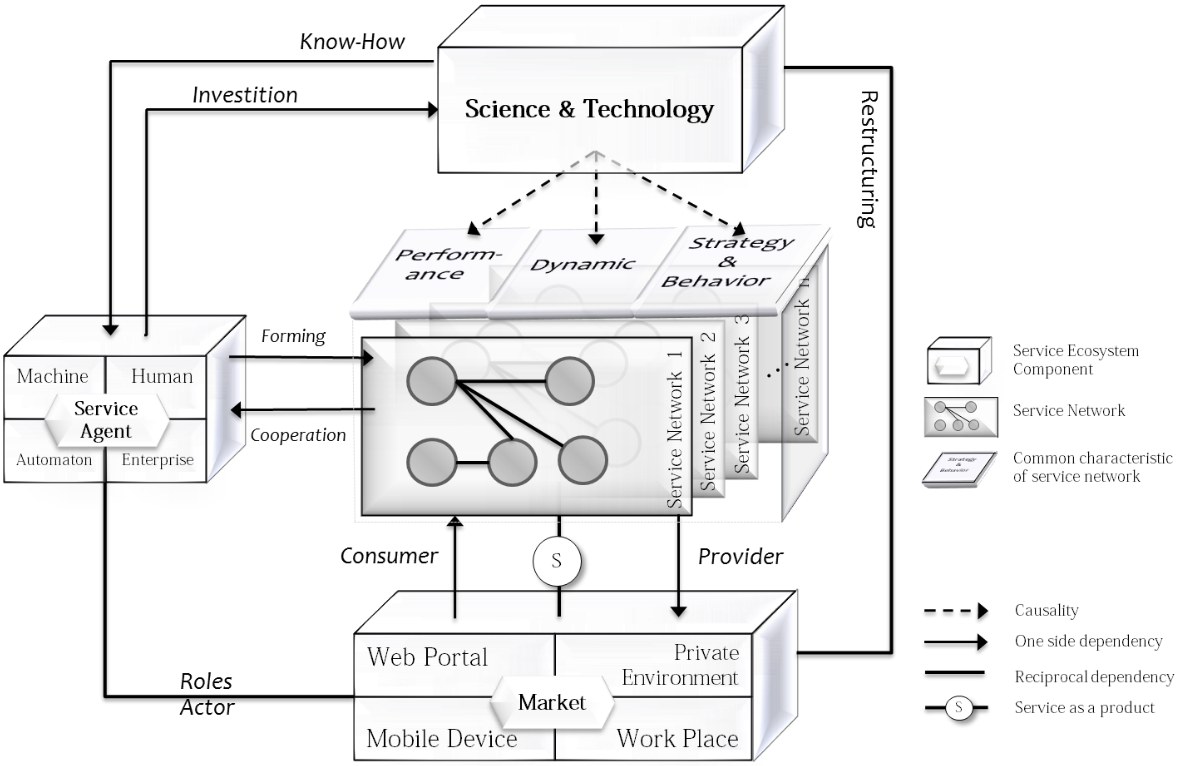

Figure 3.4: Service Ecosystem Model. The form of the model is represented by the block components, and respectively the lines connected each component, depicts the kind of functions and dependency relations.

A closer look to the form and function of Service Ecosystem will be presented in the followings Sections. First, we will examine the organization and the structure compound it, i.e., the component that builds the ecosystem (Section 3.3.1), subsequent the symbiotic interaction in the ecosystem will be illuminated (Section 3.3.2), and thus the dependency of the module will conclude the model (Section 3.3.3).

3.3.1 Service Ecosystem Components

Each of the ecosystem components holds a separate kind of interest in its affairs. They are following their own aspiration depending in what stakeholder type they belong. Moreover, as described in the fundamental aspect of ecology (cf. Section 2.3), Digital Ecosystem and Business Ecosystem merge in such as called Digital Business Ecosystem. The coupling of those two ecosystems, amplify the constituency of the component. Whether it is to ensure their survival in the digital innovation, or gain prosperity in the business operation. Nevertheless, here come the facet of service in foreground and particularly the service's environment in the digital domain. Therefore, with respect to the lateral ecosystems, we identify that a Service Ecosystem is comprised three major component's viz., *service agents*, *science and technology* (S&T) environment, and *market* field (Figure 3.5). The symbiotic interaction among these components esp. service agents emerging numerous service networks, which will discussed detailed in following section.

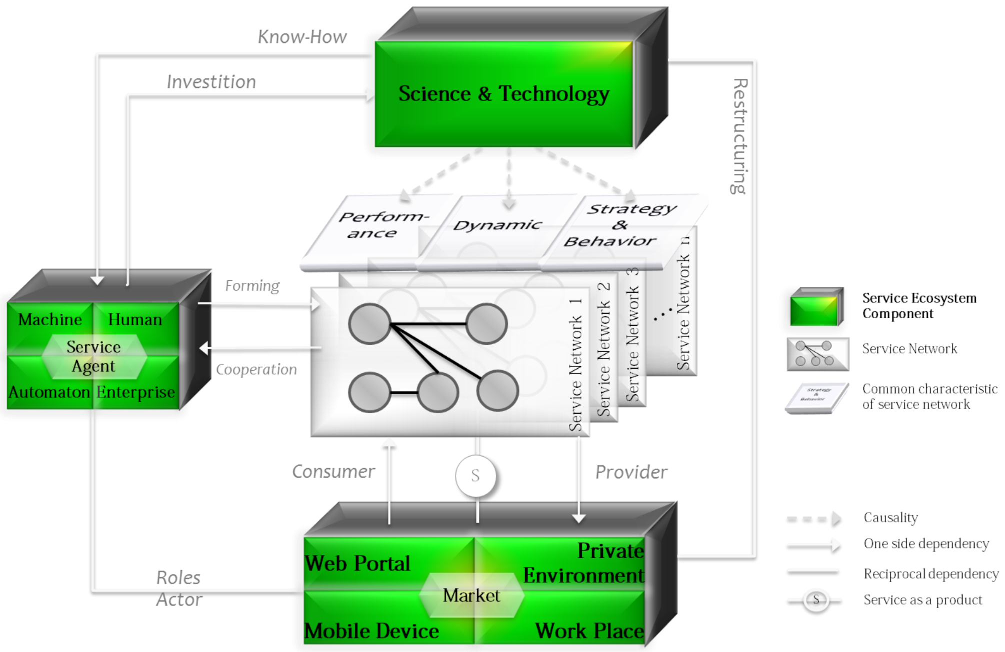

Figure 3.5: The highlighted block viz. Service Agent, Technology and Market are the Service Ecosystem components.

Service agent belongs to the active stakeholder, because they can form the Service Ecosystem merely following their interest (producing and consuming service). The demand to solve a particular task or work drives the process of birth and existence of service agent in such an ecosystem. They need to produce intangible attainment, or if they are not capable of produce it, then they need to consume a specific service. A service can be produce in some way that the reproduction cost is lower because the experience curves effect[35]. This way, a mutualism relation between service agent is strengthens its existence. As long as there is a task to be solved, a service agent will still be present in the ecosystem.

There are four *species* of service agent: *enterprise*, *human*, *machine*, and *automaton*. The species of agent is not loosely independent of another and interleaving. Let us observe a fictive scenario about a smart car as an example. Mercedes Benz is the automobile company that produces it. Mr. Smith is one of the engineers, who work in Mercedes. He is the *human* service agent, who gives his time and commitment to his employer (the *enterprise*). In the other side, Mercedes Benz provides a good quality and comfortable service as a value-added service to their main product. At the weekend, Mr. Smith wants to go to the out of town, and he gives an input to the GPS Navigation in his car. The GPS sends a signal to a satellite (The *Machine*) and it send back to the GPS as the result of the communication service from the satellite. Suddenly, there is a reindeer in the middle of the road. Nevertheless, he drives a smart car that has an active sensor (the *automaton*) inside it, thus the brake is automatically invoked. The service that provided by the automaton is a guarantee of safety for the driver. The Figure 3.6 depicts the intersection of different species of service agents.

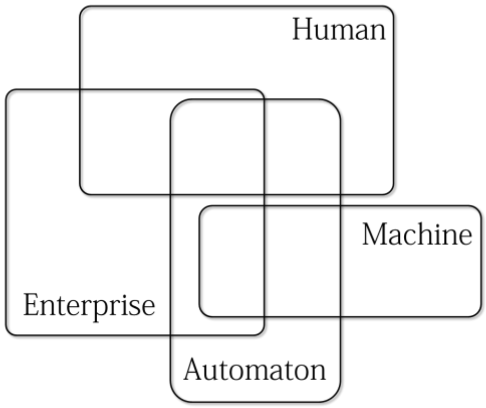

Figure 3.6: Four different types of Service Agent in Service Ecosystem and it relations

To providing machine and automaton an existential reason (to solve a task) in Service Ecosystem, we need a science and technology as the next component. At the same time, it is the reason why *S&T* field is necessary to form a Service Ecosystem. Not only general machine, science and technology create a new possibility and different kind of machine (e.g. IT Devices, web infrastructure) and automaton (e.g. BPM, genetic algorithm, bionic). The other reason is the importance of information in S&T domain. A transformation from information to knowledge is still a challenge nowadays; the essential service in this field would be the information logistic. We have argued that while there is a task that needs to be solved, consequently, a habitant of Service Ecosystem still can find it dynamic. Therefore,

[35] It states that the more often a task is performed; the lower will be the cost of doing it. The task can be the production of any good or service. Each time cumulative volume doubles, value added costs (including administration, marketing, distribution, and manufacturing) fall by a constant and predictable percentage. [201]

whilst S&T still needs the right information, to the proper time at the right place, so it will also exist in the ecosystem and be one of the components that constituted it.

Both service agent and S&T need a place (physical and/or non-psychical) to exchange mutually the service. For that reasons *market* as the third component of Service Ecosystem comes in surface. Market is the place where the service being consumed, distributed and offered. Similar to service agent, market also has four different species: *private environment*, *workplace*, *web portal* and *mobile device*. It serves as a trust gate between consumer and provider that matches the request and offering of services. The number of different species is also dependent to the advancement in S&T component. The dependency and causality between the components will be further explained the Section 3.3.3. Nonetheless, before it, we will examine the symbiotic interaction between service's agents, what kind of possible interaction types that are existed in the service network and how it affected the ecosystem (cf. Section 3.3.2).

3.3.2 Symbiotic Interaction among Service Ecosystem Agents

Symbiosis or symbiotic interaction is close and long-term reciprocal relation between different species in an ecosystem. This Section will observe it between four distinct species of service agent. The continually symbiosis between the service agents plays a central role for the sustainability and healthiness of Service Ecosystem. The interaction forms a kind of network, hence it called service network (cf. Definition 2.6). Proportional to the variety of work type, so do the number of service network in the Service Ecosystem. Collectively, the numerous service networks establish common characteristics viz. *performance*, *dynamic*, and *strategy and behavior*. *Performance* is value created by forming the service network, robustness of the network, and continuous performance enhancement or productivity of the network. *Dynamic* is the flexibility grade of network, ability to adapt to different challenge and possibility to make inter network connection. Lastly, *Strategy and behavior* connote how the network or its actor behaves to continue its existence. The highlighted box in Figure 3.7 depicts the conjunction of symbiosis and its position in the Service Ecosystem. It does not count as a component, because this has a different characteristic than other three components (cf. Section 3.3.1). Service networks are not self-evident and generated because of the existence from the rest component of Service Ecosystem as precondition.

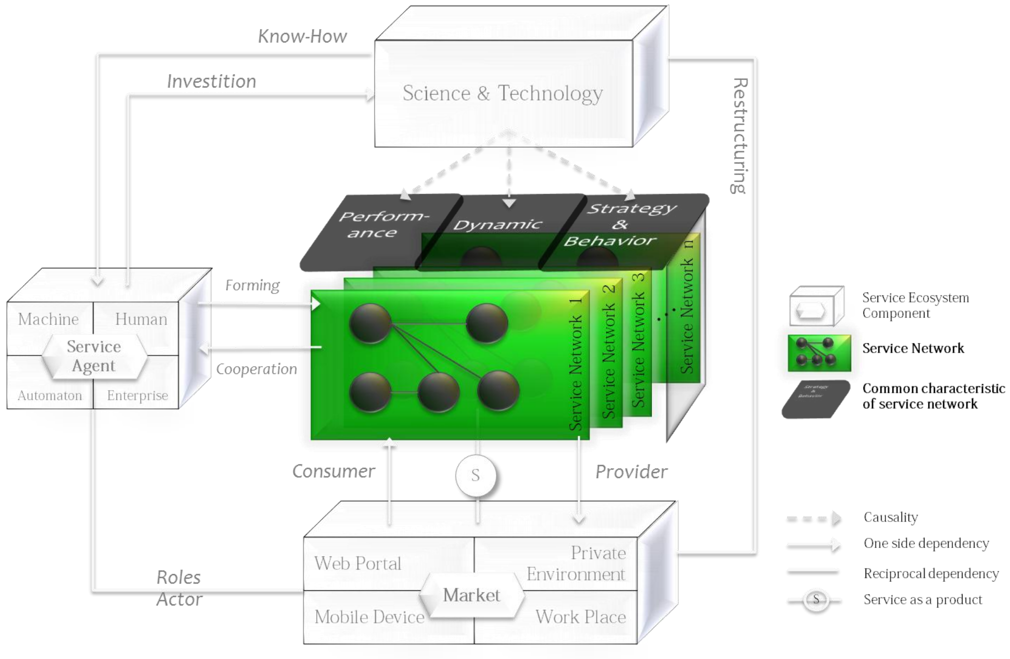

Figure 3.7: Service networks and their common characteristics as the emerging aspects in Service Ecosystem

We analyze the type of possible interaction in the service network and categorize it from two distinct perspectives (i.e., service provider and service consumer). From service provider standpoint, service can be *produced*, *aggregate*d, and *brokered* (See Figure 3.8). We make a distinction about the service category, depending on the service provider a service may online (by machine or automaton) or offline delivered (by human or enterprise). It is consistent with our proposed distinction technical service and manual service respectively. Not merely pure producing a service, a service provider can also aggregate diverse service from numerous service agents and create a new service from them. We call this as service orchestration. Likewise, an automaton can also do the aggregation of multiple services. In this case, we call this activity as service choreography. Service choreography is a form of service composition in which the automaton pick the service partner based on a predefined global scenario (e.g. Algorithm, BPM). The third kind of interaction held by the service provider is brokering. Service brokering is a form of service delivery from another service agent to another service agent. If the service does not alter during the delivery process, then it calls an intermediary otherwise, it call service provisioning.

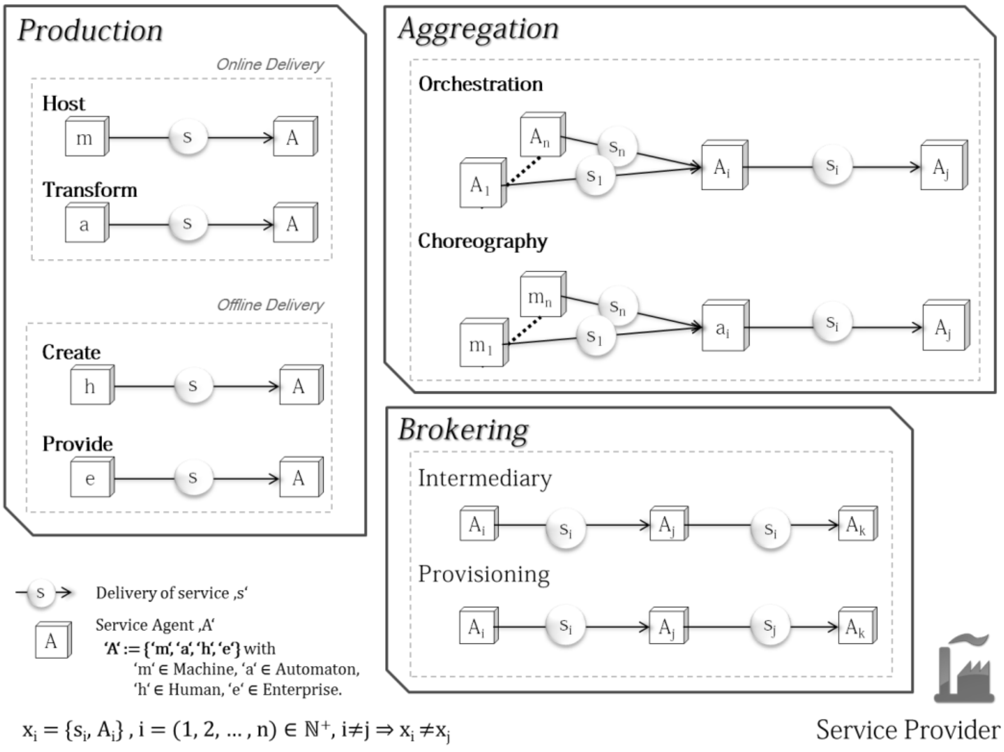

Figure 3.8: Symbiotic interactions among service agents from service provider perspective

On the other point of view, a service consumer may be able to carry out various kind of interaction (see Figure 3.9). Firstly, a service agent can simply consume a service by utilizing in a specific task. An automaton needs a certain protocol to consume a service. Therefore, it needs a gateway access before a service consumer can adopt. Technical services have a special exception by service consuming, due to the advantage of technology (automation) utilized in it. Machine can invoke another machine and consume the work that being done by other machines. Apart from that, automatons can refer different kind of services from several machines. All of that can be done automatically, depending on the triggering event. For example, cron job[36] services that execute a BPM, which is automatically, do a backup job from a remote server. The automaton has already set the reference machine, which should do the backup job. Service also needs to be discovered, likewise, an information. A service agent needs to have contact with other agents in order to discover and find the right service for it purpose. Machines have the ability for giving a recommendation to an agent (which service from which service provider that may be suitable). In our scenario of the smart car, if the fuel is getting low, the smart system that connected with the navigation device can recommend several near gas stations.

[36] "Cron" is a time-based job scheduler in Unix-like computer operating systems.

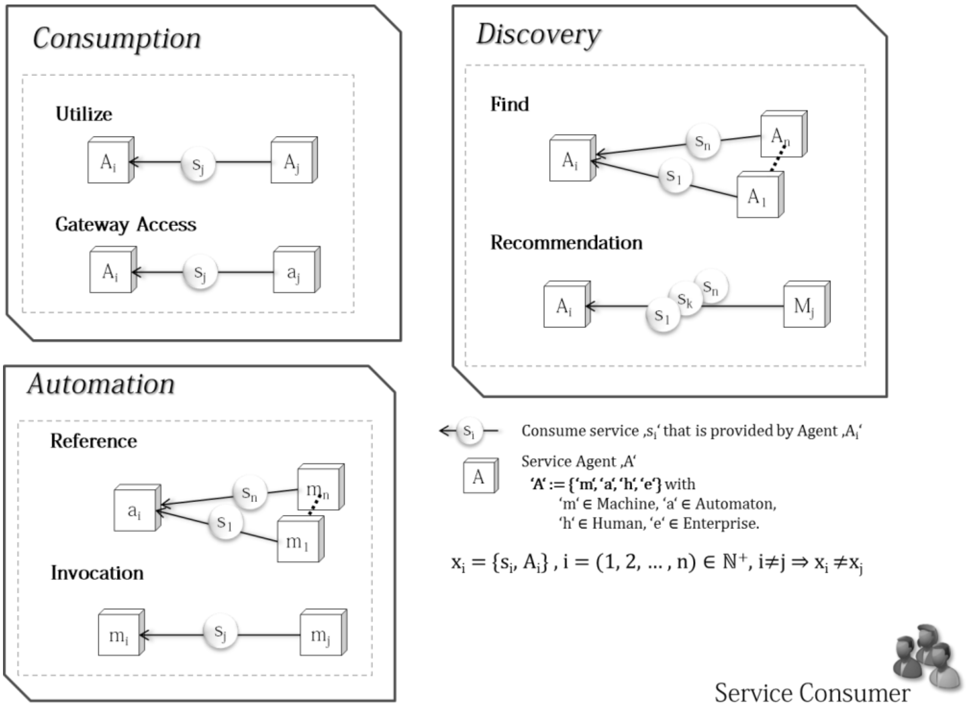

Figure 3.9: Symbiotic interactions among service agents from service consumer perspective

3.3.3 Dependency and Causality in Service Ecosystem

In the previous Sections, we have learned about the component comprised a Service Ecosystem and what is the impact if the service agents interact with each other within the influence of other components (S&T and Market). However, we still do not know yet the precise dependency and causality between the components. Thus, the line connected each block component in Figure 3.10 depicts this causality.

We have discussed how S&T development creates a new *species* of service agent (Machine and Automaton) and a different possibility of technical-enabled service. We also already discussed that each component strives for an existential motive in order to survive in the ecosystem. This aspect can be clearly inspected in following scenario. Almost all big enterprises (e.g. SAP, Daimler, IBM, ExxonMobil, etc.) are recognizing the vital role of S&T for their business. They have their own research and development department. This enterprise is investing some percentile of their budget to the development of S&T. In return, the enterprise enriched with the intangible asset i.e. patent. The active stakeholder needs to ensure the health of its ecosystem. Another example is the consultant service sector. Global player of consulting firms (e.g. McKinsey & Company, the Boston Consulting Group, Inc., Bain & Company, etc.) do the same thing, likewise, other branch company. However, they are giving also a supplementary training to their consultant, and often they may contribute significant concepts and system that push the business process further. It is a mutual benefit. With the enrichment of the knowledge, the service agent can offer a better service quality in the market

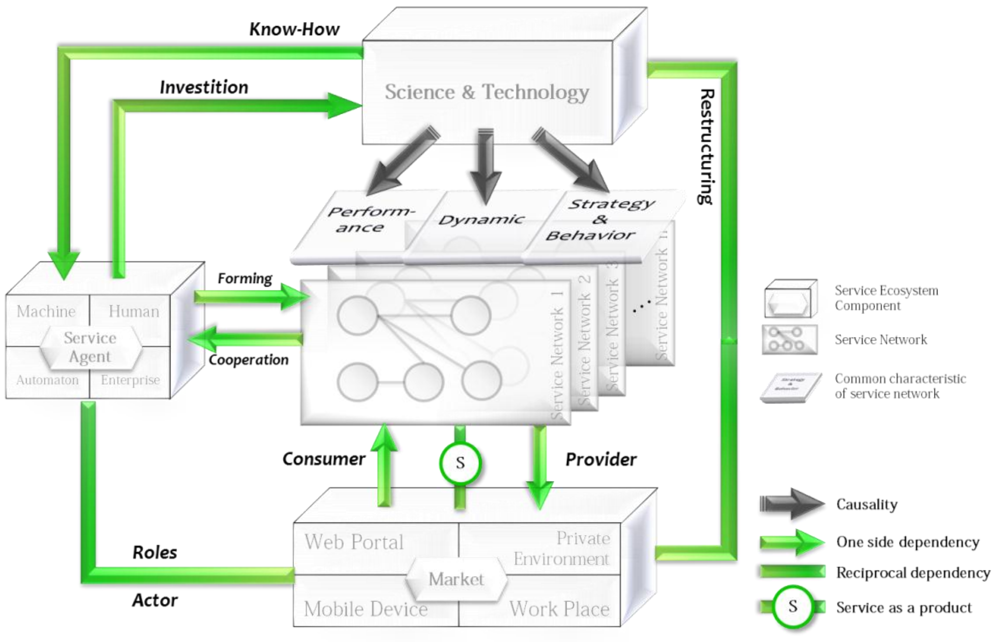

Figure 3.10: The lines illustrate the dependency between Service Ecosystem components

The market where the service is being offered and consumed in alignment with the advancement of the S&T breed new roles for service agents (Figure 3.11). We agree with the role proposed by Barros [3] because we see the consistency within the model. The *service hoster* is an example for an intermediary that catalogues special types of service offerings (e.g. IaaS and PaaS). Likewise, the *service gateway* is a certain intermediary that provides interoperability through cataloguing and interfacing with a choice of third Party B2B gateway. The *service aggregator* provides additional value by packaging and combining services. At the end of the line, the *service channel maker* is positioned at the consumer end of the service provisioning chain, where services are channeled into different place (private environment, workplace, web portal and mobile devices).

The core of the ecosystem is the interaction between the agents who formed numerous kind of service network, with a different kind of role. Because the basic motive of service agent is to be in the ecosystem, and the different kind of task needed to be done, lead to the interesting research question, about the strategy, dynamic and performance on a network. The way in which service providers and consumers are linked. It plays a critical role in realizing the economies of sharing [166].

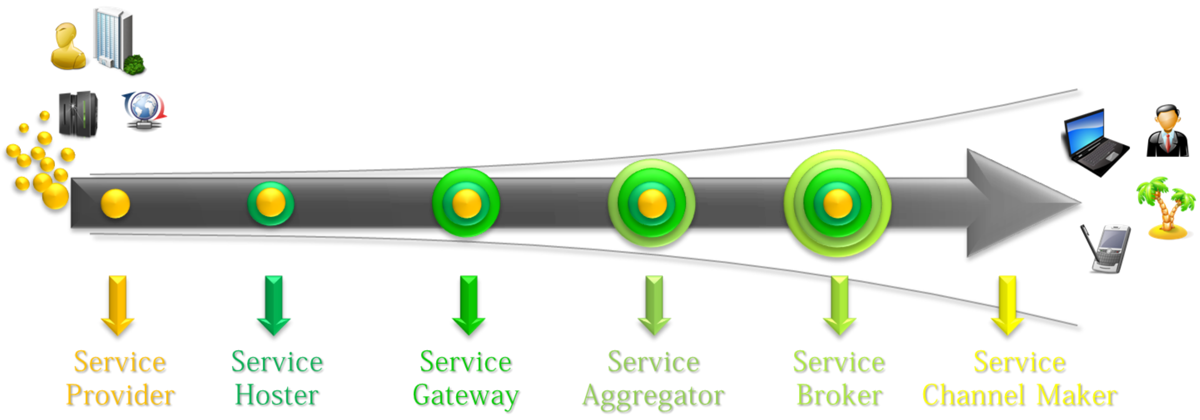

Figure 3.11: Six potential roles for service agents in the ecosystem to provide their service in the service marketplace [3]. The pipeline illustrates the service enrichment along the production and distribution chains.

To make a link is costly, because of the transaction cost [238]. The links must be spread out among the agents and characterize the efficient link patterns which optimize the trade-off. However, Kranton et.al has shown the evidence of no cooperatively pattern in the network formation [166]. This support also the theses from James F. Moore [145] about predator and prey strategy as a kind of motive to be competitive in a Business Ecosystem. Not only are the intrinsic motives of the service agent, the extrinsic aspects from S&T also catalyzing the process. Apart from that, the one who had the relevant knowledge from S&T can become the keystone in the ecosystem, "for most companies today, the only truly sustainable advantage comes from out-innovating the competition." [145]

The augmentation of S&T breeds not only a new species of service agent, but also originate another type of market channel hence may alter the market's structure. This occurrence is happening at internet economy. However, not only the disintermediation and reintermediation, but there are a several structural changing in ecosystem's market that is identified. We will address this issue further in the next section.

3.4 Artifact Mutability

One can categorize Service Ecosystem theory as an information system artifact, due to the IST coverage as the ecosystem platform. The special natures of this kind of artifact are the vigorous dynamic and high possibility of mutation. Gregor and Jones [101] recognize these aspects. That is what makes their design framework suitable to develop this kind of theory. We perceive the probability of the evolving artifact in the adaptation skill of Service Ecosystem actor. This skill is constantly determining the shape of the environment. We have talked that each component depended on each other to survive and in the same time their activity biasing other actor or may even breed a new species. The co-evolution of the component and its impact to the ecosystem will respectively present in Sections (3.4.1 and 3.4.2).

3.4.1 Coevolutionary Ecosystem

Ehrlich and Raven [61] introduced the term coevolution[37] and used it to describe the reciprocal evolution that results from the interaction of distinct species. Adaptive agents tend to alter their structures or behaviors as responses to interaction with other agents and the environment. These different species coexist in an ecosystem in which adaption by one type of entity alters the *fitness landscape* of another entity [227]. The metaphor of coevolution is used in several fields related to business ecology, namely coevolution behavior between:

- corporate [137, 145],
- business and IST [142, 155], and
- Business Processes [227].

Vidgen and Wang's work [227] on the evolution of BPM and Business/IT Relationship considers the previous works. They use the NKC[38] model from Kaufmann [107–109] to bring out the implications of coevolution for the theory and practice of BPM, business and IT. Their work is arguably the most comprehensive treatment of coevolution impact between business/IT alignments; however, the previous studies do not include a comprehensive examination of coevolution between service agents and the service product itself. Their observation are focusing on the collaboration behavior of services as the business process, thus we want to look further, how the symbiotic interaction between agents and the produced services are influencing each other (similar to the Red Queen Effect, it is a coopetition instead of competition [32, 120]). Thus, here we build on their work further.

[37] In the business ecological context, Mckelvey defining coevolution as "mutual causal change between a firm and competitors, or other elements of its niche, that may have adaptive significance" [137].

[38] NK model is a mathematical model of genetic interactions on a fitness landscape where there are N characteristics and each characteristic can take one of A states. Parameter K controls the degree of the affect grade of an activity to the fitness.

Variable	Evolutionary Biology	Business Process	SOA	Service Ecosystem
S	A species which is a population that can be treated as a homogeneous Entity	There are two species - Process Species and Software Species- i.e., S=2		Two families (Agent & Product). Agent has four species (Human, Machine, Enterprise, Automaton), and service species is the product, i.e., S=5
N	The number of genes in the evolving genotype	The number of process enacted within an organization	The number of software components (services) implemented	The number of services utilized as a compound of another service
K	The degree of internal connectedness among the genes	The degree of connectedness between processes within an organization	The degree of connectedness between software components (services) in an organization's SOA	The degree of connectedness between services in a specific Service
A	The number of alleles (alternatives states) that a gene may take	The number of possible states that a process can take	The number of possible states that a software components (service) can take	The number of possible role that a service agent can take. {Provider, Hoster, Gateway, Aggregator, Broker, Channel Maker}, i.e. Max=6
C	The coupledness of the genotype with other genotype	The coupledness of process types and service types within an organization		C_k := The Sum of coupledness of $Service_k$ C_{k_i} := The coupledness of $Service_k$ through $Agent_i$
W	Coupling to a gene in the external world that causes disturbance in one direction only	External constraints such as regulatory bodies that can restrict the way that a business process is conducted or a service executed		

Table 3.2: The NKC model applied to an organization's business processes, service oriented architecture, and Service Ecosystem. We complement the table from Vidgen & Wang [227] that adapted McKelvey [137] and [135]

Similar to the previous work, we use NKC model to identify the variable on the coevolution process, and examining the impact qualitatively. The formalisms of the co-evolution model can be used for a further research to analyze a new type of service species (service innovation) through agent-based modeling. A simulation based on this model can be done for advance identifying the coevolution impact; however, due to the scope of this study, it is deprecated. We examine the large impact of coevolution in macro environment, and emphasize the *W* Parameter of the NKC Model in the Service Ecosystem coevolution process. From the coupling of ecosystem's component, we propose the *double loop adaption model* during (co)-evolution process (Figure 3.12).

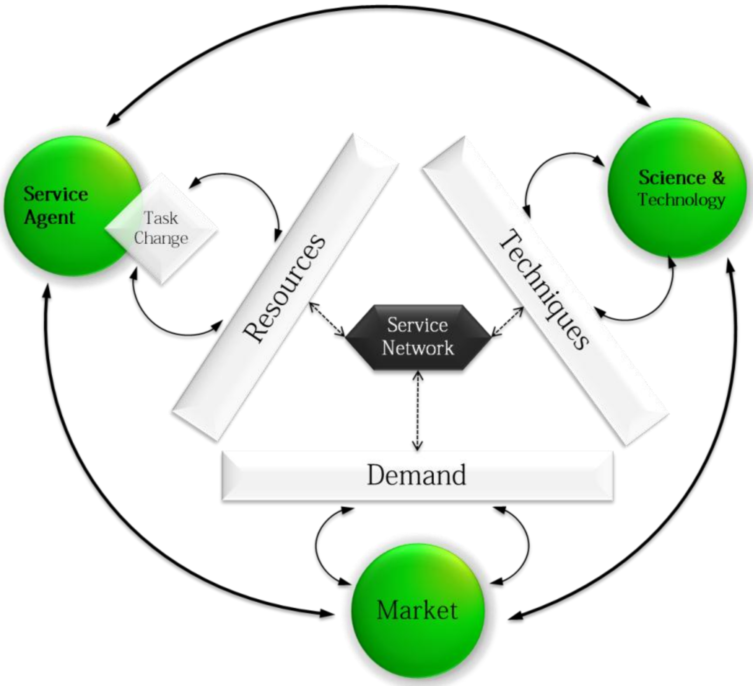

Figure 3.12: Double Loop adaption model during coevolution process in Service Ecosystem. The Inner loop illustrates the endogenous shifting and the outer loop depicts the exogenous shifting)

Adaptation is the evolutionary process whereby an organism becomes better able to live in its habitats [56]. It occurs through the gradual modification of existing structure. The environmental changes are forcing Service Ecosystem organism to adapt. There are two types of this shifting, viz., *endogenous* and *exogenous*. Endogenous shifting is proceeding from within a self, in contrary to exogenous shifting that occurs because of the extern factors[39].

Apart from that, in Service Ecosystem only the active shareholder has the endogenic factor rotating the inner shifting. Service agent is the species that able to alter their environment by changing the reason, why they exist in the ecosystem, i.e., to take care a certain task. The task

[39] The extern factor is already mentioned in the previous Chapter (cf. Section 3.3.3), as we discussed the dependency and causality between service ecosystem components, i.e., the development of IST, the possibilities to form a network, service agent, and the different kind of market place.

can change, whether it because of diversification or the higher task quality requirements. The ability to solve a task and the existed network formation needs to adapt to the new challenge. A Service is an intense connection between customers. It has a unique trait, lots of variations and frequent change. The keys design service task is positive consumer experienced, consumption oriented and market facing innovation. Unable to adapt to this change, can lead to extinction (service agent and related service network). On the other hand, if they enable to adapt to the alteration, they will gain a new resource, better capability, and more knowledge, to solve the challenging task.

The process of service agent's adaption (i.e., task changing and new resources gaining) impairs the adjacent component (S&T and Market). This impact and involvement at the same moment become the exogenous shifting cause to the other. The more challenging task or the more variation task demands the S&T research to overcome the demand. Technology is the making, usage, and knowledge of tools, machines, techniques, crafts, systems or methods of organization in order to solve a problem or perform a specific task. A research and development in this field will produce a new technique, which is per se always incrementally improved. On the other hand, this technique is also facilitating a modern way to cooperate or competing between service agents. It is not only contributes to technology field, but also in management, organization, and social environment. A new technique embraces a way of collaborative and level of openness in the ecosystem.

The S&T and service agent's behavior emerges a demand growth and variation in a service's market. It is a place where supply meets demand[40]. There is a correlation between demand and interaction structure, if the demand of market changed, then agent's interaction is changed following the alteration of exchange mechanism. We show this in the following arguments. On the one hand, the evolution of the other organism (service agents and S&T) can be observed separately, but on the other hand, it also shows us that they are inextricably interwoven and mutually shaping, thus the passive stakeholder, i.e., the market. By the adaptation of the other two component, they can now indirectly create a new art of market (Physical and digitally consumption market). This alters the exchange chain of service production (e.g. offering a service, describing a service, matchmaking, consuming a service, provisioning a service, etc.). The different *resource* breeds a new ability hence creating an innovative service product. The improved *technique* overcomes the diverse service exchange chain. Thus, these loops of the adaption cycle develop matched set of adaption in the whole Service Ecosystem, which also affect and reshape gradually the ecosystem. We will discuss the impact of this in the succeeding section.

[40] Supply is the cumulative amount of specific service being offered on the market. Demand is the cumulative quantity of specific service currently require by a service consumer. Similar to another market place, service market place also has the economic characteristic and concerning all the service spectrum supply and demand.

3.4.2 Impact of Reorganizing Ecosystem to Information and Service Economy

Modernization has always caused the changing or disappearance of a certain ecosystem's players. We can see the change in the role transformation within each economy phase, as the economy transitioned from agriculture to manufacturing and then to other industries, farmers became steelworkers, and afterwards sales clerks and middle managers. Now in the last two decades, the industries' sector started breeding a new ecosystem that is servitization of business (cf. Section 1.1), so do the role of the players and condition also changed. These shifts have carried many economic benefits. Generally, with each progression, even unskilled workers received better wages and greater chances at upward mobility. However, something more fundamental has changed as long with the progression. Today's new jobs disproportionately concentrate in the service occupations[41] (e.g. at restaurants or call centers, or as hospital attendants or temporary workers). This makes information and service to play the central role in modern economy.

Let us look at *cloud computing* as an example of (web)-Service Ecosystem to analyze such an occurrence. As the cloud platforms become ubiquitous, the relationship between cloud provider and consumer are intensifying. This inter-networking of the cloud players needs a global market for trading the online services. There are several components need to be addressed in order to realize such marketplace [165]:

- *Market-maker* for bringing service providers and consumers
- *Market registry* for publishing and discovering Cloud service providers and their services
- *Clearing house* and *brokers* for mapping service requests to providers who can meet Quality of Service (QoS) expectations
- *Payment management* and *accounting infrastructure* for trading services
- The *open platforms* that need to address regulatory and *legal issues*, which go beyond technical issues (see Section 3.5).

Currently, we are still in a phase of groundwork[42] with a few pioneers' offering services, who can be regarded as a cloud player. Meanwhile, many large high-tech companies are building data centers loaded with hundreds of thousands servers to be made available for customer requests. Amazon initiated their own ecosystem, providing access to half a million developers by way of Amazon Web Services (initially developed for internal purposes). Google is also investing huge funds in data centers. Google provides word processing and spreadsheet applications online, while software and data are stored on the servers. Google App engine

[41] In Germany, there are a 9.7 % increase of service sector occupation from 1999 to 2010 while the industry sector and agricultural plummets for about 19.1 % and 18.2 %, respectively [96]

[42] It is in the *birth* phases of ecosystem evolutionary stage (Moore [145]). A birth stage is characterized by defining a new value proposition around a seed innovation.

allows software developers to write applications that can be run free on Google's servers. Microsoft has started later but with huge investments for the creation of new data centers. In the fall of 2008, the leading software company has introduced a cloud platform called Windows Azure.

There are dramatic shifting and dynamic in this ecosystem. As Amazon initiated their service, and gradually dominated the market, they set the proprietary protocol to access the service. Thus, it amplifies the lock-in [124] and strengthens the network effect [106] to their cloud service. Other big technology enterprises (e.g. SAP AG, Software AG, 3M, CA Technologies, IBM, Red Hat, Cisco, Citrix, EMC, etc.) cooperate to propose a technology standard under the respected standard body OASIS[43]. Moreover, three keystone enterprises above (Amazon, Microsoft, and Google) do not join the group. Although this initiated group consists of big companies, they still do not have a market in the cloud, and try to shift the cloud dominance structure into more open, before the keystone company progressively expanded the market.

From keystone perspectives, this also means a co-opetition strategy [32, 120] (cooperation and competition). For example, Microsoft will enrich their cloud service's portfolio to their Azure product with technology that let users run Linux application on Azure. The two companies are a competitor in operating-system business, yet Microsoft will adapt Linux on its product. The cooperation strategy is needed to be able compete with Amazon, that also provide a multiple operating system platform. The ecosystem is reorganizing itself. It depends on which drive force is bigger (between the keystone and community) will direct the ecosystem, whether to openness or closeness system.

[43] http://www.oasis-open.org/

3.5 The Need of Dialectal Mean in Ecosystem

We believe that Service Ecosystems need a dialectal mean to maintain its sustainability. Dialectal mean is an instrument to support the dialogue between two or more organisms holding different intentions, who wish to come to an understanding. A dialectal mean is a fortiori important in the wider domain of Service Ecosystem, because of the broader of service spectrum and the actor heterogeneity. The need for the dialectal mean becomes apparent when one considers the uptake of symbiotic interaction in service networks as explained above. If a service network's participant plays a specific role in the aggregating and brokering a service, then in this case they act as intermediaries between other participants on the network (cf. Section 3.3.2). Such a new specialized role needs to disclose and exchange, as well as comprehend business information about services (across different branches) in a common way. A standardized and machine-understandable dialectal mean[44] will facilitate the interoperability for them on the business level. In order to improve the performance and face the existing and future service variability, Service Ecosystem will need to open up their service interface and distribution networks. Additionally, one important factor is to keep the transaction cost a low as possible in order to take the full benefit of the digital good (i.e. almost zero distributions' cost). Thus, a standard as a dialectal mean between service agents in the marketplaces can help to achieve this purpose.

Standards are expected to determine the professionalization and industrialization of the service sector (and servitization of business), to increase the transparency, and to lead to more valuable services, hence, to contribute to the overall development on the service economy [54]. Here comes the part of *influencer stakeholder* in Service Ecosystem. Before becoming a public standard (i.e., from standardization agency or government), a bottom-up approach normally happened whether from academic field or from a certain community. The slowness of public standard makes a competitive and innovative enterprise to set up own standard to competing with rival proprietary design. A pre-standardization may have a big effect for adopting certain standard [213]. Another view is to adopt a *market-led* approach. In the recent decade, Peter Swann [204, 205] studied the benefit of standardization from economy perspective. He convinces that standardization can enable innovation and act as a barrier to undesirable outcomes and companies can benefit from it. Standardization does constrain activities but also creates an important infrastructure for subsequent innovation. Moreover, the companies that participate actively in standards work have a head start on their competitors in adapting to market demands and new technologies, and may enjoy reduced research risks and development costs. On the contrary, a common dialectal mean may actually reduce profitability, in the same time the customer benefits from the increased competition between

[44] Service agents around a core technology platform, i.e., "organisms of the digital world", encompass any useful digital representation expressed by languages (formal or natural) that can be interpreted and processed (by computer software and/or human), e.g. software applications, web services, knowledge, taxonomies, folksonomies, ontologies, description of skills, reputation and trust relationships, training modules, contractual frameworks, laws. [150]

companies. Moreover, this dynamic keeps the ecosystem "healthy" because it is the requirement for a self-organization order in ecosystem [107].

Researchers characterized particularly the economic examination of standardization decisions in an ecosystem by the existence of so-called network effects or demand-side economies of scale [30]. Network effects occur when the benefit or surplus, that an agent' derives from a good, depend on the number of other agent's consuming the same kind of good. Based on work from Domschke and Wagner [58], Buxmann and Schade [184] are proposing two different kinds of the models: centralized[45] and decentralized[46] (cf. [232]) standardization problem (i.e. minimizing standardization cost and transaction cost).

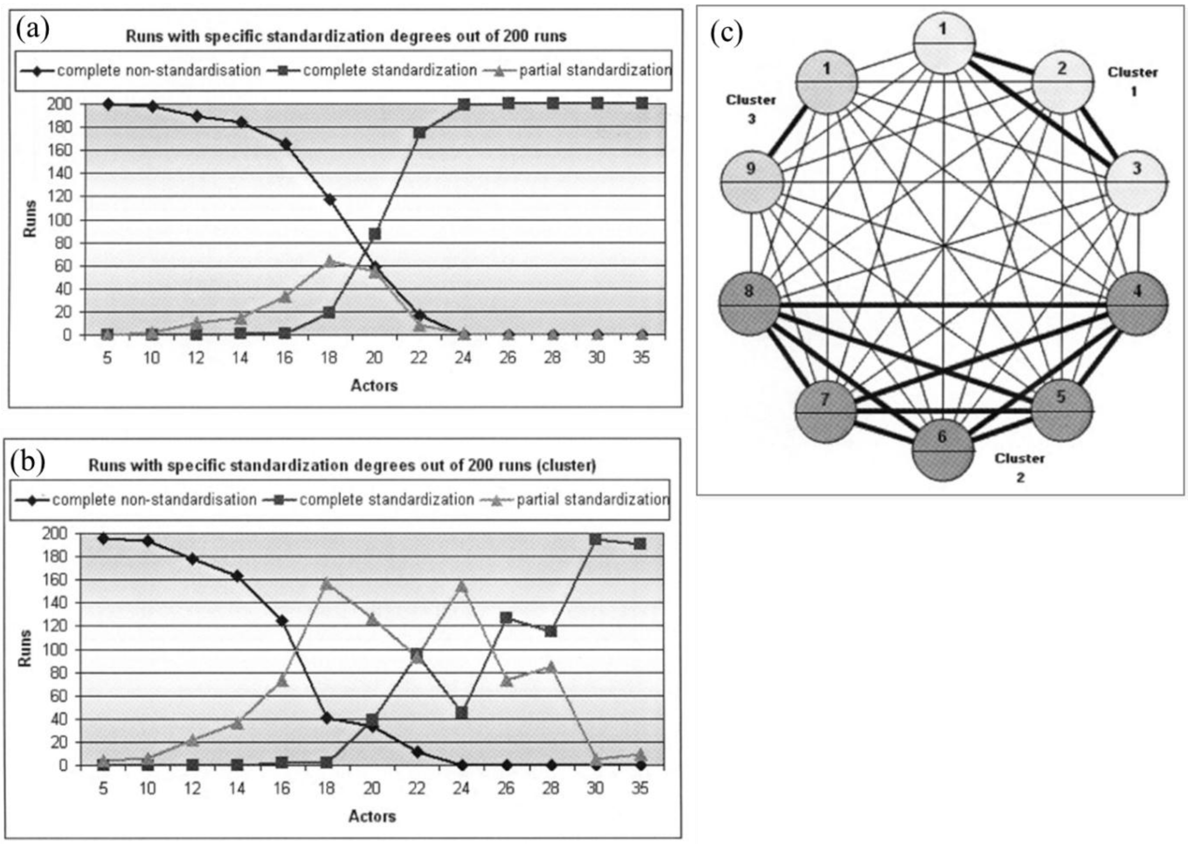

Figure 3.13: (a) The chart shows standardization Degrees of 2-Standard-Problems. (b) The result of clustered agents' simulation. (c) Network clustering. [184].

The main finding in their simulations is that the optimal standardization degree is positive correlated with the number of actors. This statement was confirmed on every tested number of available standards. Figure 3.13 above depicts the finding exemplarily for problems with two

[45] The centralized standardization problem "implies the existence of a superior entity, e.g. the CIO of a firm or a parent company credited with the aggregated results of standardization. This superior entity evaluates the entire network and makes network wide standardization decisions." [184]

[46] The decentralized standardization problem denotes "situations where autonomous actors make standardization decisions by optimizing their individual objectives and are credited individually with the results of their decisions." [184]

standards without (a) and with clusters[47] (b). Whether there is a cluster in the network or not, the more the actors there are, the more a standard will be adopted. In our case, Service Ecosystem has a large range of stakeholder, and different kind of active service agents. Moreover, a service agent needs an intensive communication with their consumer, and cooperating with other service agents. Therefore, one needs a dialectal mean in a Service Ecosystem. The unified language as tools for exchange and communication of service, become important the more actors interacting in the ecosystem. On the one hand, this kind of language can minimalize the cost because of the asymmetric information, however, on the other hand; the accruing adaptation cost wills linear correlated reach the Break-Even-Point (BEP) due to the scale of network effect. However, the bigger the network is, the more heterogeneous thus the stricter is the requirements of such language. The actors need to communicate, reveal and exchange, as well as comprehend business information about services and its processes (e.g., pricing, SLA, delivery channel, legal issues, participant, interaction, technical interface, etc.). Precisely, these issues are concerned by Unified Service Description Language (USDL), which is the dialectal mean in a Service Ecosystem, viz., IoS. We will present it in Chapter 4 and subsequently in Chapter 5, we will show its potential in concrete scenarios.

[47] Network members who have more intensive communication relations to each other are considered as a cluster, e.g. a company and vendor in supply chain first grade (vertically) will communicate more intensively than with those of other branch company.

3.6 Summary

The proposed model presented in this Chapter has focused on the structural component of Service Ecosystem, but some consideration can also be given to how the densities of service interactions among all stakeholders are observed. The theory is still in earlier stages of development, thus it aims to give a framework to identifying the instantiation of the Internet of Services and USDL within certain scenarios. Epistemological concerns and formalisms concern regarding the building and testing of Service Ecosystem were not the focus of our model. However, a number of relevant points can be deduced from our proposals in this model.

The first is the essence of a Service Ecosystem. Why networks between actors need to be analyzed from a higher abstraction level rather than from the viewpoint of individual organizations? It is because of the Service Ecosystem's global impact to the economy that can lead to emerge of new technique, technology, resource and species (agents and market), thus a service's innovation. In contrast to the narrow individual's perspective, the see such ecosystem merely to develop a corporate strategy, we rather see it as a holistic model, that coupled each other.

Second, Service Ecosystem's scope is the set of positive sum relationships (symbiosis) between actors who work together around a core technology platform. Irrespective of an organization's discrete strength, Service Ecosystem actors interacts with each other and share the success or failure on the network as a whole. However, drawing the precise clear boundaries of an ecosystem is impossible. More likely, the proposed model systematically identifies the main actors and the most closely intertwined pattern of dependencies that are likely critical to producing a service.

Third, the requisite for a dialectal mean in Service Ecosystem can be recognized. A dialectal mean is a fortiori essential in the wider domain of Service Ecosystem, because of the broader of service spectrum and the actor heterogeneity.

4 The Materialization of Service Ecosystem

In preceding Chapter, we already discussed the theory of Service Ecosystem. We have distinguished three different stakeholders, the higher and deterministic view of the construct, and the importance of dialectal mean for the heterogeneous players. The artifact of Service Ecosystem is materialized as Internet of Services (IoS) and the corresponding dialectal mean is the Unified Service Description Language (USDL). Thus, we will present the each aspect in following sections further.

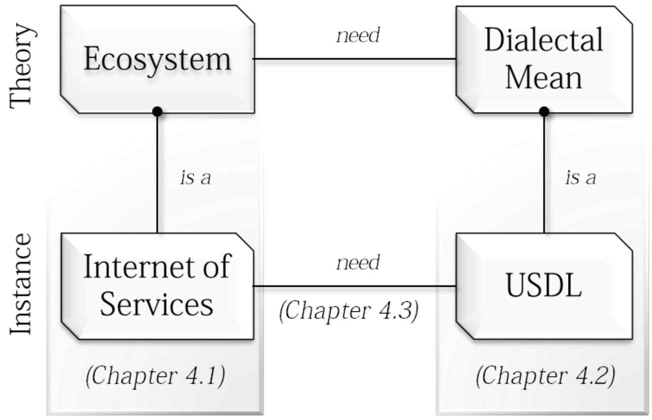

Figure 4.1: Service Ecosystem Instantiation

4.1 Internet of Services as an Instantiation of Service Ecosystem

The growth in service sector and in the meantime the fast development of internet technology catalyzed the transition toward the "new economy" [29, 57, 62, 102, 111]. It is in continuous change, which is driven by the increasing importance of knowledge, innovation, information and communication technologies, and globalization. The main actor of such economy is one with something offered to other, i.e. company. On the one hand, the internet technology is intensifying the forming of company network or business web. The linked company and its information exchange enabling the market efficiency, i.e., ideal market where the agents have complete and recent information to decide. On the other hand, internet also gives more possibilities both for keystone and niche player. The web of data has lot of potential for service's innovation. SME can form a strategic alliance and marketing their value-added services on the internet. For example, is Seekda[48], whose hoteliers can combine their service with partner and vice versa.

[48] http://www.seekda.com/

These trends create many various service networks in the internet. In the current state, although internet has such extent in the business operation, the business network seems rigid and merely is an unconnected island solution. We need a common infrastructure and organized development in IoS technologies to support the emergence of new service economy. The five-year largest publicly funded IST research program in Germany called THESEUS refers this problem. This is consistent with our proposed stakeholder categories of Service Ecosystem (cf. Section 3.2.2) viz., active, passive, and influencer. Numerous research partners are from government, academic institute, research community and industry. They are the influence stakeholder of the IoS, shaping the ecosystem by inventing new techniques and resources (cf. Section 3.4.2). The active stakeholder utilizes the result of research, i.e., IoS, currently in the industry, public service, culture and medical domain.

Service Ecosystem has many facets, due to the heterogeneity of the player intentions and the broad of a service spectrum. As we already see the higher view of IoS, thus we will analyze it construct and component as an instantiation of Service Ecosystem in Table 4.1. We also give the comparison to another instance of Service Ecosystem, i.e., the neoclassical microeconomic of a labor model. We choose this model because it is a mature Service Ecosystem, and have a different aspect than IoS.

With respect to both instances of Service Ecosystem, there is an interesting example that firstly, showing that both are not fully isolated, and secondly, the mutability of the ecosystem. Amazon Mechanical Turk (Artificial Artificial-Intelligence)[49] is a marketplace for work in the *cloud*. A Worker can offer their competence and service in the internet, and select what tasks and work whenever it is convenient to them. In the other side, the business and industry have the possibility to an on-demand, and scalable workforce through internet. Following this further, even though a labor model is already in mature stage of evolution, and IoS still in the initial stage, they still can evolve, and generating a new way of possible ecosystem, for example, is an open education Service Ecosystem that we present in the Section 5.3.2.3. There we use the Service Ecosystem theory to analyze it thoroughly.

[49] https://www.mturk.com/

Characteristics	Service Ecosystem Type	
	Internet of Service	**Labor model** (Neoclassical Microeconomic)
Stage of Evolution	Birth	Self-Renewal
Component		
▪ Service Agents		
▪ Human	People as niche player	People as dispositive factor
▪ Enterprise	SMEs	-
▪ Machine	Enterprise-SOA	-
▪ Automaton	BPM	-
▪ Science and Technology	▪ SOA ▪ Semantic Web ▪ Service Science	General Education
▪ Market	▪ Web Platform ▪ Mobile devices ▪ Private environment ▪ Work place	Business Environment
Symbiotic interaction (Producer Perspective)		
▪ Produce	In first place is *Online Delivery*. It can be as facilitator of *Offline Delivery*	*Offline Delivery* of service.
▪ Aggregate	Orchestration and Choreography	Orchestration by utilizing service provided from another labor.
▪ Broker	Provisioning and Intermediary	Provisioning and Intermediary
Service Consumer	Service agents	Company
Service Spectrum	Technical and Manual Service	Manual Service

Table 4.1: Comparison between IoS and labor model as instances of Service Ecosystem

4.2 The Unified Service Description Language

We argued that service Ecosystem requires a dialectal mean. Equivalently, so does the Internet of Services need unified language, i.e., Unified Service Description Language (USDL) [13]. Before we talked about the role of USDL as dialectal mean of IoS in Section 4.3, we need to learn about the USDL in the first place. USDL is a proposed standard (in scope of Theseus Texo research program [152] that creates a commercial envelope around a service.

We learned that a service has a wide spectrum, not merely a technical service and manual service but also a hybrid service or IT-enabled services. In a technical domain there is already several collection of web-service-related standard established under common institution e.g. W3C[50], OGF[51], OASIS[52], SNIA[53], etc. However, none of the existing approaches responds to the requirements of having a comprehensive service description in an IoS setting [65, 167]. Mostly, the efforts provided means merely for formally describing IT services, and not the business context and the commercial conditions under one can consume the service. As many services (cf. Section 3.2.3) have a hybrid character with, digital-technical and physical-manual mark, a unified language can facilitate the combination and aggregation of such services. USDL is one of the foundational technologies to set up such an Internet of Services around today's core enterprise systems [152]

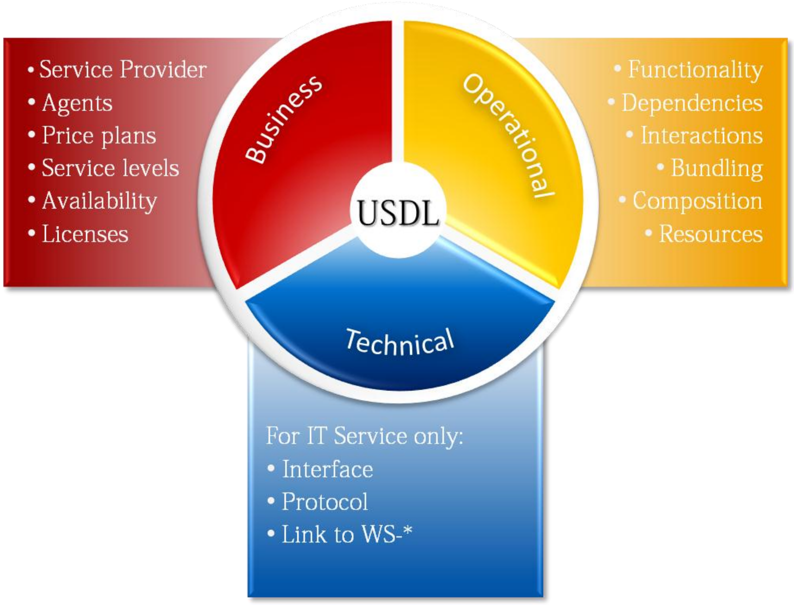

Figure 4.2: USDL unifies business, operational, and technical master data of a services [13]

[50] http://www.w3.org/

[51] http://www.gridforum.org/

[52] http://www.oasis-open.org/

[53] http://www.snia.org/

The USDL is proposed as a normative and comprehensive master data model. Figure 4.2 above depicts the holistic view of USDL that allows a unified description of business, operational and technical aspects of services. Business aspects are the central focus of USDL as an approach to describe the service, e.g. service ownership and provisioning, release stages in a service network, composition and bundling, pricing and legal aspects among others in addition to technical aspects [152]. Such encompassing service description need also the operative aspects of the service, thus it can bundle the service within the portfolio. Apart from that, the considerations of technical aspects make USDL machine-processable thus make it easily discoverable in the ecosystem. Moreover, the business aspects let the service as well as its functional and non-functional attributes better specified. It allows the service to have unique selling proposition (USP), and distinguish it with another similar service in the ecosystem. The next generation of USDL enhances the purpose of USDL as dialectal mean in IoS further, i.e. linked USDL[54]. Linked USDL uses the semantic technology such as RDF(s) and ontology, thus it is not only human but also machine understandable.

4.2.1 Design Overview of USDL

The meta-model of USDL comprises of nine different UML class model (packages) [69]. Each package represents one USDL "module" and contains one class model. The resulting split in modules follows from business commercial aspects such as pricing and legal constraints, how is the service's delivery and service level agreements, which partners have responsibility for the service and details about service functionality [153]. The nine modules are shown in Figure 4.3 and will be briefly explained in the following. It is beyond the scope of the study to describe every class diagram. Instead, detailed specifications of each module are available at [11], and we will point the main aspects of each module.

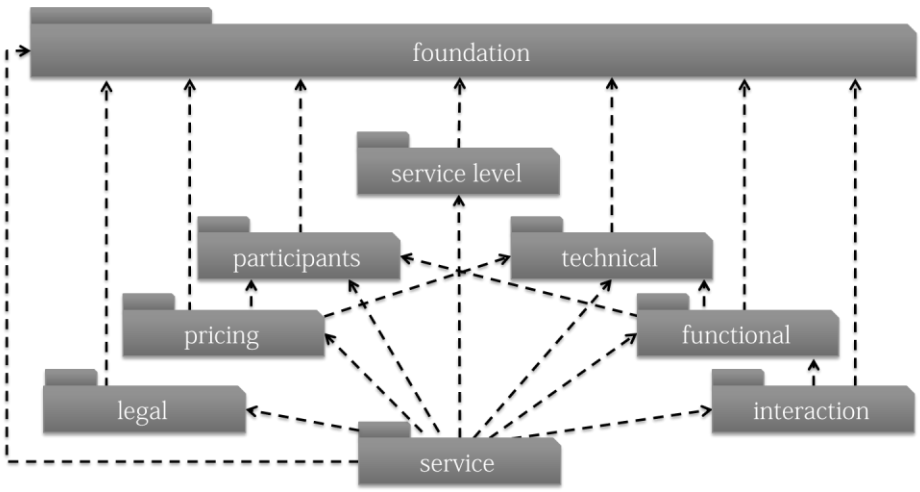

Figure 4.3: UML package diagram of USDL (the arrows represents dependencies between packages) [153]

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

The Service Module [4] is the essential module that structures the service, i.e. the building blocks of a service, because of the complexity entailed. It related to the resources/services supporting a service's delivery, and composition, concerning the different parts put together for a service's functionality. These involve multiple, recursive use of services of diverse types in and across different levels of abstraction, (a service can consume another service). This module is able to handle the customized service and diverse kind (e.g. Service variant, bundling, composite). This module considers the option to add the USP of service.

The Participants Module [8] captures the organizational actors who are important for the forming the service network with a certain role e.g. provisioning, delivery and consumption of a service. The network that formed within a service is depicted in this module. USDL exposes sufficient details of the actors behind a service, hence the symbiotic interaction between service agents is considered by USDL.

The Functional Module [6] allows the capture of service functionality at an abstract level, regardless of the proximity of the service spectrum (on the human-to-automation continuum), and free from technical implementation details. USDL gives an account to different perspectives by capturing the service functionality to three different layers respectively to three different kind of active stakeholder (cf. Section 3.2.2) in Service Ecosystem: white-box, grey-box, and black box. White-box layer contains detail functions for service producer, grey-box is for intermediaries that contain third-party delivery functionality and black box is for service consumer that focused on the interaction.

The Interaction Module [7] captures the behavioral aspect of services, complementing the Functional and Technical modules with their structural focus. The symbiotic interaction of ecosystem it dependency and causality are depicted in this module. USDL enriched the description with semantic setting.

The Technical Module [10] supports a common way of describing the technical interfaces (access mechanism) of services. With this module, USDL also considers the development one of Service Ecosystem component (i.e., S&T). A common SOA standard, e.g., WSDL, REST, SOAP, etc., can also describe in USDL. The modularity of USDL considers significant styles used in practice, with extensibility for the possibility of further support of styles that emerge. Following Semantic Web Services, the Technical Module serves to associate semantically technical interface descriptions with elements of USDL.

The Pricing module [9] concerns the charging of services as mutually understood by those who own or deliver services and those who consume them. Pricing as key issue in market dynamic is given attention by USDL. Apart from that the segmentation of pricing [151], i.e., the rules governing when and how different consumers are charged different prices are assessed in USDL.

The Service Level Module [4] is kept generic and does not specify how concrete service levels on concrete aspects should be specified. Instead, its main purpose is two-fold. First, it provides the glue between abstractly specified service level issues in other USDL concepts. For example, it specifies to which elements of a Function a certain service level shall apply and the related Role. Second, it allows for incorporation of arbitrary attribute and expression languages.

The Legal Module [25] addresses the need for legal certainty and compliance in service networks and in trading services on marketplaces. Participants need to know about the terms of usage of a particular service, for example, liability, privacy or copyright. However, this information is rarely provided in a machine-processable manner but rather as informal text. Therefore, the Legal Module covers the modeling of licensing aspects according to two different Service Ecosystems with different jurisdictions (e.g. Germany and USA).

The Foundation module [5] factorizes common parts of the remaining modules as a consistent continuation of modularization. Because of its basic character, all other modules depend on the Foundation module meaning, they reference one or more of its elements (e.g., general classes such as Artifact, Description, or Natural Person).

4.2.2 USDL Tools

USDL is considered as an instrument for facilitating service exchange in IoS. However, in order to be of practical value to users, a set of enabling tools for USDL is required. In essence, there are three basic types of enabling USDL tools [186], viz., *USDL editors*, for expert and casual users, *USDL repositories* to allow editors accessing and storing USDL description, and *USDL marketplace*, where allows providers to describe their services once and potentially trade them anywhere.

The *editor* is for creation and modification of USDL descriptions. It is the most basic tools. Currently, there are two editors [182] (for expert and causal users). Both editors address a typical problem when tool support is provided for a basic meta-model. On the one hand, the complexity and expressive power of the modeling language need to be supported in the editors, while, on the other hand, the user's mental models for the editor usage need to be as simple and straightforward as possible.

For the storage of the created USDL descriptions, a set of USDL *repositories* is needed. The repositories, once deployed to many sites, allow the interchange of USDL descriptions that have been described once for the deployment into multiple repository sites. Creating descriptions with USDL editors and storing the descriptions in USDL repositories happens in the offering phase. A service provider would have to capture a description of its service in USDL and store it in a local or third party repository. A *marketplace* is required to enable the trading of services in the matchmaking phase.

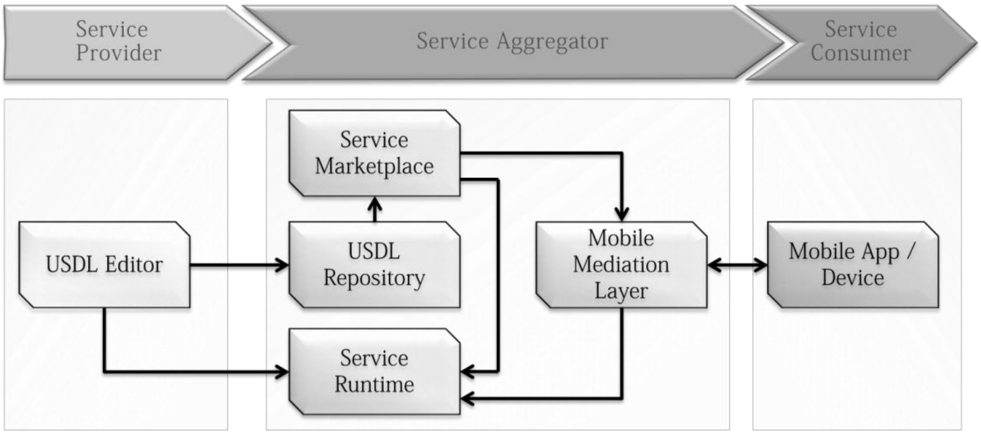

Figure 4.4: Integrative productive tools chain of USDL in IoS [181]

The service *marketplace* is capable of extracting different aspects of a USDL service description and present them tailored for a specific role. The internet-based market platform should have the capability to parse the USDL description, thus render it in a human readable format, exposing, e.g., price fences in a tabular design. Moreover, it can also expose the given USDL description with a link for further programmatic access to the description. Therefore, with such tools, USDL can make IoS as an open Service Ecosystem.

The operation of such a service marketplace requires a governance approach that lies adjacent to the requirements of a SOA and the more general governance of IT. It also has requirements of its own, especially when it comes to the description of services with languages such as USDL. Figure 4.4 illustrates the typical pipeline flow from service offering to service consuming, with its related actors and tools in each phase. With respect to the capability, tools and service distribution phases in the background, we will propose some concept for applying USDL to diverse Service Ecosystem in Chapter 5.

4.3 USDL as Dialectal Mean in IoS

Let us take a look an online fashion Store Company that has a model represents their internet application, which allow a customer to search, browse, order, and buy clothes. This model is extendable and technically implemented according to the requirement of the particular stores. On the other hand, the other vendors (e.g. partner, supplier, competitors, etc.) in the ecosystem will probably develop their model independently, and this will end up with set of different interfaces (i.e., APIs) in the ecosystem. This would be a burden when the store requires automating the order process, because each supplier has a different technic protocol. An adapter for exchanging the EDI (Electronic Data Interchange) is required. This constraint would slow down the rate of adoption and lock stores on a single supplier because of the effort required to align with software again. It represents the dead end of the ecosystem. Therefore, a dialectal mean in Service Ecosystem is necessary. Without fast business alignment, the ecosystem will be stagnant, and there will be no evolution.

Another example, consider once again the Amazon Machine Trunk. The externalities on that platform tend to be proprietary. Just like another cloud based apps store, there is a lock-in effect within the platform, a worker (service provider) or a business (service consumer) must follow the protocol and the default standard. In contrast to that, IoS (ecosystem) is different from it; because IoS facilitate the organism to be able exist in another habitat (platform or system). If service agents do not have a sufficient resource to adapt to another market, then it will be extinct from the ecosystem.

Apart from that, the network effect rules also IoS. It is comprised into direct and indirect network effects. On the one hand, direct network effects result from realizing straight correlation between good and consumer (e.g. the users of an apps store benefit from the number of apps increases with the number of other developers, same like the service consumer of a service market platform have more benefit the more service provider adopting USDL as service description standard). On other hands, indirect network effects describe a positive reliance between the diffusion of a technology or a standard and the corresponding range of complementary products and services. USDL has the diffusion of broad range both business and technical aspects. It is an important determinant for the supply of compatible industry's sector and wide-ranging service spectrum. The indirect effect occurs in the service runtime platform where the service saves in different kind of repository thus having the same description schema.

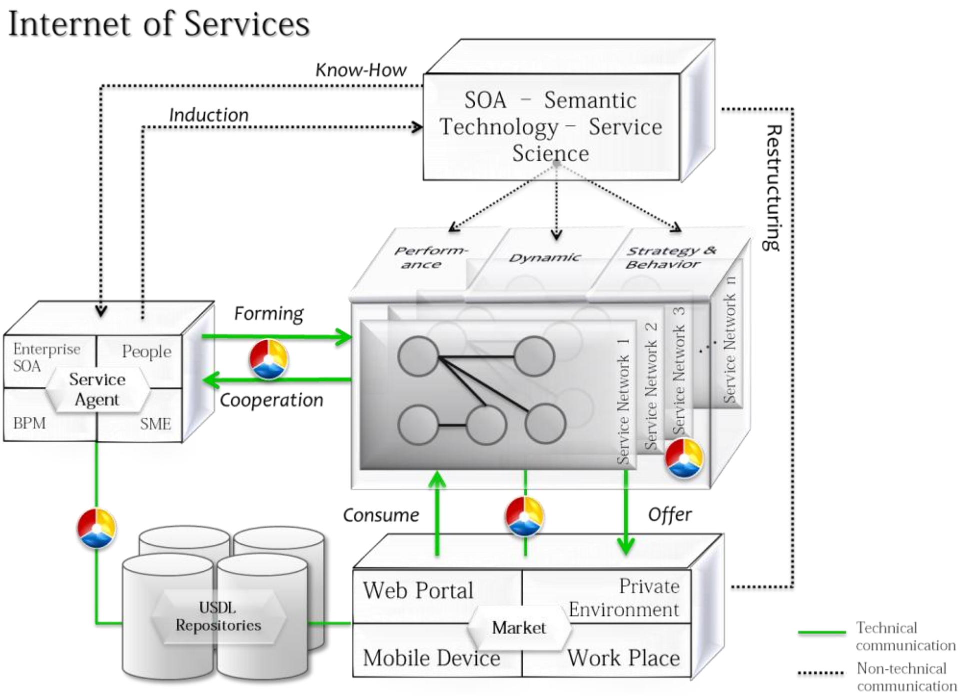

Figure 4.5: Internet of Services and USDL as an instantiation of Service Ecosystem

We have discussed that Service Ecosystem requires a way of describing services to wrap a service and expose it in a novel way. With respect to it, USDL is recommended as the normative and balanced unification of service information in IoS, which is required to capitalize further on the growth potential of the services industry. Figure 4.5 depicts the interplay of IoS and USDL as an instantiation of Service Ecosystem. The three-segmentation circle icon represents USDL. USDL is an important communication instrument between service agents and service networks. Moreover, the service offered in market and published in diverse repositories are also described in USDL to make sure the compatibility and reusability. Therefore, USDL is a proper dialectal mean for the sustainability of IoS.

4.4 Summary

The previous sections have shown about the instantiation of Service Ecosystem artifact and dialectal mean as IoS and USDL, respectively. The listing of Service Ecosystem components gives some guidelines to what might be observed in a real situation as Service Ecosystem. One could expect in an extensive, well-developed Service Ecosystem that not all components would be present in some form. For example, the labor model versus IoS, the reason is because the mutation and evolution capability of Service Ecosystem.

As of labor model need a place and common way to communicate their "commoditize," i.e. Service, so do IoS need a unified language that can be comprehended by human and machine. As many services have a hybrid character with, digital-technical and physical-manual mark, a unified language can facilitate the combination and aggregation of such services. USDL is considered as a suitable dialectal instrument for following reasons. Firstly, this ongoing standard language has the central focus on business aspects (e.g. service ownership and provisioning, composition, and bundling, pricing and legal aspects). Secondly, the considerations of technical aspects make USDL machine-processable thus make it easily discoverable in the ecosystem. Lastly, the next generation of USDL with the usage of semantic technology will serve the purpose of dialectal mean even better because of the machine-understandable capability.

5 Smart City Service Ecosystems

Internet technology is opening a gate for Service Ecosystem to evolve further, though IoS is still in its early stage. This has several consequences. On the one hand, there is a lack of well-developed use cases as references [185], while on the other hand a developing ecosystem needs more appliances in the real world. Therefore, we decided to develop possible cases where IoS and USDL can show their potential.

Apart from clarifying the Smart City scenario, our case studies are intended to evaluate the proposed theory and its instantiations. Although this qualitative analysis can hardly be seen as a validation in a rigorous sense [67, 83], we can use it to observe opportunity, detect problems, and reveal issues of the Service Ecosystem with limited effort. In this study, we decided to develop several concepts within the context of a “Smart City Vision.” Moreover, we choose Jakarta as a reference city to be explicitly used in our use cases. The notion of a smart city, and the Jakarta’s demographic background and potential will be presented in Section 5.1.

We delimit the scenario of the Smart City into two interesting vital domains, viz. transportation traffic and education, which will be discussed in Sections 5.2 and 5.3, respectively. Each of the use cases addresses the key challenges, new possible service concepts and opportunities. Subsequently, we summarize the Chapter with an analysis and preliminary conclusion regarding the implications of IoS and USDL (Section 5.3.4).

5.1 Jakarta Moves towards a Smart City

The alignment between IST and the daily social living environment introduces a new facet of the Service Ecosystem. This has been seen in recent decades, where many researchers, industry’s experts and leading technology corporations had visions about the next stage of urbanization, i.e. the Smart City [38, 82, 94]. However, based on the literature research, the term is not used in a holistic way to describe a general notion of *smart*, but more to refer to a sophisticated complex system with numerous aspects [60, 66, 189]. In their work, Giffinger et al. [77] used six parameters to measure the smartness of a city. The parameters they used are economy, people, governance, mobility, environment and living. On the other hand, Susanne and Mary [202] propose different components that are based on a smart city, viz. city services, citizens, business, transport, communication, water and energy (Figure 5.1). In other words, smart city is a notion of the common framework used to highlight the growing importance of IST, and social and environmental capital in an interconnected way. This concept stresses both the availability (quality) of IST infrastructure and the role of human capital (education) in urban development [40].

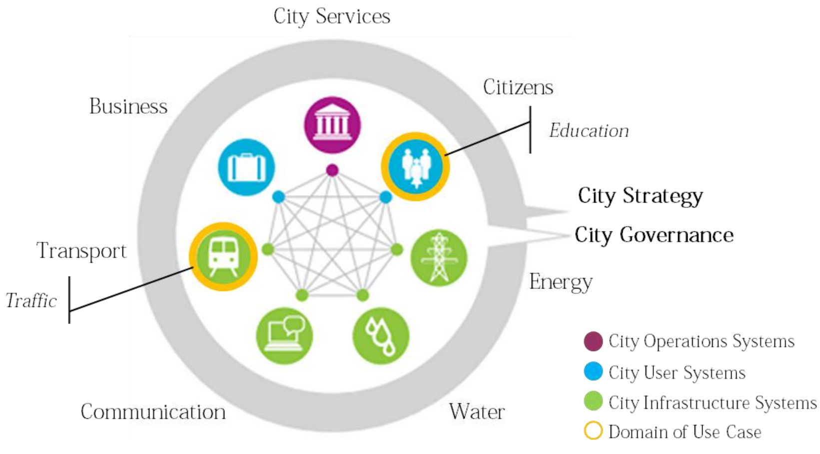

Figure 5.1: The interrelated core system of a smart city [202]. The domains with circles on the outside show where the use case of the Service Ecosystem is applied in the Smart City concept of [202].

In 2011, UK Trade and Investment conducted research analyses on the opportunities of smart cities in Asia and defined the principal challenges in moving toward a smart city concept [218]. They identified six key challenges in Asia. The first challenge is the increasing population. Expanding populations are causing social issues such as congestion and air pollution due to increased traffic. The second challenge is the growing economies; regional economies are growing faster than the rest of the world, which is driving increased energy consumption. The third challenge is the lack of social infrastructure, whereby the construction of infrastructure (e.g. power generation, hospitals and schools) is not keeping up with the demand. The fourth challenge is elevated congestion, whereby road and rail transportation is highly congested in large Asian cities, causing loss of time and money. The fifth challenge is budget constraints; the budget and GDP growth in developing counties are not sufficient to build the necessary infrastructure in time. Lastly, the sixth challenge is low broadband penetration. Apart from Japan, Singapore and South Korea, the level of broadband penetration is still low in most Asian countries.

However, these challenges also mean great opportunities for novel technology to both be adopted and show its full potential.

> “In Asia, there is a wide variation in the stage of development of Smart Cities both within and between countries… It is notable that both Japan, the most advanced Smart market, and Indonesia, which is firmly in the second group, are developing 4G LTE mobile networks. The difference … is that the former is a network upgrade whereas the latter is closer to a green field roll out the country effectively ‘skipping a cycle’ in its infrastructure development.“ [219]

This suggests that new technology (i.e., the IoS and USDL) will also find prospects in emerging markets such as Indonesia.

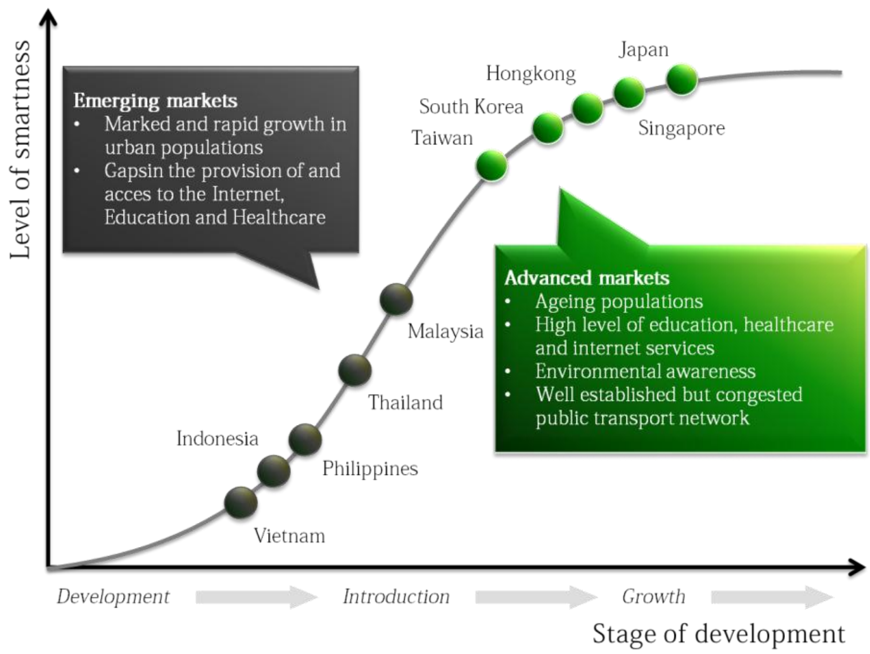

Figure 5.2: Stages of development of smart cities. The graph illustrates the current level of deployment of smart products and solutions in each city versus its overall stage of development in the move towards becoming a Smart City [219].

The IST market in Indonesia is "growing from year to year. In 2009, markets included hardware products valued at USD 979.9 Million, consulting USD 211.7 Million, and software USD 110.3 Million " [47]. Meanwhile, a fiber-optic backbone network has connected all major cities in Java and other main islands. Based on considerations for strategic positioning and the readiness of stakeholders in Indonesia, it is expected that the government will fully support the IST industries, such as the Device Manufacturing Industry, Ecosystem Development-based Services Industry, Content and Applications Industry, Ecosystem Research and Innovation [ibid.]. This will be a solid requirement in order to set the conditions to develop Jakarta as Indonesia's capital towards becoming a Smart City.

Jakarta[55] is a large-scale emerging metropolitan city. Based on the latest population statistics, "the total population residing in the Jakarta area is approximately 28 million inhabitants (2010) or more than 12 percent of the national population. Greater Jakarta is the largest urban area in Southeast Asia" [47], and fourth largest in the world (2011) [52]. About 9.6 million people live in Jakarta itself, in an area of 660 km². Its gross regional domestic product is 22% of the national GDP, showing that it is the most important region of the nation and a substantial magnet for urbanization [99]. This implies that not only urbanization of Jakarta but also its sub-urbanization has rapidly progressed; thus, the population has spread out in neighboring areas due to people seeking a better life quality or cheaper housing due to

[55] Jakarta as the center of politics, economy and social activities should be treated as a cluster rural area. It is commonly called the Greater Jakarta or the Jabodetabek area that covers the three provinces of. DKI Jakarta, Banten and West Java and seven local governments.

increasing land prices in Jakarta. The high density of population in Jakarta and the population movement toward suburban areas have generated longer travel times between residences and workplaces and have created a significant burden on the existing transport infrastructure and environment [19]. Moreover, this also affects the quality of education due to a wide-ranging social stratification class (e.g., blue collar-white collar, lower class-upper class, etc.). Although there are still many issues generated by such a mega city, we will present several smart solutions concerning two selected issues viz. transportation traffic and education, which apply USDL as an enabling technology towards a smart city Service Ecosystem.

5.2 Use Case: Smart Transportation Traffic

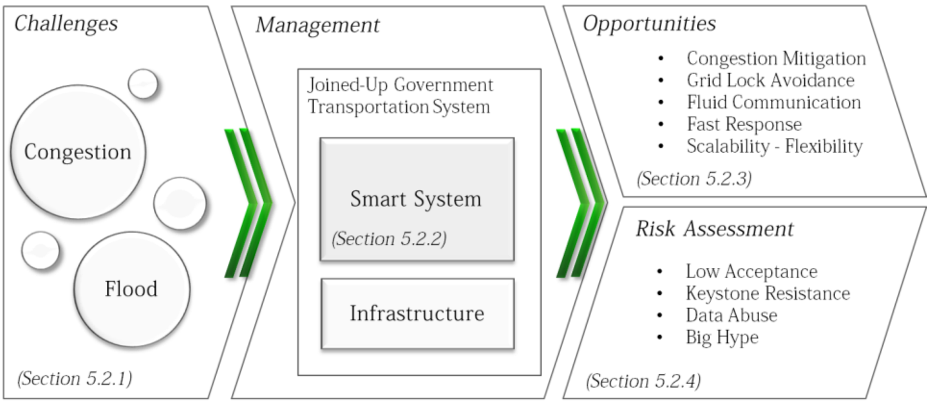

Figure 5.3: Challenges, opportunities and risks of a smart transportation concept

5.2.1 Key challenges

The management and operation of transport systems provide a vital stimulus to the economy of cities. Well-managed, accessible public transportation attracts workers into cities, brings commuters to and from work and moves goods from where they are produced to where they are consumed [203]. Congestion negatively impacts the quality of life in a city by decreasing personal and business productivity, lowering air quality and creating noise pollution [172]. This traffic congestion has been a severe problem in Jakarta for more than three decades and can often be seen in the central area of Jakarta and the radial highways every morning and afternoon, especially during rush hour. The increasing traffic demand has brought about traffic congestion resulting in longer travel times on roads. At present, the annual economic loss caused by traffic congestion in the region could be as much as IDR 3,000 billion (USD 333 million) for vehicle operating costs and IDR 2,500 billion (USD 277.5 million) for travel time. Should there be no developments undertaken during the period up to the year 2020, the accumulated economic loss would considerably upsurge to IDR 65,000 billion (USD 7.215 billion) (approximately 11 times higher) [99] (see Table 5.1).

	2004 (in Million USD)	**2020** (in Million USD)
Vehicle operating cost	333	3119
Longer travel times cost	277.5	4096
Total economic lost	**610.5**	**7215**

Table 5.1: Annual economic lost because of congestion in Jakarta from 2004 and 2020 with 12% discounted value. [99]

There are two key challenges that are the main issues resulting from overcrowded traffic: road capacity and flooding. The current road capacity in Jakarta is substantially below the capacity required to accommodate vehicle movement (see Figure 5.4). The growth of the number motor vehicles is much higher (i.e., 9.5 percent every year) than the growth of road capacity (i.e., 0.01 percent) and this could lead to a total gridlock in future years [163, 162]. While heavy traffic jams are serious, they are exacerbated by the floods, which hit Jakarta occasionally. The annual floods inundate many parts of Jakarta and paralyze the traffic and thus also the business activity [33]. In 2008, a flood event closed the airport toll road, cancelling over 1,000 flights and causing serious disruptions for the city. The incidences recurred in 2009 and continued into 2010, worsening the congestion and cutting off the public transportation network [24]. Apart from these two central issues, there are also other factors such as the fast population growth, preference private vehicles, saturated sections and intersections and inefficient fuel consumption, etc. [19]

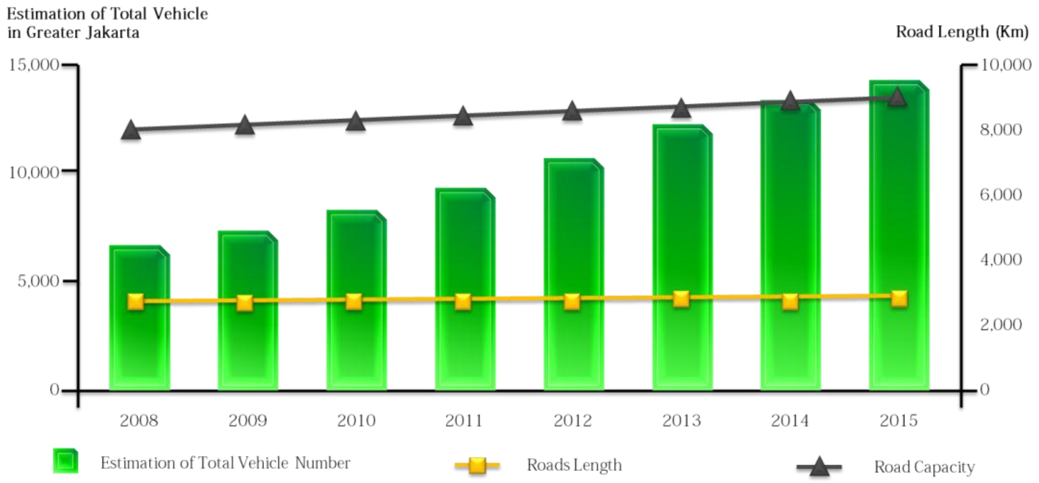

Figure 5.4: Comparison between estimated number of vehicles and highway capacity in Jakarta. [47]

In order to address these urgent issues, the governments of Jakarta have conducted several studies [19, 208] and have proposed a master plan to develop a better infrastructure [99]. However, the challenge here is that the high population density in Jakarta and thus the rarity of free land makes it more difficult to build new roads or other public transport infrastructures. Furthermore, there are few approaches to handle the problems from other perspectives, i.e., the information system. Although there is already an interconnected nationwide traffic closed circuit television (CCTV) and central IT System (National Traffic Management Center[56]), the multi organization coordination, communication and collected data are still not optimally used. For these reasons, we propose the introduction of USDL as an enabling technology of a crowd sourcing traffic Service Ecosystem, and propose possible actions that can be taken by merely utilizing the existing infrastructure, system and data.

[56] http://lantas.polri.go.id

5.2.2 Smart Transportation Concepts

A smart transportation is one that uses technology to transform its core systems and optimize the return from largely finite resources. By using resources in a smarter way, it will also boost innovation, a new way of service possibility. However, no system operates in isolation; an island solution is outdated since a SOA technology is already in practice. “SOA can facilitate communication and collaboration among diverse and disparate systems [42].” With respect to this technology, USDL aids to improve the transport system service not only for the government but also for mass consumption of road users. In the following sections, we present how a Service Ecosystem (for avoiding traffic congestion) can be realized with the help of USDL. We consider both a decentralized and a centralized perspective of traffic management

5.2.2.1 Traffic Congestion Avoidance Service

Currently, the Traffic Congestion Avoidance Service (TCAS) already exists in Jakarta in some capacity. Jakarta police traffic and NTMC are providing road users with public accessible CCTV, and in 2008, a social platform of road users was developed[57]. Currently, NTMC provides 25 accessible CCTVs and *lewatmana.com* provides 86 live captured CCTVs for image, feed, and information. However, the flaw is in the time-consuming manual access. Furthermore, the users of such service need to have more than basic knowledge and experience of Jakarta conditions. A tourist, a city newcomer or maybe a navigation device will have difficulty using the raw information provided by current services. Therefore, the proposed system needs to be smarter than the previous system.

For the scenario, let us assume that a USDL technology infrastructure (repository, editor, service marketplaces, service runtime and mobile mediation layer) is already established in Jakarta and has gained popularity. Consequently, the usual operation of the current TCAS will be considerably changed. Let us consider a hypothetical experiment by imagining that the CCTVs not only deliver images but also information, which can be directly used without further elaboration. Moreover, consider being able to install and deinstall CCTV in a matter of minutes wherever we want (scalability and flexibility), hence, all the provided information can be used by the navigation devices to suggest a route with less traffic congestion. In other words, it is possible to have an intelligent, scalable, machine-processable and real-time TCAS system.

[57] http://lewatmana.com/

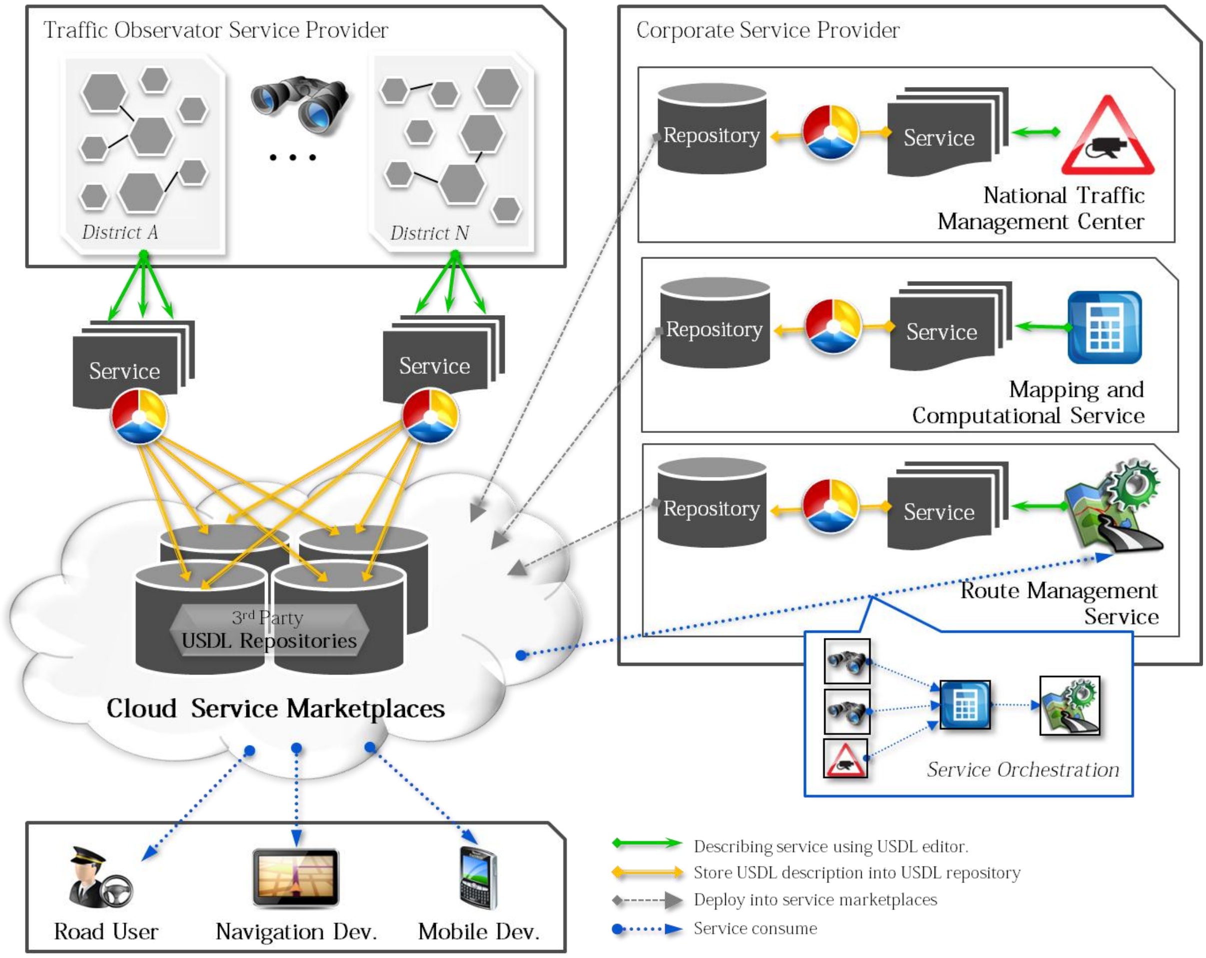

Figure 5.5: Traffic Congestion Avoidance Service

To realize a new TCAS system, we need to understand the experiences and local knowledge of the people within our travel route. On the one hand, USDL technologies make it possible for every person to provide such services, to describe them using USDL, storing them in the third party repository, thus offering them in the marketplace (i.e., traffic observer - service provider). On the other hand, this also helps a new service to emerge, such as a CCTV service, mapping service or computational service, as well as the orchestration from a diverse service. Figure 5.5 illustrates an exemplary ecosystem of TCAS. This ecosystem shifts the market structure and creates a new business model. The service provided by the traffic observer can be combined with another professional service (e.g., accident information, demonstration information, flood information, CCTV image service from NTMC), thus creating a service that is more suitable for the consumer (whether it is a road user or a machine device).

For example, a road user, *Aurelia,* calls a service from her mobile device to calculate the fastest route from her home to the office. Her mobile application subscribed to a *route* *management service*. *PT. Okula Service*[58] is a fictitious company that provides the service aggregation that orchestrates several services (cf. Section 3.3.2) such as, data provided by the traffic observatory from district A to F, CCTV image from NTMC, mapping and computation service. *PT. Okula Service* does not have its own Jakarta route map; therefore, it uses a service from *PT. Map & Route,* who also provides a service to calculate a route. *PT. Okula Service* received the parameter from *Aurelia* and then forwards it to the computation services. However, the service gives feedback. It says that the route needs more districts data than that given (i.e., district A-F) in order to recommend a good result, thus the BPM of *Okula Service* can easily subscribe to more services, and automatically redirect the information back to the computation service. Hence, the result is decoded and presented back in the display of the mobile device. These advantages combine the actual and large scalability of the data. Moreover, USDL as the dialectal means of such an ecosystem ensures not only the compatibility and compliance between technical services but also across manual services (cf. Section 3.3.2).

5.2.2.2 Traffic Management Service

The previous scenario depicts the Service Ecosystem from several perspectives at the same time (decentralized); thus in the followings paragraphs we will show how the traffic avoidance can be centrally managed using one system. With respect to the study by [42], in which the SOA technology is analyzed to enable collaboration in international flight travel, we use the basic idea and conveyed it into a traffic management service, while at the same time show the potential of USDL to complement the SOA paradigm.

This year, 2012, the Indonesian government has a plan to develop a Flood Management Information System (FMIS) under the flood mitigation project, as a technical assistance instrument to improve institutional coordination for operations and maintenance flood events in Jakarta [211]. One expected function of FMIS is the establishment of flood forecasting with a built-in early warning system. As the flood or water level rises in the road, it can worsen the traffic congestion. A flood prediction function from FMIS will greatly assist in predicting the resulting heavy traffic congestion.

The collaboration between the FMIS and NTMC systems can create a better quality of traffic congestion prediction. Currently, this can be done by distributing the system and utilizing the SOA and web service architecture [228]. However, it is limited to technical associations, i.e., the data interchange through web services. A sophisticated and smart Traffic Management Service should not be restricted to that level; moreover, it should be able to consider the operational, business, and technical aspects. The effort to develop the new NTMC system will include the establishment of functions such as, traffic congestion prediction, flood prediction,

[58] PT. is an abbreviation for "Perusahaan Terbuka" (i.e. Indonesian public traded company).

monitoring congestion level, controlling the number of vehicles in a district, route diversion, adjusting electronic road pricing, and coordination of multiple agents by flood event. This demonstrates that the USDL technology complements the SOA paradigm [152], whereby the service is not only considered as a technical interface, but also as an economic or social transaction with a broader context.

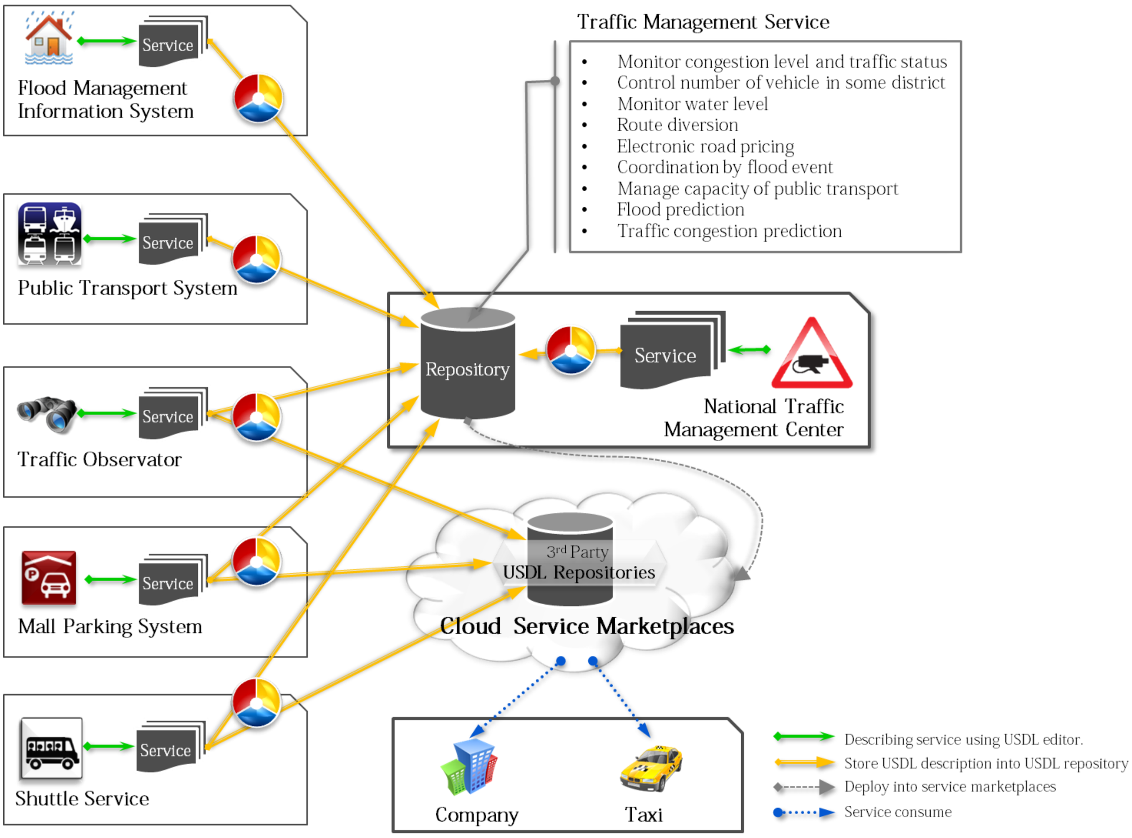

Figure 5.6: Central Traffic Management Service.

Figure 5.6 illustrates how the USDL underlying the SOA technology could be used to provide access and service commitment to a local repository of NTMC as the central commando. It also clearly shows a number of different types of services and transactions that support several different processes. We can rehearse, from the prior scenario, where the public traffic observer can also provide a service, and can be registered in the NTMC repository. Thus, by aggregating numerous services from different service providers, NTMC can elaborate and improve their public service. For example, they can now provide a real time service or alert for the public that informs of any impending traffic congestion in a certain district. Therefore, NTMC is not only consumed internally, but this service can also be offered in the cloud marketplace. Such service information could most likely provide better assistance for a taxi company, to reroute or adjust the number of vehicles in the strategic area. An IT oriented and dynamic company can also benefit from this service, if, for example, when employees are incapacitated or are unable to attend an important meeting on time because of the latent traffic congestion, then another decision can be made, e.g., Teleconference, or home office.

As the central authority that manages and monitors the traffic in Indonesia and specifically in Jakarta, NTMC use mainly CCTV to stay updated with the traffic conditions. However, with the IoS technology that opens a host of new options, the system can be extended in order to consume another information source. The NTMC should have a local repository that brings together several essential services for traffic management in one place. Firstly, as mentioned above, FMIS can offer information and calculated data to detect the probability of flood events. Secondly, public residents can also provide extensive data about the current condition of water levels in their districts. Thirdly, a citywide mall parking system can deliver the number of vehicles as another indicator of an overcrowded area. These are only a few examples of such essential services.

From many information sources, the capability of the NTMC system to make a prediction of traffic congestion can be improved significantly. Moreover, it could be possible that through this system, the responsible authority can make a responsive decision to avoid the congestion such as automated adjusting electronic road pricing, making a route diversion, adjusting the amount of available public transport, or maybe coordinating several extra commercial shuttle buses for a certain track. In addition, all of these services could be seamlessly connectable in one system. Furthermore, if a better service provider or innovative service such as a carpooling service or mass pickup-drop off service, etc. should become available during this process, then these can be utilized within the system since these services are attachable or detachable on demand (Figure 5.7).

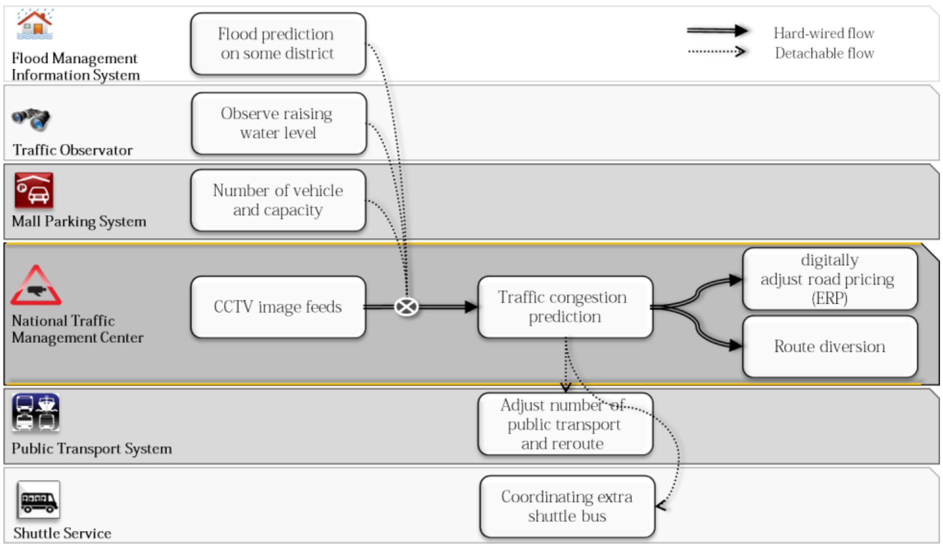

Figure 5.7: Activity flow from data provisioning to post activity of traffic congestion. The sequence is a central view from NTMC system.

Therefore, this concept is designed to supplement traffic congestion easing measures such as expanding the infrastructure (developing more districts with a mix of land uses and an interconnected network of streets designed to encourage walking and bicycling) or developing a Mass Rapid Transport (MRT). Jakarta needs to implement other innovative methods (e.g., electronic road pricing, shuttle services, carpool-matching services, telecommuting, downzoning, and better parking management in downtown areas, etc.). We have presented here some promising smart solutions in the context of an integrated traffic Service Ecosystem that are currently possible because of IoS and USDL technology.

5.2.3 Opportunities and Benefits

Smart traffic data management will start to encourage road users to develop more effective habits, e.g. traffic avoidance, readiness to use public transport, agile reaction towards congestion or flood prediction, and making wise road usage decisions by using intelligent road pricing, etc. This transformation could be realized if these new domains are accessible by clear and well-defined interfaces. Hence, we believe that USDL could contribute to simplify the service exchange. The standard of service description could be a more effective and efficient means of communication between diverse service agencies and all other participants or devices (cf. Sections 3.5 and 4.3)

If keystone organizations (e.g. NTMC or FMIS) were to build these Service Ecosystem concepts, there is a strong case for other service agents to adapt the technology. The keystone could provide highly standardized and low-priced services with economies of scale or highly tailored premium services. The collaborative integration fostered by USDL repositories and marketplaces could provide potentially significant strategic operations and financial benefits. The strategic and operation benefits of this approach include:

- A new business model and job opportunities emerge for district residents. By providing local expertise and real-time information, a type of micro service provider can enrich the ecosystem.
- There is potential to reduce delay and disruption in congestion or flood events. A high-standardized data and service interchange decreases the asymmetry information cost between the different systems.
- The ability to anticipate and prevent disruption increases as more information is available earlier in the process, within numerous channels, both in real time and electronically.

While the financial benefits can vary depending on the stakeholder, an overall smart traffic Service Ecosystem can help to realize the efficient usage of a road’s infrastructure. Moreover, because of the congestion ease and gridlock avoidance, the global economic effects are much greater than the individual profits. Table 5.2 summarizes the value propositions and the key metrics for the stakeholder.

Service agents	Value propositions	Key metrics impacted
Government		
▪ National Traffic Management Center (NTMC) ▪ Directorate general for water resources	▪ Enhance communication and coordination compliance ▪ Improve responsiveness to handle potential congestion ▪ Improve reaction to handle flood occurrence in area ▪ Reduce traffic congestion ▪ Improve public service quality ▪ Enhance risk and crisis management performance ▪ Improve data supply and information management	▪ Economic loss ▪ Transportation cost ▪ Congestion pricing ▪ Flood prediction parameter ▪ Commercial service price ▪ Road capacity level
▪ Public transport company	▪ Extend Market ▪ Improve responsiveness for demand change (scalability and flexibility) ▪ Improve data supply and information management	
Enterprise		
▪ Cloud service provider	▪ Enhance cloud service portfolio ▪ Service enrichment with USDL Standard ▪ Improve trade operations and management	
▪ Telecommunication company	▪ Improve public service quality ▪ Enrich public service portfolio ▪ Enhance trade and regulatory performance ▪ Improve network externalities	
Society		
▪ District resident	▪ Create new job opportunities ▪ Contribute to lower congestion ▪ Improve reaction to handle flood occurrence in area	
▪ Road user	▪ Reduce travel time ▪ Reduce travel cost ▪ Improve prior plan and better decision	
▪ Car owner (Car Sharing provider)	▪ Create new job opportunities ▪ Contribute to lower congestion	

Table 5.2: Value propositions and key metrics for stakeholders in smart traffic Service Ecosystem

5.2.4 Risk Assessment

The journey toward smart traffic in Jakarta is possible with our current technology. On the one hand, innovative concepts and technology can bring numerous opportunities and benefits to society. On the other hand, there will always be a cost to pay i.e. risks. We identify four potential risks that may occur under certain circumstances.

The first risk is that of low acceptance because of the digital divide within society and the large entry barrier for the service provider. The inequalities of the knowledge share between Jakarta residents most likely can curb the network externalities. Furthermore, if there is no extensive documentation and support for a service provider, then the complexity of USDL will possibly be a notable entry barrier for the niche service provider.

The second risk is the resistance of the keystone provider. As mentioned in Section 3.2.1, the keystone provider dominates the ecosystem. The fact that our concepts encourage a new form of Service Ecosystem may perturb the existing keystone, i.e., NTMC. In economic terms, NTMC could question why they should invest in new IT-technology if they have already established their proprietary system. While the possibility of such resistance is palpable, it is nonetheless rather unlikely because the opportunities and benefits that are offered outweigh the cost. Moreover, the keystone in our case is a non-profit oriented provider, thus it serves broad public services.

The third risk is the abuse of private consumer data. The subscription of TCAS requires a trustworthy provider because consumers periodically send information about their position. Irresponsible providers can easily misuse the data by chronologically sorting the location data of a specific customer to make a route profile. This data could then be sold to another agency or advertising company, or could be used to prepare various crimes. To control this risk, a government would need to set up a regulation or a certification body that assesses the service provider. However, this risk has most likely already occurred in the ecosystem that is well developed.

The fourth risk is the considerable hype surrounding the novel ecosystem. Indonesia is listed as the most active country in terms of eagerness and openness to new technology[59]. While this can attract enormous hype for modern concepts, it has a twofold effect. On the one hand, it can accelerate the maturity process of a new ecosystem, thus emphasizing the network effect. On the other hand, it may also create bubbles of replicating providers that hamper the service matchmaking with the customer.

[59] In 2010, Indonesia had the highest penetration of Twitter users in the world, followed by Brazil and Venezuela [97]. In 2012, Indonesia is the third largest country of Facebook users behind United States and India [192]. In the mobile device segment, in just 2 years Indonesia has seen RIM's market share rise from 9% to 47% with over 5 Million subscribers today [239].

5.3 Use Case: Smart Education

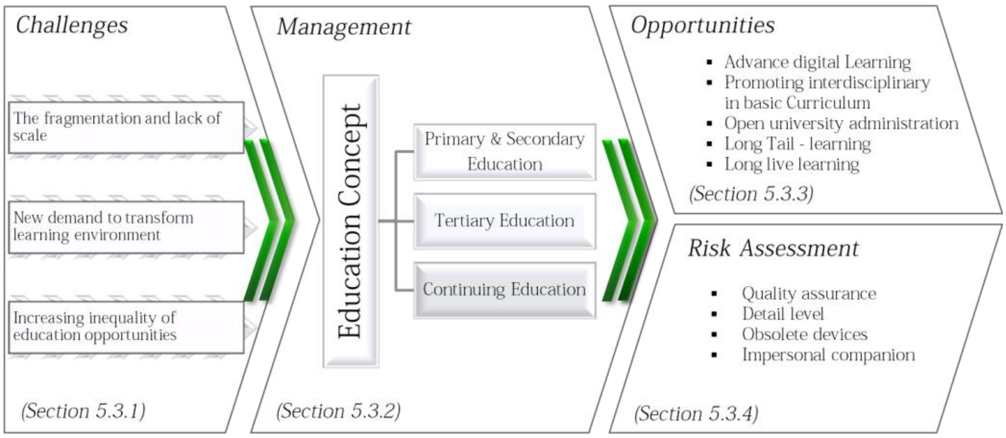

Figure 5.8: Challenges and opportunities of a smart education concept

5.3.1 Key challenges

The Indonesian school system is immense and diverse, where in the year 2010 there were over 66 million students and 4.2 million teachers in more than 320,000 schools [95]. According to the World Bank [240], it is the third largest education system in the Asian region and the fourth largest in the world (behind only China, India, and the United States). Currently, two ministries are responsible for handling the education system, with 84 percent of schools under the Ministry of National Education and the remaining 16 percent under the Ministry of Religious Affairs. Furthermore, private schools play an important role in the education system. While only 7 percent of primary schools are private, the share increases to 56 percent in junior secondary and 67 percent in senior secondary [ibid.].

Currently in Jakarta, there are approximately 7041 schools and 89 international schools that are accredited by the National School Accreditation Authority [21]. The city urbanization and the massive density of population in Jakarta raise some issues for the education system, but they also nurture opportunities for a well-developed city to adopt innovations that can address the challenges. The issues include the fragmentation of the education institute, a new demand to change the education environment and the increasing inequality of education opportunities by income level. The aforementioned challenges will be discussed further in the following paragraphs.

Fragmentation and the lack of scale

The numerous Jakarta residents comprise a broad range of different social statuses, where there is an absence of connection between well-educated society and the groups of less-educated residents. This gap between the groups indicates poor interrelationships between schools or education institutions in Jakarta. The government needs to encourage existing providers (education service) to increase capacity, or make it easier for new providers to enter the education market. Moreover, it is necessary to maintain high-quality standards and prevent any crowding out of existing providers. On the one hand, this encourages the trend towards private education, but on the other hand, it has provoked reactions ranging from disdain and dismay to alarm on the part of public institutions [122, 123]. The responsible authority should attain equilibrium, because if the growth of private education in Indonesia is imbalanced, then it will exacerbate existing issues of governance, quality, equity and state regulatory capacity, while the privatization of public providers and the development of transnational providers also adds to the difficulties faced by the sector [233]. An additional ingredient of this volatile mix was the somewhat hastily implemented educational decentralization [16].

New demands to transform learning environments using advanced IT infrastructure

The first demand is that of a new learning environment for children. Many parents seize opportunities to pay for various non-formal education services (e.g. private lessons, tutorials, learning guidance centers, etc.) for their children to undertake additional learning. Mostly, this is because they do not have enough time and are too busy to assist their children to learn in the home. However, such extra services have little impact on improving student performance and instead, parents and schools within the area need to have personal communication to determine what the children most need and in what way it can be given. The second demand is the parents themselves or general business professionals who need to improve their subject-specific competency. They want easy access, irrespective of time or location, to a less stressful education than formal lessons. Thus, an advanced IT infrastructure can establish a knowledge center to encourage life-long learning [36, 51], improve and develop the quality of higher education, create knowledge management and share educational resources among educational institutions efficiently and effectively. Thirdly, the government or the responsible education authority demands a highly competitive education system with highly regarded national exams [242]. The increasing competition is mostly generated by international agencies; moreover, the strong tradition of centralism in Indonesia, where power, influence and money flow from Jakarta, supports the decentralization system [233].

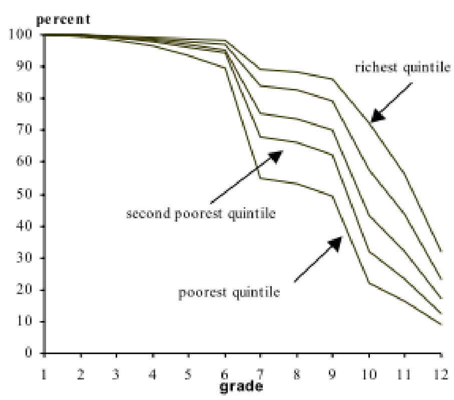

Figure 5.9: Highest grade completed by 16-18 year olds by income quintile [115]

Increasing inequality of education opportunities by income and social level

In Indonesia, stark income disparities persist, where the poorer regions have a per capita income of one-tenth that of Jakarta [115]. Education has been distributed very unevenly, in terms of both geography and gender. The past enrollment expansion closed the enrollment gap between males and females and across income groups, especially at the primary education level, but striking disparities remain at the junior secondary and senior secondary levels. In 2002, the net admission rate in junior secondary school of the richest one-fifth (quintile) of the population was 69 percent higher than that of the poorest quintile, and their senior secondary net enrollment rate was three and a half times that of the poorest quintile [ibid.]. While nearly all children enter the early primary grades, those who belong to the poorest income quintile drop out first, thus completing the fewest years of schooling (Figure 5.9). These patterns point to the critical junctions in the school cycle when children from poor households begin to fall far behind [ibid.].

5.3.2 Smart Education Concepts

The smart education concept tries to consider the current learning environment as a rounded Service Ecosystem, without reinventing the wheel. In this case, the service agents such as governments, responsible authorities, educational institutions (formal and non-formal), parents and learners must begin to see themselves as part of a holistic system. "However, how do educational systems respond when they are facing the challenges of limited resources, inflexible infrastructures, entrenched processes, increasingly incoherent and incompatible data, and rising consumer demands?" [176]. The Service Ecosystem model, with its instantiations of IoS and USDL will try to resolve these problems using three concepts as presented in this section.

The concepts take a systemic view of the education stage. The first step is to evaluate students in multiple dimensions. We look at the education process throughout the students' lives from primary, secondary, tertiary, to further or continuing education. Subsequently, scenarios are prepared specifically addressing the challenges that occur in Jakarta.

The concept that addresses primary and secondary education focuses on how to handle the fragmentation while maintaining the standard quality of the basic curriculum (5.3.2.1). The next stage demands a greater collaboration between administration and research and a more efficient management instrument that does not waste important resources (5.3.2.2). Lastly, with respect to the concept of learning throughout life from the Delors Report by UNESCO [51], we develop a scenario that suggests how a knowledge worker or a professional can keep improving their competency within an open education service ecosystem (5.3.2.3).

5.3.2.1 Standard Guarantee for Primary & Secondary Education

The primary and secondary education stages are compulsory, and are vital phases that forge the basic knowledge and the requirement for learning that will last a lifetime. The standard basic curriculum should ease the fragmentation of school quality in Jakarta. However, a curriculum is merely a direction or type of manual that may be implemented in different ways. The regular schools may follow the instruction of minimum standard requirements and some top schools are often not content with the curriculum and massively extend it further. The second problem is the range of student performance, in which a student may be unmotivated by the curriculum, thus the school is already overwhelmed by the circumstances.

A concept is needed to guarantee a curriculum standard (Teacher's qualification, teacher-pupil ratio, and coordination among institutions in implementing innovation) and related to the personal learning path of the student. Certainly, there are still many conceivable solutions from pedagogic, psychological or sociologic perspectives; nonetheless, here we provide an elucidation to those issues with respect to the IST innovation, i.e. the smart education Service Ecosystem.

The Ministry of Education as the keystone of the Service Ecosystem should provide means and infrastructure to support the implementation of the national curriculum (e.g. recommended textbooks, teaching materials, minimum qualification of teacher, nationwide portal for teacher recruitment, teaching curriculum in the classroom situation, etc.). Teachers' qualification and certification levels are significantly correlated with student performance. "With regard to certification, the process of achieving certification itself, linked to professional development workshops and preparation of professional portfolios, were also correlated with achievement (This is a particularly positive finding given the large investment the Government of Indonesia has made to certify 2.7 million teachers by 2015) [2]. Therefore, this central instrument can be realized through the implementation of a National Curriculum Marketplace that is managed and monitored by the Ministry of Education (Figure 5.10). In this marketplace, the qualified service provider should register their service in the repository. The curriculum serves as a service choreography template, which can recommend a suitable service provider while still assuring with the standard. Moreover, a high achieving and good-quality school can offer the bundled service compounded from the best practice they use. In this case, the other school can learn or tailor the service to their need.

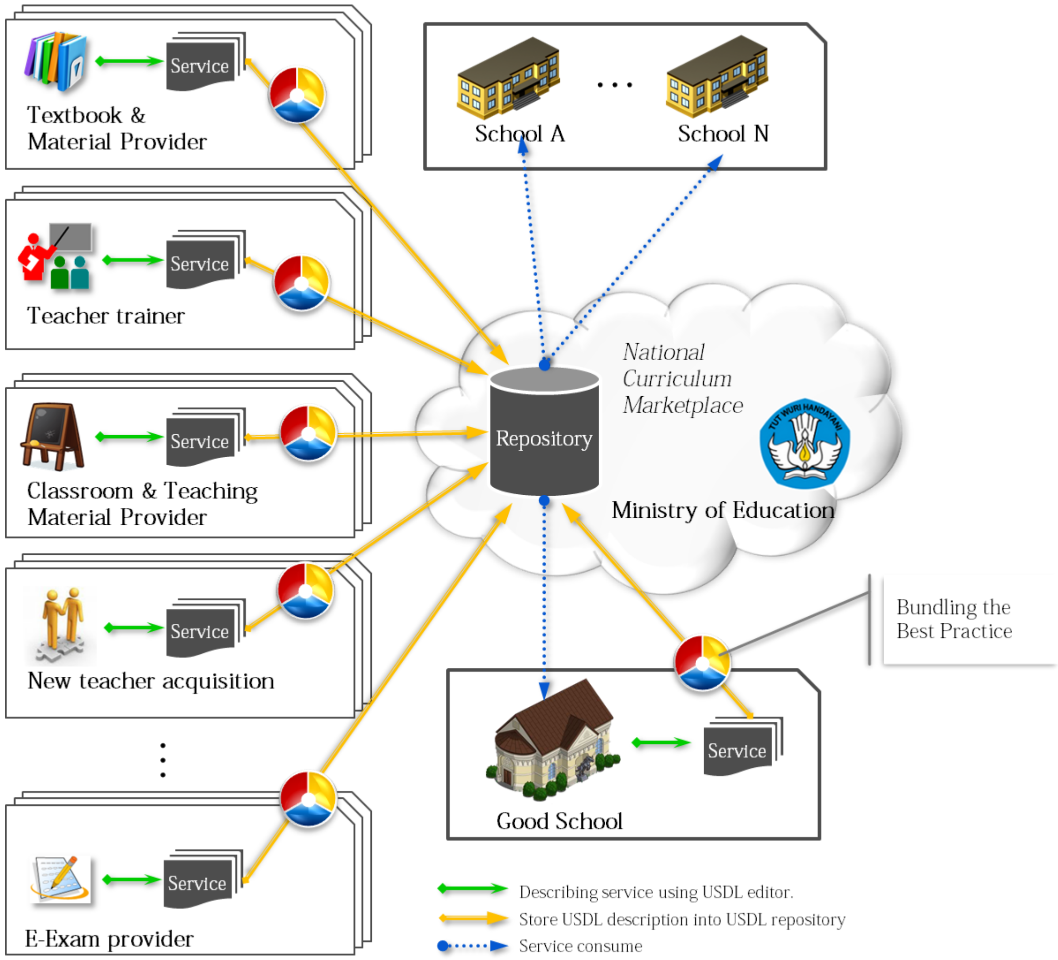

Figure 5.10: Curriculum Standard

This Service Ecosystem concept for maintaining the basic quality of the curriculum standard is progressing well with the feature provided by USDL. “The USDL Service Level Module captures concepts concerned with guarantees regarding quality of service operation, which are claimed/requested by different actors involved in the provisioning, delivery and consumption of a service” [134]. The monitoring for curriculum implementation in schools is now considerably more practical, clearly due to the normative describable service, well defined Key Performance Indicators (KPI), and standardized Service Level Agreement (SLA) measurement. The monitoring (cf. Figure 5.11) is purposeful and is driven by determinate indicators derived from curriculum objectives. If there is a failure to meet this requirement, the service provider concerned can be exchanged with another provider effortlessly.

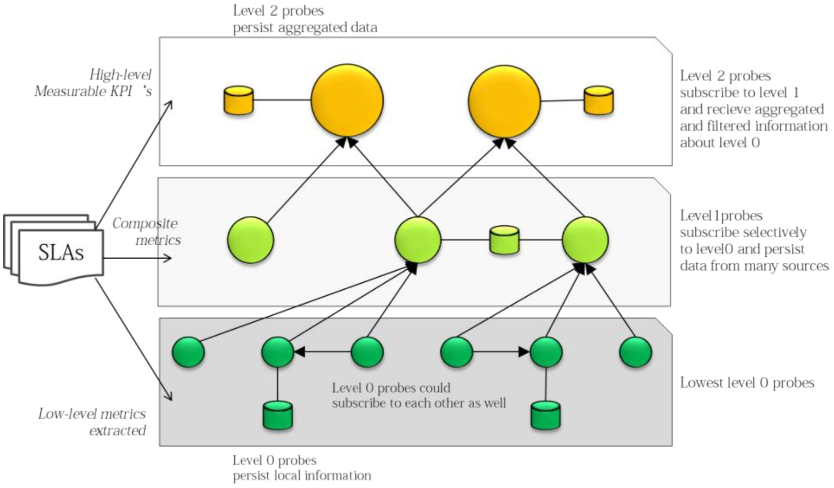

Figure 5.11: Conceptual architecture for SLA monitoring [134]

5.3.2.2 Service Governance in Tertiary Institutions

The third stage of the education system is higher education, which is defined as a place for the common heritage of knowledge [51]. The student gains the preparation for research and teaching. It offers very specialized training adapted to the needs of various social and economic lives in a place of culture and learning open to all. Moreover, the institution in this phase enriches the dialogue between peoples and cultures through international co-operation [ibid.]. The tertiary institutions have a close relation to the industry and business world. They prepare the student to be a professional or a knowledge worker[60]. However, how the tertiary education business is managed is rarely discussed. Therefore, in this scenario a method for using a Service Ecosystem model to manage the business and operation of tertiary education is presented.

The public universities in Indonesia are financed from a government budget (60 percent) and funds from tuition fees (40 percent). According to the government's calculation, one student in a public university for the year 2005 needed about USD 2,500 per year to achieve a high-quality education, whereas the government only provides USD 1,000 per year on average [206]. Moreover, a student in a public university normally pays tuition fees of from USD 50 to USD 500 per annum. Public universities are therefore opening special or extension programs to enhance their income in order to address the lack of funds. However, in the recent economic recession, aside from an increasing capacity, the common cost management strategies are not enough. Educational institutions must develop smarter approaches and reassess key processes to reduce operational costs in order to direct more assets to research

[60] Knowledge workers are individuals who are valued for their ability to act and communicate with knowledge within a specific subject area. The main attribute is the use of analytic and research skills to advance the overall understanding of that subject through defining problems or identifying alternatives [48].

and instruction. A focus on the investments in education is required to ensure lasting transformation.

The Service Ecosystem of administrative and operational works for higher education can help educational institutions position themselves for a better prospect. From the technical operation through to the business aspect, and from daily to strategically operational work, a higher-education institution is similar to a company, which needs to be managed professionally. Service governance will be an important notion due to the emergence of interconnected services (e.g. an interoperable banking and financial system in which a student mid-yearly transfers funds for tuition, an administration system, event management system, IT-services, building management, research collaboration, technology transfer, etc.). All these services would be covered by USDL, which means that numerous types of services can be described normatively and can be understandable by both humans and machines. Consequently, this opens a new possibility to the prominent best-practice collection of IT-Service-Management, i.e. ITIL (IT Infrastructure Library) [207], and COBIT (Control Objectives for Information and Related Technology) [187] as a framework to ensure the integration between IT-Governance and Corporate Governance [149]. USDL may thrive on the ITIL/COBIT at the next level, which involves governing the technical and manual services (Figure 5.12).

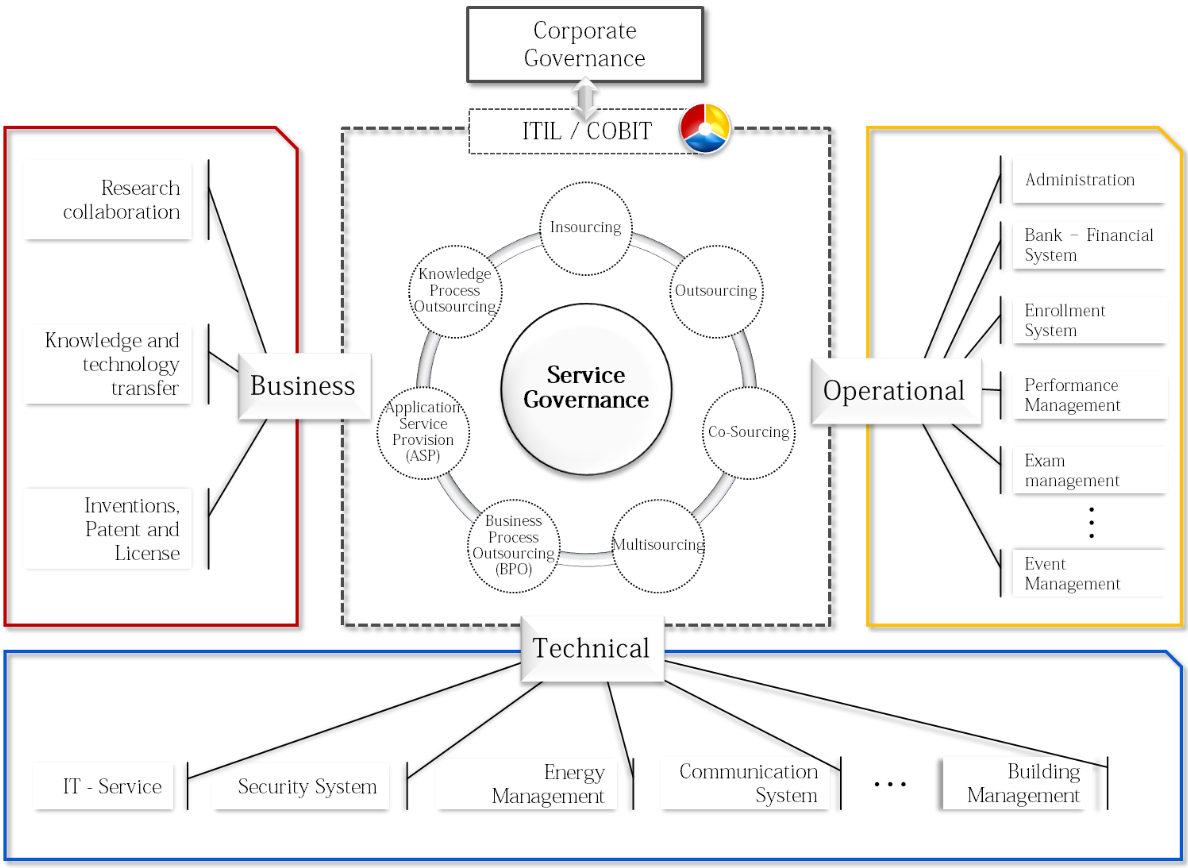

Figure 5.12: Service Governance in Tertiary Institutions

The common denominator of higher education is the commitment to collaboration. Educational institutions, industrial partners, commercial vendors, government, community and all other associated organizations must make a thoughtful commitment to sustain the partnership. They should collaborate within and across educational institutions to build new processes, innovation and services. USDL enables such collaboration for institutions and commercial partners, because it

> "…allows providing the detailed information for the technical access and consumption of services, also covering the case where a business service exposes several technical interfaces, e.g., a SOAP-based interface and a proprietary EDI interface (such an SAP RFC). …, the generic constructs in USDL allow integrating description standards of other types of technical interfaces, e.g., for services that can be accessed by email, fax, telephone as well as manual services that cannot be accessed (requested or delivered) by any technical means." [118]

5.3.2.3 Open Education Ecosystem for Lifetime Learning

Chronologically, the next stage of an education process is adult education or continuing education [61]. It recognizes the form of post-secondary learning activities within the domain, including personal enrichment, autodidactic choices (personal path of learning), informal career training, workforce training, certificating, etc. "The service-based economies of tomorrow will increasingly require the meta-skills of critical thought, information literacy and creativity to solve problems that haven't yet been encountered. Knowledge workers of the future will function within a web of collaborators and almost limitless information and computational resources" [176]. We note that this endorses not only the education unit for the professional, but also for general adults outside of traditional undergraduate education institutions, i.e., lifetime learning.

The concept of learning throughout life is the key that gives access to the 21st century. It goes beyond the traditional distinction between preliminary (primary, secondary and tertiary education) and continuing education. It links with another concept often put forward, that of the learning society, in which everything affords an opportunity of learning and fulfilling one's potential [51]. Learning throughout life provides the means to participate in a rapidly changing world, to develop and to improve our skills. The Delors Commission highlights the need for places that favor non-formal learning throughout life. These places are necessary to allow for the thriving and diversity of individual talents. They offer practical answers, adapted to common circumstances of domestic life, everyday life and professional life. They contribute to the discovery of solidarity and citizenship [ibid.].

A similar notion is used in human-resource management, which is systematically aimed at enhancing the performance of individuals and groups in an organizational setting. Normally,

[61] In the United Kingdom and Ireland, continuing education is called further education.

such talent development programs that use planned learning agenda are purposely designed in order to achieve or maintain a certain competitive qualification for the organization. This concept can be improved further, and adjusted to the broader context of long life learning. For example, we could consider the human-resource manager who has wide connections with training, coaching, and mentoring service providers; we could assemble different types of learning activities and integrate them into our individual path of learning. Secondly, the education service provider might be able to enhance their service portfolio by collaborating with other expert institutions or persons. Furthermore, the method to deliver such a service can also be extended (e.g. virtual classroom, e-learning, podcast, education apps, etc.) and individually customized, enabling a continual performance analysis. Therefore, we need an Open Education Ecosystem (cf. Table 5.3).

This basic concept itself is not exactly novel as it is similar to the Open University [62] concept. However, due to the development of current technology, it is now possible to combine all the benefits and concepts of the notion of Open University [157], Open Platform [175] and Social Network [230]. An open Education Ecosystem refers to education environments that are developed openly by community or academic institutions, rather than a single keystone vendor. The ecosystem requires a platform or portal, where people can discover, customize, monitor, collaborate, network and consume the education units offered (file sharing, course management systems, personal curriculum, performance analysis, service portfolio repositories, etc.). On the other hand, this platform facilitates comprehensive and extensive offerings because of the long tail effect that is now also applied to service as a digital product. To summarize, this Service Ecosystem enables people to study their preferred subject anywhere they live, to study a variety of courses from educational institutions (university, open community, private person, vocational institute, etc.) and its high flexibility allows the individual to assemble their learning to achieve their own personal enrichment.

[62] Open University is an education institute that offers learning, teaching and research for remote places. It is notable for having an open entry policy [158]. Open University was firstly established in the United Kingdom in 1969 [209], and 1983 in Japan [210]. In 2002, MIT also launched their OpenCourseWare (OCW), which has been reinforced by the launch of similar projects at Michigan University, Yale and the University of California Berkely [237].

<table>
<tr><th>Properties</th><th colspan="4">Open Education Ecosystem</th></tr>
<tr><td rowspan="5">Service Ecosystem Component</td><td colspan="2">Service Agents</td><td>Science and Technology</td><td>Market</td></tr>
<tr><td>Human</td><td>▪ People
▪ Teacher
▪ Student
▪ Knowledge Worker</td><td rowspan="4">▪ SOA
▪ Semantic Web
▪ Mobile Technology
▪ Telecommunication Provider
▪ Open Data
▪ Web 2.0 (e.g. Wiki, Blog, CMS, Portal, etc.)
▪ Open Platform
▪ USDL</td><td rowspan="4">Cloud Education Marketplace :
▪ USDL Repository
▪ Mobile Delivery Channel
▪ Multiplatform channel</td></tr>
<tr><td>Enterprise</td><td>▪ University
▪ College
▪ School
▪ Vocational
▪ Non-Formal</td></tr>
<tr><td>Machine</td><td>Cloud services</td></tr>
<tr><td>Automaton</td><td>Data compliance Middleware</td></tr>
<tr><td rowspan="2">Symbiotic interaction (Producer Perspective)</td><td colspan="2">Produce</td><td>Aggregate</td><td>Broker</td></tr>
<tr><td colspan="2">▪ Offline delivery of service education unit
▪ Cloud services and online delivered service serves as support services</td><td>Services Orchestration are common to bundling and delivered value added Education.</td><td>▪ A scientific work is one common type of service provisioning
▪ Reuse of teacher material and student transcripts (intermediaries)</td></tr>
<tr><td rowspan="2">Symbiotic interaction (Consumer Perspective)</td><td colspan="2">Consumption</td><td>Discovery</td><td>Automation</td></tr>
<tr><td colspan="2">▪ Direct utilization of the provided service
▪ Student information exchange between education institution through gateway access of the middleware</td><td>The service agents can find their suitable services from the marketplace, whether they are to be consumed, bundled or re-commercialized</td><td>The automation service consumption can only be done in the technical service context i.e., cloud service or marketplace mechanism.</td></tr>
<tr><td>Service Spectrum</td><td colspan="4">The service provider may commit to performing some act, lending resources, giving temporary access to their assets, and make a licensing agreement. The telecommunication vendors and mobile device industry agree to some standard that ensure the openness of the ecosystem.</td></tr>
</table>

Table 5.3: Open Education Service Ecosystem

On the one hand, knowledge workers, teachers, education practitioners and experts can offer their skills and experience of a certain subject that is now normatively describable with USDL. On the other hand, through the technical module of USDL and mobile mediation layer, different devices can now uniformly consume a certain service education unit. Moreover, the open-source software for a learning management system (e.g. ILIAS[63], Moodle[64], Sakai[65], etc.) can now serve as an interconnected portal with a linkage to the central education marketplace.

5.3.3 Opportunities and Benefits

The trend of an interconnected education network is emerging, and the open-source movement emphasizes the collaboration of community development [161]. This is why the open education ecosystem will become even more important in the future. Moreover, an ecosystem needs a core technology to exist (cf. Definition 3.1). This creates the need for an open platform. We now need to determine why such a platform is also important for the success of an open education Service Ecosystem.

First, with the growth in the number, complexity and interdependency of diverse institutions' applications, the cost of maintenance and upgrade is spiraling out of control (cf. Service Governance in Tertiary Institutions). Second, many commercial products are not well tailored to education requirements and are difficult to customize. Third, consolidation in the IT industry in general is leading to unfair use by an increasingly smaller number of vendors. For example, in today's environment, a request for a student's transcripts and learning artifacts requires many individual communications with multiple education institutions and other learning providers [175].

In terms of the individual learning track experience, the utilization of SOA technology allows institutions to support the interchange of services and data without direct dependency on each institution's proprietary implementation of its underlying business process. Instead, with SOA, individual learning services provided by these heterogeneous institutions can function with complete transparency for the student and other institutions so that a portable individual curriculum is possible [175]. However, the problem is to determine how the different types of data from different institutions can be exchanged seamlessly with minimum effort and cost. Although the SOA already has a standard for data exchange and Web services, the education ecosystem is much more complex than a mere technical service. Here, USDL can help to describe the interdisciplinary context of services, from the technical service, the collaboration aspect, up to the monitoring of service quality.

[63] http://www.ilias.de/

[64] http://moodle.de/

[65] http://sakaiproject.org/

The various concepts presented in the previous sections highlight the opportunities of a service ecosystem, whether it is for certain institutions, person or even the whole ecosystem. The value propositions and the key metrics for the stakeholders are summarized in Table 5.4 and the opportunities are as follows:

- The national curriculum marketplace can guarantee the standard for a diverse range of schools. Thus, the fragmentation of school quality can be resolved because USDL provides a module to assess the quality of service with the determined KPI. It gives the opportunity for a good school to share their best practice, which can be reused, by other schools.
- The service governance in higher education empowers institutions to make appropriate, informed assessments and better facilitating in all areas, including financial performance, research collaboration, student admission, public facility and management, etc. The shared services offer efficiency and savings by integrating back-office systems and processes or developing centers for administrative functions.
- The open education ecosystem that uses open and community-source applications built on open standards enables interoperable processes and workflows. Creating shared service centers that thrive on economies of scale, cloud computing and virtualization to provide high-quality services while reducing costs. Moreover, it is transforming the learning environments that improve student achievement by increasing access to resources and tools for collaboration in an uncluttered environment according to individual needs, preferences, time, devices and aspirations.

Service agents	Value propositions	Key metrics impacted
Government		
▪ Ministry of Education	▪ Enhance coordination compliance ▪ Improve the teacher student ratio balance ▪ Increase communication and information sharing to help improve low-performing school ▪ Maintain standard implementation quality of curriculum ▪ Providing digital curriculum resources	▪ Knowledge Transfer ▪ Openness ▪ Transaction cost ▪ Administration cost ▪ Commercial service price ▪ Economy of scope ▪ Economy of scale ▪ Geographically separation ▪ Knowledge digitalization
▪ Public School	▪ Easing the collaboration with other instances ▪ Ensuring the quality standard	
Enterprise		
▪ Cloud service provider	▪ Enhance cloud service portfolio ▪ Service enrichment with USDL Standard ▪ Improve trade operations and management	
▪ Telecommunication company	▪ Improve public service quality	
▪ Company	▪ Increase the possibility for HR department ▪ Enhance the personal development program	
▪ Education Institutions	▪ Easing the collaboration with other instances ▪ Lowering the administrative and operation cost ▪ Improve data and information flow	
Society		
▪ People	▪ Opening a new way for lifelong learning ▪ Facilitating personal enrichment ▪ Creating new job opportunities	

Table 5.4: Value proposition and key metrics for stakeholders in smart education Service Ecosystem

5.3.4 Risk Assessment

Many uncertainties can occur with the concept's application in Jakarta, because of the diversity of the rich ecosystem. We assess four potential risks that have a high probability of occurring: lack of quality assurance due to the diverse curriculum implementation, service description's detail, obsolete devices and the impersonal companion. The followings paragraphs will discuss it further.

The approach to guarantee a minimum standard quality for a school's system with a curriculum marketplace may be a virtue in the heterogonous ecosystem. In the offering phase of services, we can still predict whether it fulfills the least requirement. However, the practical aspect of the service delivery is not well covered, i.e., the real quality of the promised services. This is difficult to quantify, because it depends solely on the subjective evaluation of the former customer that can also be counterfeited.

In contrast to the concept of smart traffic where the keystone is a non-profit provider, the smart education concept may have a profit-oriented provider. This has an implication for the detail level of the described service. For example, a certification exam from a large technology company that offers e-learning courses will gain more profit if its description of the service is as complex as possible. This way, the service consumer cannot easily compare it with other providers. In contrast, it is also possible that a niche provider cannot describe their service properly. In other words, a service can be both over-described and under-described.

Another risk arises when the school infrastructure cannot keep up with the progress of the technology development and the standard is not backward compatible. The obsolete devices can no longer access the newest marketplaces or repository standards. Thus, it needs to periodically update and reinvest in the information technology, rather than in the education itself.

A basic education process needs intensive attendance from a teacher. The personal observations and relationship between a teacher and student cannot be replaced by a digital ecosystem of linked resources. This needs strong determination and discipline that are barely developed in the initial or primary stage of education. Therefore, the overuse of the smart education concept with its lack of direct contact with a teaching process in the primary stage, may lead to impersonal tutoring that cannot replace the procurement of social skills.

5.4 Analysis and Discussion

In the previous sections, we have presented five scenarios in the context of Smart City, especially in transportation traffic and education domains. Each scenario has its own distinctive character; to analyze it further we need to identify the positioning of each scenario within the proposed Service Ecosystem theory. We use the Construct of Service Ecosystem (Section 3.2) and plotting on the bubble chart. The ordinate and abscissa scale is respectively network scale (cf. Section 3.2.1) and stakeholder heterogeneity (cf. Section 3.2.2). In addition, the size of the bubble illustrates the scope of the service spectrum (cf. Section 3.2.3). Figure 5.13 depicts the distribution of the five scenarios in the Service Ecosystem grid. We decided to use these three parameters because, from the construct of the Service Ecosystem, we can identify several implications that will be discussed in the following paragraphs. First, the perpendicular projection from the x- and y-axis can be used to identify the requirement and risks that have emerged. Furthermore, the size of the bubble is important for analyzing the functionality of USDL.

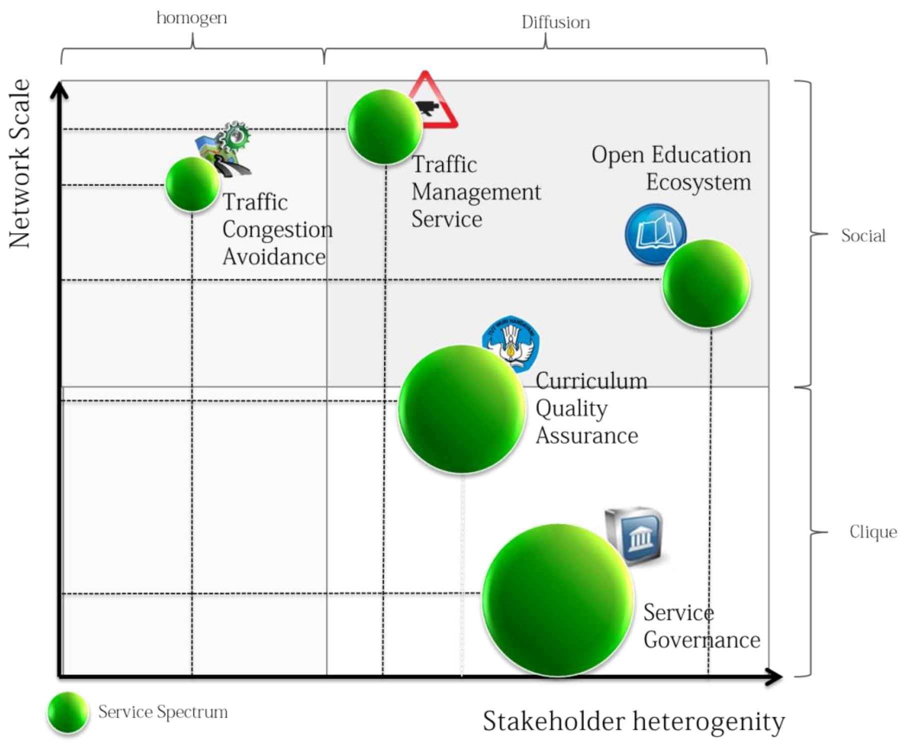

Figure 5.13: The positioning of diverse scenario shows different types of Service Ecosystem. The positioning plotted using the Construct of Service Ecosystem (cf. Section 3.2). The abscissa and ordinate are the stakeholder heterogeneity and service network scale, respectively. The size of the circle represents the scope of the service spectrum.

Requirements

It can be seen that Open Education Ecosystem for Lifetime Learning is the most complex scenario due to the diversity of its stakeholder, especially compared to the first scenario of

Traffic Congestion Avoidance Service, which merely uses the technical aspect. The relative small network formed in the three scenarios from the Use Case: Smart Education implies that each stakeholder has the opportunity to address a number of service commitments, through direct connectivity, customized or integrated systems. However, these scenarios have higher heterogeneity as in the Use Case: Smart Transportation Traffic. Therefore, a heterogenic scenario such as Open Education Ecosystem for Lifetime Learning has challenges that need to be addressed in order to become a dominant driver for education in the future.

First, the technical platform, SOA Technology, and Industry Partner (e.g. Telecommunication Company, Mobile device producer, etc.) must resolve the question of how services will be defined, described, managed and reliably delivered. Commonly, education keystones (e.g. Ministry of Education) have chosen to define proprietary models for applications or infrastructure, with interoperability occurring only at the internal or structured data level. Second, as in the Service Governance in Tertiary Institutions scenario, the issue is that of the economics of an SOA environment. In education, each application traditionally often has had its own maintenance and support costs, and the "owner" department is liable for paying these. Because SOA makes business functionality available as Web enabled services across the institution and potentially also across external organizations (cf. Standard Guarantee for Primary & Secondary Education), new models for pricing and recharging must be created between the provider and consumer [175], which is already answered by USDL. However, its relative ability to address the issues is summarized in Table 5.5.

Both the Traffic Congestion Avoidance Service and Traffic Management Service have a higher potential network scale and relative homogeny. For large, extensive service network participants, the ability to influence the metrics (cf. Section 5.2.3) presents a compelling argument for pursuing the type of system integration described in these scenarios. Consequently, the service agents that hosted the repository and service runtime should also ensure the scalability of its system. However, the network externality also has another side. If the system shuts down, then the effect is also multiplied and immense, thus disaster-recovery management is needed.

Coverage analysis

The coverage analysis allows us to convey how well USDL and its tools meet the case studies scenarios. In principle, we find that determining the size of the bubble in Figure 5.13, i.e., the scope of the Service Ecosystem, is correlated to the intensity of the USDL module being used, which is more than necessary to describe most of the service types. However, for usability and the design phase of services, the USDL editor should give a better aid, e.g. graphical editor, ontology recommendation vocabulary and template. To be practical in wider usage such as in Transportation scenarios, clear, simple, and practice oriented tools will help to ensure the adaption. Moreover, several requirements for the repository and marketplaces, with some additional tools, may be needed, depending on the scenarios.

Case Study		USDL Tools				
		Module	Editor	Repository	Marketplace	Additional
Smart Transportation Concept	Traffic Congestion Avoidance Service	*S* : + *SL* : + *Pr* : + *Pa* : + *T* : +++ *I* : + *F* : + *L* : .	▪ Ultra-light ▪ Ease of use ▪ Practice ▪ Template ▪ No over spec.	▪ Platform neutral ▪ Remotely accessible ▪ Multichannel ▪ Routine Backup ▪ Semantic extension ▪ Scalability ▪ Distributed storing management ▪ Stable	▪ Multichannel ▪ Portability ▪ Support economic of scales business model	Portal for data and information input
	Traffic Management Service	*S* : + *SL* : . *Pr* : . *Pa* : +++ *T* : +++ *I* : +++ *F* : + *L* : .	Graphical aid for describing intensive collaboration		▪ Privacy ▪ Trustworthy ▪ Secure	Automated feedback procedure integrated in the system
Smart Education Concept	Standard Guarantee for Primary & Secondary Education	*S* : +++ *SL* : +++ *Pr* : + *Pa* : . *T* : . *I* : ++ *F* : +++ *L* : ++	▪ Template ▪ Ontology recommendation ▪ Intuitive ▪ Simple		▪ Proprietary ▪ Assessment for minimum quality ▪ Certification	Monitoring service quality and delivery
	Service Governance in Tertiary Institutions	*S* : + *SL* : ++ *Pr* : + *Pa* : + *T* : ++ *I* : +++ *F* : + *L* : +++	▪ Ease of use ▪ Integration with main system theme			Dashboard for service portfolio
	Open Education Ecosystem for Lifetime Learning	*S* : +++ *SL* : ++ *Pr* : ++ *Pa* : +++ *T* : + *I* : . *F* : +++ *L* : +++	▪ Consistency ▪ Template ▪ Ontology recommendation		▪ Open ▪ Public assessment and ranking	Portal for learning resources creation & consump.

Table 5.5: Coverage Analysis of case study and USDL tools. The *module* column, represent the importance of the each USDL module for the scenario. The range is ascending (. , +, ++, +++). *S*: Service, *SL*: Service Level, *Pr*: Price, *Pa*: Participants, *T*: Technical, *I*: Interaction, *L*: Legal.

5.5 Summary

Smart City is a notion of a common framework used to highlight the growing importance of IST, social and environmental capital in an interconnected way. Thus, the Service Ecosystem is found to greatly assist the development of several scenarios to help realize the vision of a Smart City. We selected Jakarta as the reference city to develop the case study because we can identify the real problems and can therefore propose solutions. Moreover, the fact that it is a green field, allowing the cycle in its infrastructure development to be skipped, accelerates the adaption. This demonstrates that new technology such as IoS and USDL will also find prospects in an emerging market such as Indonesia.

	Challenges	Smart System	Opportunities	Risk
Smart Transportation Concept	▪ Congestion ▪ Flood ▪ Urbanization ▪ Island Solution	▪ Traffic Avoidance Service ▪ Crowdsourcing ▪ National Traffic Management Service	▪ Congestion Easing ▪ Grid Lock avoidance ▪ Fluid communication ▪ Scalability	▪ Keystone clustering ▪ Digital divide resident ▪ Multiplicati on loss
Smart Education Concept	▪ Quality fragmentation ▪ Learning environment ▪ Education opportunities	▪ Standard guarantee ▪ Service governance ▪ Open Education Ecosystem	▪ Digital Learning ▪ Curriculum assurance ▪ Open university ▪ Long live learning	▪ Trustworth y ▪ Governance ▪ Security

Table 5.6: Challenges, solutions, opportunities and risk for transportation and education field in Jakarta

IoS (Service Ecosystem) can be seen as a complement to existing systems and does not fundamentally change those systems or mandate new systems, because it underlies the SOA Technology, enabling any participant in the process to connect to another participant without specific, point-to-point custom solutions. IoS holds great promise for the Smart City concept, in a context where many institutions are reaching the point where there are too many data, applications, interfaces and services to be intelligently collaborated. The current hard wired and proprietary system changes supposedly small projects into expensive, complex, tedious and lengthy efforts. By using USDL to wrap existing services, business process data and functionality, companies and organizations can potentially improve their IT-Governance and expose their services in a novel way. IoS offers the best opportunity to direct innovation and avoid reinventing the wheel. A common service delivery model, data exchange standard, open source platform, and sustainable Service Ecosystem provides the core basis for delivering smart services in the Smart City.

6 Conclusions

The previous chapters have presented the theory of Service Ecosystem with its underlying knowledge, context, and how it can be instantiated in the real world. Subsequently, in this Chapter we want to conclude the study by summarizing the key points (Section 6.1), explaining the significance of the findings (Section 6.2) and discussing the implication for further research (Section 6.3).

6.1 Summary

This thesis is about a theory of Service Ecosystem that is established to analyze and develop possible concepts for realizing the Smart City vision. Our theoretical approach is keen on adopt ecological perspectives as formed out of deterministic effects (either economic or technological), which explores the complex nature and drivers of network relationships. The choice of a particular theoretical framework is essential to design the model, which later is used as guidance and limit the number of dimensions to examine the current trend in service sectors. Without a clear assistance of theory, it is easy to become lost in overwhelming subjective interpretation for Service Ecosystem studies due to the complexity of real-life occasions, for example, the internet-enabled commercialization of service.

As we can see, how one can effortlessly offer and consume the digital goods nowadays, it is very unfortunate, that in the era of service dominance, we still cannot do the same thing with the service product. Even though it economic value worth more than double of good commodities. As of the technology facilitates the origin of digital good in contrast to classic real goods, so it is also possible to digitalize service from manual service. Furthermore, as of the traditional distribution-chain is transformed, so do in the service commercialization and collaboration process. Thus, it will cause the rise of new ecosystem of service, where multiple service agents symbiotically interact around a core technology. For now, the technology is internet (Internet of Services). In the near future, we will anticipate how service will become digitally commercialized and tradeable. One essential precondition is the dialectal mean in such ecosystem i.e., how the service agent can communicate, wrapping it service and exchange the information within it seamlessly. One matching candidate for it is USDL (Unified Service Description Language). Moreover, we also present some scenarios how these concepts can be applied to realize the Smart City concept.

To sum up, our study highlights the importance of socio-economic strategy that wraps the activities around service providers. We conducted this study, precisely to address those interdisciplinary issues related to the Service Ecosystem and its appliances. Table 6.1 summarizes the study wireframe on this thesis, and gives a brief overview of the main discussion's topics, how we approach it and what the intentions of it.

Chapter	1. Introduction	2. Fundamental Aspects	3. Theory of Service Ecosystem	4. The Materialization of Service Ecosystem	5. Smart City Service Ecosystems	6. Conclusions
Main Discussions	▪ The growth of service sector ▪ Hardly find definition of Service Ecosystem ▪ Lack of practice appliances of USDL	▪ Transformation of economy structure ▪ Service is digitally tradeable ▪ Holistic view of network and system	▪ Objective and systematical view of Service Ecosystem ▪ The demand of dialectal mean	▪ Instantiation of Service ecosystem as IoS ▪ USDL as a dialectal mean for Service Ecosystem (IoS)	▪ Possible scenarios and opportunities ▪ Service Ecosystem view to help solve real problem ▪ Requirements	Synthesize the result of the thesis
Methods	▪ Introduce the broad research area and its context ▪ Construct the structure of the study	▪ Literature Research ▪ Positioning Service Ecosystem in the interdisciplinary fields	▪ Qualitative analyze ▪ Use of theory design framework ▪ Modeling	▪ Formal argument ▪ Interview with Experts	Case Study	Summarizing
Role in the study	▪ Show the motivation to conduct the study ▪ Describe the study topic, the scope and limitations	Justificatory knowledge for theory building	Main instrument to : ▪ examine IoS and USDL ▪ Scenario development	Testable proportions of proposed theory	▪ Practicability of the theory ▪ Evaluation of IoS and USDL	▪ Stress the importance of the thesis ▪ Globally view

Table 6.1: Summary of the thesis

6.2 Contributions

One cannot overlook the advent of Service Ecosystem in the fast pace service-based economy. Moreover, we have learned that a service is more than the typical technical invocation, in the broader context it is the intense and individual interaction between consumer and producer. Nevertheless, the notion of Service Ecosystem is being used in a wide range of science fields. With respect to all previous research from economic, information technology, and service sciences related studies. The results from our work can be considered to contribute in these three aspects:

1. Clarifying the notion of Service Ecosystem
2. Validating the need of USDL in IoS
3. Showing the prospects of applying USDL in diverse Service Ecosystem

The proposed theory of Service Ecosystem is in the initial phase that still needs a lot of improvement. However, the substantial notion of Service Ecosystem is expected to give an objective understanding about the real-world phenomenon due to the emerging of service sector and internet technology. Consequently, it supposed to help the practitioner to explain the causation from associated event and argumentatively calculate the possible action. For example, how one observes the partnership between hotel, travel bureau, and Taxi Company, and what are the opportunities that may be elaborated using the current technology. The theory dissolves the traditional boundaries between business, service, and technology to provide profound impact on the logistics of information and therefore, a continuum of intangible collaboration. From executive perspective, CIOs will have a crucial role on this new era of business servitization.

Technically speaking, the IoS as one of the research initiative program sounds the theses about the need of USDL. Through theoretical approaches, we attempt to validate this statement by introduce the notion of dialectal mean. The positive result will in particular way strengthen the development and improvement of USDL, thus ripen this technology to broaden adaption and realizing the Service Ecosystem, i.e., The Internet of Services.

Additionally, to accelerate the maturity of such preliminary ecosystem and technology, we were proposing five concepts concerning Smart City. It shows what is possible from the holistic view of Service Ecosystem by utilizing the current technology. This has two implications. Firstly, the described scenarios can encourage broader public to create more innovative or practicable use cases, thus it may amplify the network effect of USDL and expedite the standardization process. Secondly, through the case studies we can anticipate what will be happened in the several years, thus business actors and the CIOs can make a better preparation or decision for their IT-Investments.

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6.3 Future works

The study conducted in this thesis could be argued as an interdisciplinary work. Moreover, the proposed theory of Service Ecosystem is relatively still not yet well-developed and profound explored. We see that it has a tendency to be more fragmented and disorganized than established construct of knowledge. However, if such disorderliness goes with the domain of interdisciplinary, then on contrary, it what makes this field worth more to be examined further.

> "The empirical basis of objective science has thus nothing 'absolute' about it. Science does not rest upon solid bedrock. The bold structure of its theories rises, as it were, above a swamp. It is like a building erected on piles. The piles are driven down from above into the swamp, but not down into any natural or 'given' base; and if we stop driving the piles deeper it is not because we have reached firm ground. We simply stop when we are satisfied that the piles are firm enough to carry the structure, at least for the time being." [160]

The quote from Popper above connotes that a theory never be complete. Moreover, the green field of Service Ecosystem theory, is one big building site that can be in a numerous way explore. As the limitation to our work, we cannot handle all the scope of the theory viz. for analyzing, describing, supporting action, explanation and prediction. However, we provide a foundation to construct and develop the theory further. An interesting research outlook is the formalism or mathematic modeling of the theory to predict the heterogeneity agent interaction in Service Ecosystem. A controlled simulation study about the mutability and evolution of the ecosystem can give a stance to study the future economic. How the service agents or service network are globally interconnected, the collaborations between diverse Service Ecosystem, and what are the implications for the society and industry.

The formalism methodology would allow greater confidence in the theoretical result. However, such study will rather too general and hardly capable to validate the practicable appliance. To take the research in the practical venue, a qualitative study will be helpful to be conducted upon the underlying results. Apart from that, the future works may also answer one of the most challenging matters for industry and government in times of globalization of the information-intense service economy, i.e., the agility for evolving and adapting in dynamic ecosystem.

References

[1] Abe, J. M., Dempsey, Patricia E, and Bassett, David A. 1998. *Business ecology. Giving your organization the natural edge*. Butterworth-Heinemann, Boston.

[2] Ali, M., Kos, J., Lietz, P., Nugroho, D., Furqon, Zainul, A., and Emilia, E. 2011. *Quality of Education in Madrasah. Main Study*. FINAL REPORT.

[3] Alistair Barros and Uwe Kylau. 2011. Service Delivery Framework -- An Architectural Strategy for Next-Generation Service Delivery in Business Network. In *Proceedings 2011 Annual SRII Global Conference SRII 2011, 30 March - 2 April 2011, San Jose, California, USA*. IEEE Computer Society Conference Publishing Services (CPS), 47-58.

[4] Alistair Barros, Christian Baumann, Anis Charfi, Matthias Flügge, Steffen Heinzl, Tom Kiemes, Uwe Kylau, Florian Marienfeld, Norman May, Oliver Müller, Francesco Novelli, Daniel Oberle, Jonas Pattberg, Philip Robinson, Benjamin Schmeling, Wolfgang Theilmann, Heiko Witteborg, Jan Finzen, Andrea Horch, and Maximilien Kintz. 2011. *Unified Service Description Language (USDL) ‒ Service Module* Version 3.0, Milestone M5. SAP Research.

[5] Alistair Barros, Christian Baumann, Anis Charfi, Steffen Heinzl, Tom Kiemes, Uwe Kylau, Norman May, Oliver Müller, Francesco Novelli, Daniel Oberle, Philip Robinson, Benjamin Schmeling, Wolfgang Theilmann, and Heiko Witteborg. 2011. *Unified Service Description Language (USDL) ‒ Foundation Module* Version 3.0, Milestone M5. SAP Research.

[6] Alistair Barros, Christian Baumann, Anis Charfi, Steffen Heinzl, Tom Kiemes, Uwe Kylau, Norman May, Oliver Müller, Francesco Novelli, Daniel Oberle, Philip Robinson, Benjamin Schmeling, Wolfgang Theilmann, and Heiko Witteborg. 2011. *Unified Service Description Language (USDL) ‒ Functional Module* Version 3.0, Milestone M5. SAP Research.

[7] Alistair Barros, Christian Baumann, Anis Charfi, Steffen Heinzl, Tom Kiemes, Uwe Kylau, Norman May, Oliver Müller, Francesco Novelli, Daniel Oberle, Philip Robinson, Benjamin Schmeling, Wolfgang Theilmann, and Heiko Witteborg. 2011. *Unified Service Description Language (USDL) ‒ Interaction Module* Version 3.0, Milestone M5. SAP Research.

[8] Alistair Barros, Christian Baumann, Anis Charfi, Steffen Heinzl, Tom Kiemes, Uwe Kylau, Norman May, Oliver Müller, Francesco Novelli, Daniel Oberle, Philip Robinson, Benjamin Schmeling, Wolfgang Theilmann, and Heiko Witteborg. 2011. *Unified Service Description Language (USDL) ‒ Participants Module* Version 3.0, Milestone M5. SAP Research.

[9] Alistair Barros, Christian Baumann, Anis Charfi, Steffen Heinzl, Tom Kiemes, Uwe Kylau, Norman May, Oliver Müller, Francesco Novelli, Daniel Oberle, Philip Robinson, Benjamin Schmeling, Wolfgang Theilmann, and Heiko Witteborg. 2011.

Unified Service Description Language (USDL) – Pricing Module Version 3.0, Milestone M5. SAP Research.

[10] Alistair Barros, Christian Baumann, Anis Charfi, Steffen Heinzl, Tom Kiemes, Uwe Kylau, Norman May, Oliver Müller, Francesco Novelli, Daniel Oberle, Philip Robinson, Benjamin Schmeling, Wolfgang Theilmann, and Heiko Witteborg. 2011. *Unified Service Description Language (USDL) – Technical Module* Version 3.0, Milestone M5. SAP Research.

[11] Alistair Barros, Christian Baumann, Anis Charfi, Steffen Heinzl, Tom Kiemes, Uwe Kylau, Norman May, Oliver Müller, Francesco Novelli, Daniel Oberle, Philip Robinson, Benjamin Schmeling, Wolfgang Theilmann, and Heiko Witteborg. 2011. *Unified Service Description Language (USDL) Module Specifications* Version 3.0, Milestone M5. SAP Research.

[12] Alistair P. Barros and Marlon Dumas. 2006. The Rise of Web Service Ecosystems. *IT Professional* 8, 5, 31–37.

[13] Alistair, B. and Daniel, O., Eds. 2012. *Handbook of Service Description. USDL and its Methods*. Service Science: Research and Innovations in the Service Economy. Springer, New York, USA.

[14] Almeida, P. 2009. *The Service Enterprise. A Key Concept for the Sociology of Work*. VDM Verlag Dr. Müller, Saarbrücken.

[15] Alter, S. 2008. Service system fundamentals: work system, value chain, and life cycle. *IBM Systems Journal* 47, 1, 71-85.

[16] Amirrachman, A., Syafi'i, S., and Welch, A. 2009. Decentralising Indonesian Education: The Promise and the Price. In *Decentralisation, School-Based Management, and Quality*, J. Zajda and D. T. Gamage, Eds. Globalisation, Comparative Education and Policy Research. Springer Netherlands, 141–157.

[17] Anderson, C. 2006. *The long tail. Why the future of business is selling less of more*. Hyperion, New York, NY.

[18] Antonio Basile Colugnati, F., Lopes, L. C. R., and Barretto, S. F. A. 2010. *Digital Ecosystems. Third International Conference, OPAALS 2010, Aracuju, Sergipe, Brazil, March 22-23, 2010, Revised Selected Papers*. http://dx.doi.org/10.1007/978-3-642-14859-0.

[19] Asri, D. U. and Hidayat, B. 2005. Current Transportation Issues in Jakarta and its Impacts on Environment. In *Proceedings of the Eastern Asia Society for Transportation Studies*, 1792–1798.

[20] Ayachitula, N., Buco, M., Yixin Diao, Maheswaran, S., Pavuluri, R., Shwartz, L., and Ward, C. 2007. IT service management automation - A hybrid methodology to integrate and orchestrate collaborative human centric and automation centric workflows. In *Services Computing, 2007. SCC 2007. IEEE International Conference on*, 574–581.

[21] Badan Akreditasi Nasional Sekolah. *Statistik Sekolah Jakarta*. http://www.ban-sm.or.id/statistik. Accessed 8 March 2012.

[22] Baines, T., Lightfoot, H., Benedettini, O., and Kay, J. 2009. The servitization of manufacturing: A review of literature and reflection on future challenges. *Journal of Manufacturing Technology Management* 20, 5, 547–567.

[23] Barnum, B. J. S. 1994. *Nursing theory*. *Analysis, application, evaluation*. Lippincott, Philadelphia, PA.

[24] Bates, C., Haryanto, U., and Karana, K. P. 2010. 'It Was the Worst Traffic I Have Ever Seen in Jakarta'. *The Jakarta Globe* (Oct. 2010).

[25] Baumann, C., Kylau, U., and Oberle, D. 2011. *Unified Service Description Language (USDL) ~ Legal Module* Version 3.0, Milestone M5. SAP Research.

[26] Bell, D. 1999. *The coming of post-industrial society*. *A venture in social forecasting*. Basic Books, New York.

[27] Bendik Bygstad and Tor-Morten Grønli. 2011. Service Oriented Architecture and Business Innovation. In *44th Hawaii International International Conference on Systems Science (HICSS-44 2011), Proceedings, 4-7 January 2011, Koloa, Kauai, HI, USA*. IEEE Computer Society, 1–10.

[28] Beverungen, D., Knackstedt, R., Hatfield, S., Biege, S., Bollhöfer, E., Krug, C., Wienhold, D., Müller, P., Stelzer, C., and Köbler, F. 2009. *Hybride Wertschöpfung - Integration von Sach- und Dienstleistung*. PAS 1094. Beuth, Berlin.

[29] Black, S. E. and Lynch, L. M. 2004. What's driving the new economy? The benefits of workplace innovation. *The Economic Journal* 114, 493, F97-116.

[30] Blind, K. 2004. *The economics of standards*. *Theory, evidence, policy*. Elgar, Cheltenham.

[31] Bosch, J. 2009. From software product lines to software ecosystems. In *Proceedings of the 13th International Software Product Line Conference*. SPLC '09. Carnegie Mellon University, Pittsburgh, PA, USA, 111-119.

[32] Brandenburger, A. M. and Nalebuff, B. J. 1998. *Co-opetition*. *1. A revolutionary mindset that combines competition and cooperation; 2. The Game Theory strategy thatś changing the game of business*. Currency Doubleday, New York, NY.

[33] Brinkman, J. and Hartman, M. 2008. *Jakarta Flood Hazard Mapping Framework*.

[34] Bryson, J. R. and Daniels, P. W. 2007. *The handbook of service industries*. Elgar original reference. Edward Elgar, Cheltenham, UK, Northampton, MA.

[35] Bullinger, H.-J. 2006. *Service Engineering*. *Entwicklung und Gestaltung innovativer Dienstleistungen*. Springer-Verlag, s.l.

[36] Burnett, N. 2008. The Delors Report. A guide towards education for all. *European Journal of Education* 43, 2.

[37] Buxmann, P., Diefenbach, H., and Hess, T. 2011. *Die Softwareindustrie*. *Ökonomische Prinzipien, Strategien, Perspektiven*. Springer, Berlin.

[38] Cairney, T. and Speak, Gavin. 2000. *Developing a smart city*. *Understanding information technology capacity and establishing an agenda for change*. Centre for Regional Research and Innovation, University of Western Sydney, Sydney.

[39] Cali, M., Ellis, K., and Velde, D. W. t. 2008. *The contribution of services to development and the role of trade liberalisation and regulation*. http://www.odi.org.uk/resources/download/2610.pdf.

[40] Caragliu, A., Del Bo, C., and Nijkamp, P. *Smart cities in Europe*. Research memorandum / Vrije Universiteit, Faculteit der Economische Wetenschappen en Bedrijfskunde 2009,48, Amsterdam.

[41] Caro, T. M. and Girling, S. 2010. *Conservation by proxy. Indicator, umbrella, keystone, flagship, and other surrogate species*.

[42] Caspersen, J. and DiMare, J. 2008. *Making Connections. Using SOA to enable collaboration in travel and transportation*. IBM Corporation, New York, NY, USA.

[43] Central Intelligence Agency. 2011. *The World Factbook. GDP - Compoisiton by Sector*. https://www.cia.gov/library/publications/the-world-factbook/fields/2012.html. Accessed 10 March 2012.

[44] Clark, C. 1957. *The conditions of economic progress*. Macmillan, London.

[45] CNN Wire Staff. 2012. *Wikipedia, other websites back after anti-piracy bill protest*. http://edition.cnn.com/2012/01/18/tech/sopa-blackouts/index.html. Accessed 22 February 2012.

[46] Cook, M., Bhamra, T., and Lemon, M. 2006. The transfer and application of Product Service Systems: from academia to UK manufacturing firms. *Journal of Cleaner Production* 14, 17, 1455–1465.

[47] Coordinating Ministry For Economic Affairs, R. o. I. 2011. *Masterplan for Acceleration and Expansion of Indonesia Economic Development. 2011-2025*.

[48] Cortada, J. W. 1998. *Rise of the knowledge worker*. Resources for the knowledge-based economy. Butterworth-Heinemann, Boston.

[49] Couturier, H., Neidecker-Lutz, B., Schmidt, V. A., and Woods, D. 2011. *Understanding the Future Internet*. Evolved Technologist Press, New York.

[50] David, P. A. and Steinmueller, W. E. 1994. Economics of compatibility standards and competition in telecommunication networks. *Information Economics and Policy* 6, 217–241.

[51] Delors, J. 1996. *Learning: the treasure within. Report to Unesco of the International Commission on Education for the Twenty-First Century*. Unesco Publ, Paris.

[52] Demographia. 2011. *Demographia World Urban Areas*. http://www.demographia.com/db-worldua.pdf. Accessed 26 February 2012.

[53] Derfus, P. J., Maggitti, P. G., Grimm, C. M., and Smith, K. G. The Red Queen Effect. Competitive Actions and Firm Performance. *Academy of Management Journal* 51, 1, 61-80.

[54] Deutsches Institut für Normung (DIN). 2002. *Grundstruktur für die Beschreibung von Dienstleistungen in der Ausschreibungsphase*, Beuth Verlag, Berlin.

[55] Dini, P., Darking, M., Rathbone, N., Vidal, M., Hernandez, P., Ferronato, P., Briscoe, G., and Hendryx, S. 2005. *The Digital Ecosystems Research Vision: 2010 and Beyond*. European Commission - Information Society and Media.

[56] Dobzhansky, T. 1968. On Some Fundamental Concepts of Darwinian Biology. *Evolutionary Biology* 2, 1-34.
[57] Dolgin, A. 2012. *Manifesto of the new economy. Institutions and business models of the digital society*. Springer, Berlin ;, Heidelberg.
[58] Domschke, W. and Wagner, B. 2005. Models and methods for standardization problems. *European Journal of Operational Research* 162, 3, 713–726.
[59] Dubin, R. 1978. *Theory building*. Free Pr, New York.
[60] Eberl, U. 2011. *Zukunft 2050. Wie wir schon heute die Zukunft erfinden*. Beltz & Gelberg, Weinheim.
[61] Ehrlich, P. R. and Raven, P. H. Butterflies and Plants: A Study in Coevolution. *Evolution* 18, 4, 586-608.
[62] El-Shagi, M. 2004. *Die neue Ökonomie*. Centaurus-Verl.
[63] Engelhardt, W. H., Kleinaltenkamp, M., and Reckenfelderbäumer, M. 1993. Leistungsbündel als Absatzobjekte. Ein Ansatz zur Überwindung der Dichotomie von Sach- und Dienstleistungen. *Schmalenbachs Zeitschrift für betriebswirtschaftliche Forschung*.
[64] European Communities. 2009. *Future Internet 2020. Visions of an Industry Expert Group*. European Commission - Information Society and Media, Belgium.
[65] Ferrarui, R., Guarino, N., Trampus, R., Laskey, K., Hartman, A., and Gangadharan, G. R. 2012. Service System Approaches. Conceptual Modeling Approaches for Services Sciences. In *Handbook of Service Description. USDL and its Methods*, B. Alistair and O. Daniel, Eds. Service Science: Research and Innovations in the Service Economy. Springer, New York, USA, 75–110.
[66] Fischedick, M. and Lechtenböhmer, S. 2012. Smart City. Schritte auf dem Weg zu einer CO2-armen Stadt. In *Smart Energy. Wandel zu einem nachhaltigen Energiesystem*, H.-G. Servatius, U. Schneidewind and D. Rohlfing, Eds. Springer, Berlin [u.a.], 395–414.
[67] Flick, U. 2009. *An introduction to qualitative research*. SAGE, Los Angeles ;, London.
[68] Fourastié, J. and Lutz, B. 1969. *Die grosse Hoffnung des 20. Jahrhunderts*. Bund-Verlag.
[69] G. Booch, J. Rumbaugh, and I. Jacobson. 2005. *Unified Modeling Language User Guide*. Addison-Wesley Object Technology Series. Addison-Wesley Professional.
[70] Galeotti, A. and Goyal, S. 2002. Network Formation with Heterogeneous Players. *SSRN Journal*.
[71] Garud, R. and Kumaraswamy, A. Technological and organizational designs for realizing economies of substitution. In *The strategic management of intellectual capital and organizational knowledge*. Oxford Univ. Press, Oxford [u.a.].
[72] Gautschi, D. and Ravichandran, T. *Industrialization of Services: An Agenda for a Scientific Management Approach to Services*.
[73] Georgios Tselentis, John Domingue, Alex Galis, Anastasius Gavras, David Hausheer, Srdjan Krco, Volkmar Lotz, and Theodore Zahariadis, Eds. 2009. *Towards the Future Internet – A European Research Perspective*. IOS Press, Amsterdam, The Netherlands.

[74] Gerard Briscoe and Philippe De Wilde. 2007. Digital Ecosystems: Evolving Service-Orientated Architectures. *CoRR* abs/0712.4102.

[75] Gershuny, J. I. and Miles, I. D. 1983. *The New Service Economy*. *The transformation of employment in industrial societies*. Pinter, London.

[76] Gharajedaghi, J. and Ackoff, R. L. 1994. Mechanisms, organisms and social systems. In *Tsoukas : Haridimos*. Butterworth-Heinemann, Oxford, 25–39.

[77] Giffinger, R., Fertner, C., Kramar, H., Kalasek, R., Nataša, P.-M., and Meijers, E. 2007. *Smart cities*. *Ranking of European medium-sized cities*. Final report. Vienna: Centre of Regional Science, Vienna.

[78] Graedel, T. E. and Allenby, B. R. 1995. *Industrial ecology*. Prentice Hall, Englewood Cliffs, N.J.

[79] Gregor, S. 2002. A Theory of Theories in Information Systems. In *Information systems foundations*. *Building the theoretical base*, S. D. Gregor and D. N. Hart, Eds. Australian National University, Canberra, 1–20.

[80] Grönroos, C. 2007. *Service management and marketing*. *Customer management in service competition*. Wiley, Chichester.

[81] Groover, M. P. 2008. *Automation, production systems, and computer-integrated manufacturing*. Pearson/Prentice Hall, Upper Saddle River, N.J.

[82] Haas, Tigran. 2008. *New Urbanism and beyond*. *Designing cities for the future*. Rizzoli, New York.

[83] Hardcastle, W. A. 2009. *Qualitative analysis*. Royal Society of Chemistry.

[84] Hayes, B. 2008. Cloud computing. *Commun. ACM* 51, 9-11.

[85] Hefley, B. and Murphy, W. 2008. *Service Science, Management and Engineering*. *Education for the 21st Century*. Service science. Springer-Verlag, s.l.

[86] Henry Chesbrough and Jim Spohrer. 2006. A research manifesto for services science. *Commun. ACM* 49, 7, 35–40.

[87] Hilpinen, R. 2011. Artifact. In *The Stanford Encyclopedia of Philosophy*, Edward N. Zalta, Ed.

[88] Hobsbawm, E. J. 1996. *The age of revolution 1789-1848*. Vintage Books, New York.

[89] Hsu, C. *Service Enterprise Integration*. *An Enterprise Engineering Perspective*. http://deposit.d-nb.de/cgi-bin/dokserv?idn=985585994.

[90] Hudson, P. 1992. *The Industrial Revolution*. Reading history. Arnold, London.

[91] Hungenberg, H. and Wulf, T. 2011. *Grundlagen der Unternehmensführung*. *Einführung für Bachelorstudierende*. Springer-Lehrbuch. Springer, Berlin.

[92] Iansiti, M. and Levien, R. 2004. Strategy as ecology. *Harv Bus Rev* 82, 3, 68-78, 126.

[93] Iansiti, M. and Levien, R. 2004. *The keystone advantage*. *What the new dynamics of business ecosystems mean for strategy, innovation, and sustainability*. Harvard Business School Press, Boston, Mass.

[94] IBM. 2012. *A Smarter Planet - Overview*. http://www.ibm.com/smarterplanet/uk/en/overview/ideas/. Accessed 23 February 2012.

[95] Indonesian Ministry of Education. 2011. *Ikhtisar Data Pendidikan Nasional*. *Tahun 2009 / 2010*. http://www.pdsp.kemdiknas.go.id/Pages/DaftarStatistikPendidikan.aspx. Accessed 8 March 2012.

[96] Institut für Arbeitsmarkt- und Berufsforschung. 2012. *Berufe im Spiegel der Statistik*. *Sozialversicherungspflichtig Beschäftigte*. http://bisds.infosys.iab.de/bisds/result?region=19&beruf=AB0&qualifikation=2. Accessed 22 February 2012.

[97] Jakarta Globe. 2010. *Indonesia Tops World Twitter Rankings*. http://www.thejakartaglobe.com/home/indonesia-tops-world-twitter-rankings/390851. Accessed 20 March 2012.

[98] James F. Moore. 1993. *Business Ecosystem*. *Proven models*. http://www.provenmodels.com/574. Accessed 19 February 2012.

[99] JICA and National Development Planning Agency (BAPPENAS). 2004. *The Study on Integrated Transportation Master Plan (SITRAMP) for the The Study on Integrated Transportation Master Plan (SITRAMP) for the Jabodetabek Phase 2. Final Report*. *Technical Report*, Jakarta, Indonesia.

[100] Johansen, J., Karmarkar, U. S., Nanda, D., and Seidmann, A. 1995. Computer Integrated Manufacturing: Empirical Implications for Industrial Information Systems. *Journal of Management Information Systems* 12, 2, 59–82.

[101] Jones, D. and Gregor, S. 2007. The Anatomy of a Design Theory. Journal of the Association for Information Systems. *Article 19* Vol. 8, Iss. 5.

[102] Jones, D. C., Ed. 2003. *New economy handbook*. Elsevier; Academic Press, Amsterdam, Heidelberg, San Diego, Calif.

[103] Kahin, B. and Varian, H. R. 2000. *Internet publishing and beyond*. *The economics of digital information and intellectual property*. MIT Press, Cambridge, Mass., London.

[104] Kandiah, G. and Gossain, S. 1998. Reinventing value: The new business ecosystem. *Strategy & Leadership* 26, 5, 28–33.

[105] Karmarkar, U. S. 2010. The industrialization of information services. In *Handbook of service science*. Springer, New York, NY, 420–435.

[106] Katz, M. L. and Shapiro, C. 1985. Network Externalities Competition and Compatibility. *American Economic Review* 75, 3, 424-440.

[107] Kauffman, S. A. 1993. *The origins of order*. *Self-organization and selection in evolution*. Oxford Univ. Press, New York.

[108] Kauffman, S. A. 1995. *At home in the universe*. *The search for laws of self-organization and complexity*. Oxford Univ. Press, New York, NY.

[109] Kauffman, S. A. 1995. Escaping the red queen effect. *The McKinsey Quarterly* 1, 1, 118-129.

[110] Kayastha, S. 2011. Defining Service and Non-service Exchanges. *Service Science* 3, 4, 313–324.

[111] Kelly, K. 1999. *New rules for the new economy*. Fourth Estate.

[112] Kennedy, J., Vidal, M., and Masuch, C. 2007. Digital Business Ecosystems (DBE). In *Digital EcoSystems and Technologies Conference, 2007. DEST '07. Inaugural IEEE-IES*, 1.

[113] Kim, H., Lee, J.-N., and Han, J. 2010. The role of IT in business ecosystems. *Commun. ACM* 53, 151-156.

[114] Kim, W. C. and Mauborgne, R. 2007. *Blue ocean strategy*. *How to create uncontested market space and make the competition irrelevant*. Harvard Business School Press, Boston, Mass.

[115] King, E., Aarons, A., Crouch, L., Iskandar, S., Larisson, J., and Moegihadi, H. 2004. *Education in Indonesia Managing the Transition to Decentralization*. http://siteresources.worldbank.org/EDUCATION/Resources/278200-1099079877269/547664-1099080026826/Edu_Indonesia.pdf. Accessed 8 March 2012.

[116] Klodt, H. 1997. *The transition to the service society*. *Prospects for growth, productivity and employment*. Kiel working paper 839. Inst. of World Economics, Kiel.

[117] Kun, G. 2003. Low Labor-Input Technology Utilization in the Construction Industry. *Joint International Symposium of CIB Working Commissions Knowledge Construction* 2003.

[118] Kylau, U., Stollberg, M., Weber, I., and Barros, A. 2012. Service Functionality and Behavior. In *Handbook of Service Description*. *USDL and its Methods*, B. Alistair and O. Daniel, Eds. Service Science: Research and Innovations in the Service Economy. Springer, New York, USA, 269–293.

[119] Laskowski, M. 2009. E-DeMa. In *E-Energy*, A. Picot and K.-H. Neumann, Eds. Springer Berlin Heidelberg, 51–58.

[120] Le Roy, Czakon, W., and Gnyawali, D. 2009. On the theory of coopetition. *Journal of Entrepreneurship*, 3-4.

[121] León Rivera, L. and Dini, P. 2008. *Digital Ecosystems in the EULAKS Project: Research context and strategies for the introduction of the Digital Ecosystem concept at the regional level*. London School of Economics and Political Science, London, UK.

[122] Levy, D. 1999. When Private Higher Education Does Not Bring Organizational Diversit. Argentina, China, Hungary. In *Private Prometheus*. *Private higher education and development in the 21st century*, P. G. Altbach, Ed. Contributions to the study of education no. 77. Greenwood Press, Westport, Conn, 17–50.

[123] Levy, D., Ed. 2002. *Unanticipated Development*. *Perspectives on Private Higher Education's Emerging Roles*.

[124] Liebowitz, S. J. and Margolis, S. E. 1995. Path Dependence, Lock-In, and History. *Journal of Law, Economics, and Organization* 11, 1, 205–226.

[125] Lively, C. M., Craddock, C., and Vrijenhoek, R. C. 1990. Red Queen hypothesis supported by parasitism in sexual and clonal fish. *Nature* 344, 6269, 864–866.

[126] Locke, S. 2004. ICT adoption and SME growth in New Zealand. *Intelligence* 4, 1/2, 93–102.

[127] Lovelock, C. and Gummesson, E. 2004. Whither Services Marketing?: In Search of a New Paradigm and Fresh Perspectives. *j serv res* 7, 1, 20–41.

[128] Lovelock, C. H. 2011. Classifying Services to Gain Marketing. *Journal of Marketing* 47, 3, 9-20.

[129] Luftman, J. 2003. Assessing It/Business Alignment. *Information Systems Management* 20, 4, 9–15.

[130] Lundberg, A. *Press Release Business Ecology Initiative*, Needham, MA, USA. http://www.omg.org/news/releases/pr2011/01-11-11.htm.

[131] Ma, J., Asomaning, K., and Kulishenko. 2010. *What is Service Science, Management, Engineering, and Design (SSMED)?*

[132] Maglio, P. P. and Spohrer, J. 2008. Fundamentals of service science. *Journal of the Academy of Marketing Science* 36, 1, 18–20.

[133] Maglio, P. P., Kieliszewski, C. A., and Spohrer, J. C. *Handbook of Service Science*. http://dx.doi.org/10.1007/978-1-4419-1628-0.

[134] Marienfeld, F., Höfig, E., Bezzi, M., Flügge, M., Pattberg, J., Serme, G., Brucker, A. D., Robinson, P., Dawson, S., and Theilmann, W. 2012. Service Levels, Security, and Trust. In *Handbook of Service Description*. *USDL and its Methods*, B. Alistair and O. Daniel, Eds. Service Science: Research and Innovations in the Service Economy. Springer, New York, USA, 295–326.

[135] McCarthy, I. P. 2003. Technology management - a complex adaptive systems approach. *International Journal of Technology Management* 25, 8, 728.

[136] McDermott, M. 2011. *Organism Is the Wrong Construct for Business Ecology*. http://blog.business-ecology.org/2011/06/organism-is-the-wrong-construct-for-business-ecology.html.

[137] McKelvey, B. 1999. Avoiding Complexity Catastrophe in Coevolutionary Pockets: Strategies for Rugged Landscapes. *Organization Science* 10, 3, 294–321.

[138] McKnight, L. W. and Bailey, J. P. 1997. An introduction to internet economics. In *Internet economics*, L. W. McKnight and J. P. Bailey, Eds. MIT Press, Cambridge, MA, USA, 3-24.

[139] McKnight, L. W. and Bailey, J. P., Eds. 1997. *Internet economics*. MIT Press, Cambridge, MA, USA.

[140] Meier, G. M. and Rauch, J. E. 2000. *Leading issues in economic development*. Oxford University Press, New York, Oxford.

[141] Michael Armbrust, Armando Fox, Rean Griffith, Anthony D. Joseph, Randy H. Katz, Andrew Konwinski, Gunho Lee, David A. Patterson, Ariel Rabkin, and Matei Zaharia. 2009. *Above the Clouds: A Berkeley View of Cloud Computing*. UC Berkeley Reliable Adaptive Distributed Systems Laboratory, Berkeley.

[142] Mitleton-Kelly, E. and Papaefthimiou, M. C. 2000. Co-evolution and an enabling infrastructure: a solution to legacy? In *Systems engineering for business process change*. *Collected papers from the EPSRC research programme*. Springer, London ;, New York, 164–181.

[143] Mitra Barun Sarkar, Brian S. Butler, and Charles Steinfield. 1995. Intermediaries and Cybermediaries: A Continuing Role for Mediating Players in the Electronic Marketplace. *J. Computer-Mediated Communication*, -1-1.
[144] Mont, O. 2004. *Product-service systems,* Univ.
[145] Moore, J. F. 1993. Predators and Prey: A New Ecology of Competition. *Harvard Business Review* 71, 3, 75-86.
[146] Moore, J. F. 1997. *The death of competition. Leadership and strategy in the age of business ecosystems*. Harperbusiness, New York (N.Y.).
[147] Mueller, U. G., Poulin, J., and Adams, R. M. M. 2004. Symbiont choice in a fungus-growing ant (Attini, Formicidae). *Behavioral Ecology* 15, 2, 357–364.
[148] Murray, K. B. and Schlacter, J. L. 1990. The impact of services versus goods on consumers' assessment of perceived risk and variability. *JAMS* 18, 1, 51–65.
[149] Musson, D. 2002. Corporate Governance and IT Governance. Exploring the board ' s perspective. *Computing,* SOX.
[150] Nachira, F., Dini, P., Nicolai, A., Le Louarn, M., and Rivera Lèon, L. 2007. A Network of Digital Business Ecosystems for Europe. Roots, Processes, and Prespectives. In *Digital Business Ecosystem*, F. Nachira, P. Dini, A. Nicolai, M. Le Louarn and L. Rivera Lèon, Eds. 6. Luxembourg: Office for Official Publications of the European Communities, Luxembourg, 5–24.
[151] Nagle, T. T., Hogan, J. E., and Zale, J. 2011. *The strategy and tactics of pricing. A guide to growing more profitably*. Prentice Hall, Boston.
[152] Orestis Terzidis, Alistair Barros, Andreas Friesen, and Daniel Oberle. 2012. The Internet of Services and USDL. In *Handbook of Service Description. USDL and its Methods*, B. Alistair and O. Daniel, Eds. Service Science: Research and Innovations in the Service Economy. Springer, New York, USA, 1–20.
[153] Orestis Terzidis, Axel Fasse, Barbara Flügge, Markus Heller, Kay Kadner, Daniel Oberle, and Thorsten Sandfuchs. 2011. Texo: Wie THESEUS das Internet der Dienste gestaltet -- Perspektiven der Verwertung. In *Internet der Dienste*, Lutz Heuser and Wolfgang Wahlster, Eds. acatech diskutiert. Springer, 141–161.
[154] Parasuraman, R. and Mouloua, M. 1996. *Automation and human performance. Theory and applications*. Human factors in transportation. Lawrence Erlbaum Associates, Mahwah, NJ.
[155] Peppard, J. and Breu, K. 2003. Beyond Alignment: A Coevolutionary View of the Information Systems Strategy Process. *Information Systems Journal*, 743-750.
[156] Perry, M. 1990. Business service specialization and regional economic change. *Regional studies*.
[157] Perry, W. 1977. *The Open University*. Jossey-Bass Publishers, San Francisco.
[158] Perry, W. 1988. *The Open University*. Open University Press, Milton Keynes.
[159] Petrie, C. and Bussler, C. 2008. The Myth of Open Web Services: The Rise of the Service Parks. *IEEE Internet Computing* 12, 3, 96–95.
[160] Popper, K. 1978. *Unended quest. An intellectual autobiography*. Fontana, London.

[161] Publishing, O. 2010. *Trends Shaping Education 2010*. OECD, s.l.

[162] Pusat Data dan Informasi. 2010. *Statistik Perhubungan 2010*. *Transportation Statistics*. Buku 1. Ministry of Transportation - Republic of Indonesia, Jakarta, Indonesia.

[163] Pusat Data dan Informasi. 2010. *Statistik Perhubungan 2010*. *Transportation Statistics*. Buku 2. Ministry of Transportation - Republic of Indonesia, Jakarta, Indonesia.

[164] Quah, D. *Digital goods and the new economy*. Discussion papers / Centre for Economic Performance 563. Centre for Economic Performance, London.

[165] Rabindra, K. and Jena, N. W. 2010. Cloud Computing. Need of the Hour. In *Proceedings of ISCET 2010*, 44.

[166] Rachel E. Kranton and Deborah F. Minehart. 2001. A Theory of Buyer-Seller Networks. *American Economic Review* 91, 3, 485–508.

[167] Raso-Zapata, I. S., Leenheer, P. D., Gordijn, J., and Akkermans, H. 2012. Service Network Approaches. In *Handbook of Service Description*. *USDL and its Methods*, B. Alistair and O. Daniel, Eds. Service Science: Research and Innovations in the Service Economy. Springer, New York, USA, 45–74.

[168] Rathmell, J. M. 1996. What is Meant by Services ? *The Journal of Marketing* 30, 4, 32-26.

[169] Richardson, G. 1972. The organisation of industry. *Economic Journal* 82, 327, 883–896.

[170] Roberta Ferrario and Nicola Guarino. Towards an Ontological Foundation for Services Science FIS 2008, Vienna, Austria, September 29-30, 2008, Revised Selected Papers. In . Lecture Notes in Computer Science, 152–169.

[171] Roberta Ferrario and Nicola Guarino. 2008. Towards an Ontological Foundation for Services Science. In *Future Internet - FIS 2008, First Future Internet Symposium, FIS 2008, Vienna, Austria, September 29-30, 2008, Revised Selected Papers*. Lecture Notes in Computer Science. Springer, 152–169.

[172] Rodrigue, J.-P., Comtois, C., and Slack, B. 2009. *The geography of transport systems*. Routledge, London.

[173] Rogers, E. M. and Gauntlett, D. 2001. The Digital Divide. *Convergence: The International Journal of Research into New Media Technologies* 7, 4, 96-111.

[174] Roy, R. 2000. Sustainable product-service systems. *Futures* 32, 3-4, 289–299.

[175] Rudd, J. 2009. *Education for a Smarter Planet*. *The Future Learning*. CIO Report on Enabling Technologies. http://www.redbooks.ibm.com/redpapers/pdfs/redp4564.pdf. Accessed 8 March 2012.

[176] Rudd, J., Sullivan, P., King, M., Bouchard, F., Turner, K., Olson, M., Schroeder, K., and Kaplan, A. 2011. *Education for a Smarter Planet*. *The Future of Learning*. Executive Insight.

[177] Ruth Sara, A.-S. 2004. Business process modelling: Review and framework. Production Planning and Control. *International Journal of Production Economics* 90, 2, 129–149.

[178] Sampson, S. E. 2000. Customer-supplier duality and bidirectional supply chains in service organizations. *International Journal of Service Industry Management* 11, 4, 348-364.

[179] Sampson, S. E. 2010. The unified service theory. A paradigm for service science. In *Handbook of service science*. Springer, New York, NY [u.a.], 107–131.

[180] Sampson, S. E. and Froehle, C. M. 2006. Foundations and Implications of a Proposed Unified Services Theory. *Production and Operations Management* 15, 2, 329-343.

[181] SAP Research. 2011. *SAP TEXO CEBIT Integrierte Werkzeugkette*. Accessed 22 February 2012.

[182] SAP Research. 2012. *USDL Editor*. SAP Research.

[183] Satchell, P. M. 1998. *Innovation and automation*. Ashgate, Aldershot, England.

[184] Schade, S. and Buxmann, P. 2005. *A Prototype to Analyse and Support Standardization Decisions* 35795. Darmstadt Technical University, Department of Business Administration, Economics and Law, Institute for Business Studies (BWL).

[185] Schäffler, M., Thede, A., Leferink, B., Kadner, K., Horch, A., Kintz, M., Weidman, M., and Weiten, M. 2012. Case Studies. In *Handbook of Service Description. USDL and its Methods*, B. Alistair and O. Daniel, Eds. Service Science: Research and Innovations in the Service Economy. Springer, New York, USA, 465–486.

[186] Schmeling, H., Leidig, H., Sandfuchs, D., and Allgeier, K. 2012. Enabling USDL by Tools. In *Handbook of Service Description. USDL and its Methods*, B. Alistair and O. Daniel, Eds. Service Science: Research and Innovations in the Service Economy. Springer, New York, USA, 385–414.

[187] Schmidt, A. 2005. *Prozessorientiertes Service Management: CobiT*. Grin Verlag, s.l.

[188] Schöler, A. 2004. Service Automation - Unterstützung der Serviceprozesse im Front- und Back-Office. In *IT-Systeme im CRM. Aufbau und Potenziale*. Gabler, Wiesbaden.

[189] Servatius, H.-G., Schneidewind, U., and Rohlfing, D., Eds. 2012. *Smart Energy. Wandel zu einem nachhaltigen Energiesystem*. Springer, Berlin [u.a.].

[190] Singh, N. *Services-led industrialization in India. Assessment and lessons*. http://sccie.ucsc.edu/workingpaper/2006/Singh_IndDev21stC_Nov2006.pdf.

[191] Slepniov, D., Waehrens, B. V., and Johansen, J. 2010. Servitization as a Stragey for Survival: an Investigation of The Process in Danish Manufacturing Firms. *Cambridge International Manufacturing Symposium,* 15.

[192] socialbakers.com. 2012. *Leading countries based on number of Facebook users as of January 26, 2012 (in millions)*. http://www.statista.com/statistics/157705/top-15-countries-by-number-of-facebook-users/. Accessed 20 March 2012.

[193] Soley, R. 2010. Business ecology in the digital ecosystem. In *Digital Ecosystems and Technologies (DEST), 2010 4th IEEE International Conference on*, 102.

[194] Spath, D. 2009. *Das Internet der Dienste. Neue Wege durch Service-basierte E-Business-Anwendungen in Marketing und Vertrieb ; Anwenderforum Stuttgarter E-Business-Tage 2009, 03. November 2009, Institutszentrum Stuttgart der Fraunhofer-Gesellschaft*. Fraunhofer Verlag, Stuttgart.

[195] Spillner, J., Kursawe, R., and Schill, A. 2011. *Case Study on Extending Internet of Services Techniques to Real-World Services*. Technische Universitat Dresden - Faculty of Computer Science.

[196] Spohrer, J. 2006. Service innovations, employment and exports. In *Moderne Dienstleistungen*. Campus-Verl, Frankfurt/Main [u.a.], 27–33.

[197] Spohrer, J. and Kwan, S. K. 2008. Service Science Management Engineering and Design (SSMED): Outline & References. *Foundations* 1, 3, 1-31.

[198] Spohrer, J. and Maglio, P. P. 2010. Service Science: Toward a Smarter Planet. In *Introduction to Service Engineering*. John Wiley & Sons, Inc, 1-30.

[199] Stampfl, N. S. 2011. Industrialisierung der Servicewelt: Dienstleistungen am laufenden Band. In *Die Zukunft der Dienstleistungsökonomie*, N. S. Stampfl, Ed. Springer Berlin Heidelberg, Berlin, Heidelberg, 119–158.

[200] Stampfl, N. S., Ed. 2011. *Die Zukunft der Dienstleistungsökonomie*. Springer Berlin Heidelberg, Berlin, Heidelberg.

[201] Stern, C. W. and Deimler, M. S. 2006. *The Boston Consulting Group on strategy*. Wiley, Hoboken, NJ.

[202] Susanne, D. and Mary, K. 2009. *A vision of smarter cities*. *How cities can lead the way into a prosperous and sustainable future*. IBM Corporation, United States of America.

[203] Susanne, D., Mary, K., and Gurdgiev, C. 2010. *Smarter cities for smarter growth*. *How cities can optimize their systems for the talent-based economy*. IBM Corporation, United States of America.

[204] Swann, G. M. P. 2000. The economics of standardization: final report for Standards and Technical Regulations Directorate. *Final Report for Standards and Technical Regulations Directorate Department of Trade and Industry*.

[205] Swann, G. M. P. 2010. The economics of standardization: an update. *Psychology and psychotherapy* 77, March, 1-83.

[206] Tadjudin, M. K. 2005. Country Paper on Indonesia. Higher education in Indonesia and The Role of Cross-Border Higher Education. *UNESCO Forum Occasional Paper Serie* Regional Seminar for Asia Pacific, 9.

[207] Taylor, S. 2007. *ITIL*. *[IT service management practices ; ITIL v3 core publications]*. TSO, London.

[208] The Coordinating Ministry of Economic Affairs and Japan International Cooperation Agency. 2010. *JABODETABEK Urban Transportation Policy Integration*. http://jutpi.com/. Accessed 28 February 2012.

[209] The Open University. 2012. *History of the OU*. http://www8.open.ac.uk/about/main/the-ou-explained/history-the-ou. Accessed 8 March 2012.

[210] The Open University Of Japan. 2012. *Overview*. http://www.ouj.ac.jp/eng/about/overview.html. Accessed 8 March 2012.

[211] The World Bank. 2011. *Jakarta Urgent Flood Mitigation Project*. *(Jakarta Emergency Dredging Initiative)*.

http://web.worldbank.org/external/projects/main?pagePK=64283627&piPK=73230&theSitePK=226309&menuPK=287105&Projectid=P111034. Accessed 3 March 2012.

[212] Thomas, O. 2009. *Dienstleistungsmodellierung. Methoden, Werkzeuge und Branchenlösungen*. Physica-Verl; Physica, Heidelberg.

[213] Tobias Ackermann, Thomas Widjaja, and Peter Buxmann. 2009. Increasing the Diffusion of Communication Standards - A General Simulation Framework from the Vendor?s Perspective. In *Proceedings of the 6th International Conference on Standardization and Innovation in Information Technology (SIIT 2009)*, 1-14.

[214] Townsend, A. K. 2006. *Green business. A five-part model for creating an environmentally responsible company*. Schiffer Pub., Atglen, PA.

[215] Townsend, A. K. 2009. *Business ecology. Why most green business practices don't work : and what to do about it*. Schiffer Pub., Atglen, Pa.

[216] Tselentis, G. and Galis, A. 2010. *Towards the future internet. Emerging trends from European research ; [FIA, the Future Internet Assembly]*. IOS Press, Amsterdam.

[217] Uckelmann, D., Harrison, M., and Michahelles, F. 2011. *Architecting the Internet of Things*. Springer Berlin Heidelberg, Berlin, Heidelberg.

[218] UK Trade & Investment. 2011. *Smart Cities Of The Future In Asia. The Opportunities For UK Business*. Interim finding. UK Trade & Investment, United Kingdom.

[219] UK Trade & Investment. 2012. *Smart Cities Of The Future In Asia. The Opportunities For UK Business*. UK Trade & Investment, United Kingdom.

[220] van Kranenburg, R. and Dodson, S. 2008. *The internet of things. A critique of ambient technology and the all-seeing network of RFID*. Institute of Network Cultures, Amsterdam.

[221] VanDerMerwe, S. and Rada, J. F. 1988. Servitization of business. Adding value by adding services. *European management journal*.

[222] Vaquero, L. M., Rodero-Merino, L., Caceres, J., and Lindner, M. 2008. A break in the clouds: towards a cloud definition. *SIGCOMM Comput. Commun. Rev* 39, 50-55.

[223] Vargo, S. L. and Lusch, R. F. 2008. Evolving to a new dominant logic for marketing. *The history of marketing thought*, 253–283.

[224] Vargo, S. L. and Lusch, R. F. 2008. Service-dominant logic. Continuing the evolution. *Journal of the Academy of Marketing Science* 36, 1, 1–10.

[225] Veneris, Y. 1984. *The Informational Revolution, Cybernetics and Urban Modelling*. PhD Thesis, University of Newcastle upon Tyne.

[226] Veneris, Y. 1990. Modelling the transition from the industrial to the informational revolution. *Environment and Planning A* 22, 3, 399–416.

[227] Vidgen, R. and Wang, X. 2007. From business process management to business process ecosystem. *Journal of Information Technology* 21, 4, 262-271.

[228] W3C. *Web Services Architecture*. http://www.w3.org/TR/ws-arch/. Accessed 3 March 2012.

[229] Walls, J., Widmeyer, G., and Sawy, O. E. 1992. Building an Information System Design Theory for Vigilant EIS. *Information Systems Research* 3,, 1, 36–59.

[230] Wasserman, S. and Faust, K. 2009. *Social network analysis. Methods and applications*. Structural analysis in the social sciences 8. Cambridge Univ. Press, Cambridge.

[231] Weeks, R. and Du Plessis, J. 2011. Servitization: Developing a business model to translate corporate strategy into strategic projects. In *Technology Management in the Energy Smart World (PICMET), 2011 Proceedings of PICMET '11*, 1–10.

[232] Weitzel, T., Beimborn, D., and Konig, W. 2006. A unified economic model of standard diffusion: The impact of standardization cost network effects and network topology. *MIS Quarterly* 30, August, 489-514.

[233] Welch, A. R. 2006. Blurred Vision?: Public and Private Higher Education in Indonesia. *Higher Education* 54, 5, 665-687.

[234] Wikipedia. *Anti-Counterfeiting Trade Agreement*. http://en.wikipedia.org/wiki/Anti-Counterfeiting_Trade_Agreement. Accessed 22 February 2012.

[235] Wikipedia. *PROTECT IP Act*. http://en.wikipedia.org/wiki/PROTECT_IP_Act. Accessed 22 February 2012.

[236] Wikipedia. *The Stop Online Piracy Act*. http://en.wikipedia.org/wiki/SOPA. Accessed 22 February 2012.

[237] Wikipedia. 2012. *OpenCourseWare*. http://en.wikipedia.org/wiki/OpenCourseWare. Accessed 8 March 2012.

[238] Williamson, O. E. 2008. Transaction-cost economics. The governance of contractual relations. In *Supply chain management*. Routledge, London [u.a.], 99–127.

[239] Wong, D. 2011. *The Other Half Of The Research In Motion Story: Canada, U.K. And Emerging Markets*. http://seekingalpha.com/article/310921-the-other-half-of-the-research-in-motion-story-canada-u-k-and-emerging-markets. Accessed 20 March 2012.

[240] World Bank. 2012. *World Bank and Education in Indonesia*. http://web.worldbank.org/wbsite/external/countries/eastasiapacificext/indonesiaextn/0,,contentMDK:21521167~pagePK:1497618~piPK:217854~theSitePK:226309,00.html. Accessed 8 March 2012.

[241] World Bank. 2012. *SME Statistics*. http://siteresources.worldbank.org/CGCSRLP/Resources/SME_statistics.pdf. Accessed 22 February 2012.

[242] Yulaelawati, E. 2000. *Education Reform in Indonesia: Contexts and Challenges in New Times*. http://www.ibe.unesco.org/curriculum/Asia%20Networkpdf/indonesia.pdf. Accessed 8 March 2012.