Service Ecosystem Evolution and Controlling: A Research Framework for the Effects of Dynamic Services

Yi Liu
Department of Automation
Tsinghua University
Beijing, China
yi-liu10@mails.tsinghua.edu.cn

Yushun Fan
Department of Automation
Tsinghua University
Beijing, China
fanyus@tsinghua.edu.cn

Keman Huang
Department of Automation
Tsinghua University
Beijing, China
hkm09@mails.tsinghua.edu.cn

***Abstract*- The correlations between services, service vendors and service platform, as well as environmental factors weave the service system into a complex ecosystem. Dynamic factors introduce continuous co-revolution to the system. Seeing the dynamic mechanism of service ecosystem is the premise of reforming and controlling the system. A research framework is proposed in this paper, which is built to explore what are the changes of services, which indicators can be used to evaluate the effects and how the dynamic factors are spread. We clarify the definition as well as structure of service ecosystem based on recent work. Then a stereo network model for service ecosystem is built. Also, the usual dynamic activities of services are presented and discussed, and then the most crucial indicators of service ecosystem are summarized. Finally, a research framework is built, and the relevancy of the dynamic activities, correlations and indicators is given.**

Keywords-service ecosystem; dynamic service; network model; service correlation; indicators

I. INTRODUCTION

The transformation from traditional industry model of software to SaaS (Software as a Service) greatly changes the academic and economic domain of software, which brings about the prevalent research trend of service science [1]. Web service is a typical kind of delivery method for SaaS, fueled by protocols and technologies (WSDL, REST, UDDI, BPEL, and SOAP etc.) [2, 3]. A variety of service platforms emerge with services (including typical web services and open API) covering all kinds of functional domains; Examples are APP Store of Apple, Programmable Web, Salesforce, StrikeIron, and GrandCentral [4]. At the same time, service industry is attracting tremendous global attention as it has been experiencing an enormous growing in the past ten years and encapsulated nearly 80% of U.S. gross domestic product (GDP)[5, 6]. With the widely accepted SOA (Service-Oriented Architecture), we are gradually accustomed to the ubiquitous and easily accessible service, both online and offline [7].

In the service-oriented environment, the multitudinous needs of consumers make it a must for enterprises to focus on just a few process steps instead of the whole industry chain. Furthermore, the ICT (Information and communication technologies) enable the services and enterprises to collaborate with each other to satisfy the demand of consumers [8]. The sophisticated correlations between services, service vendors and consumers connect the service industry into a highly related value co-creation network, which is so called Service Ecosystem, consisting of people, organization, technology and information [9, 10]. Also service ecosystems are considered as complex adaptive systems (CAS) due to the open, dynamic and adaptive nature of people. The mechanism of self-organization and co-evolution in the system grant them with the ability of continuously getting adapted to new business challenges and opportunities [11].

Services are different from products as they involve more of human activities [12]. Due to the indeterminacy and variability of human, services bring great dynamic factors to the whole service systems. According to Wei Jiang et al [13], the WSDL of about 5% web services change in every 2 weeks out of 10,000 web services. These dynamic factors can spread through the various correlations [14, 15] between service, service compositions, their vendors etc. and thus influence the property of whole ecosystem [16]. While a lot of researches into service ecosystem evolution have been done [17-19], most of the work focuses on the engineering problems caused by service dynamics to recompose service composition[13], predict and valuate stochastic services QoS value[20, 21], as well as renegotiate between services [22] and so on. Rare research has been done on the effects of service dynamic activities on the whole service ecosystem to reveal questions including: *which of the service activities affect the system; how the effects spread in the system through the correlations; what will the effects be etc*. As no business unit or ecosystem role is isolated nowadays [23], knowing about how the ecosystem is and will be is crucial to nearly all the stakeholders in service ecosystems. Moreover, with the target of controlling the system, we have to know about the dynamic mechanism as premises. This paper aims at shedding light on the answers to the aforesaid questions. We conclude current work on the correlations in the service system to clarify the propagating channels of evolution effects for the research, and a network model is built. The most important service activities resulting in system evolution are presented. Also, the key variables for evaluating the ecosystem are demonstrated and classified. Furthermore, a research framework for dynamic services and their impacts on the service ecosystem is demonstrated.

The paper is structured as follows. In the next section, we provide the background for our research, in which the definition and structure of service ecosystem is clarified. Next, we illustrate the correlations between services and other key elements in the system. We then describe the dynamic factors of services. Also the indicators are presented to evaluate the ecosystem. Then the possible effects of dynamic impacts on the ecosystem and how they spread are discussed. Based on the previous parts, the research framework for the dynamic services is presented in section VI. Finally, future work is depicted.

II. SERVICE ECOSYSTEM

A. Definition

Ecosystem is a word originated from ecology, defined as *all the animals and plants in a particular area, and the way in which they are related to each other and to their environment* (Longman dictionary of contemporary English, 2008). In an ecosystem, animals, plants and other environmental factors are included and researched. The factors are related to each other and their activities, as well as their interactions drive the entire ecosystem to emerge, maintain, develop, deteriorate and disappear. The whole life cycle of ecosystem is referred to as the *evolution* of ecosystem. The ecosystem can be explained as two significant components: one is the dynamic units in the system while the units may have different behaviors; the other is the connections between the basic units, by which the isolated units are tied to each other and weaved into a complex network with self-organize and continuous co-evolution properties.

In modern society, business units are connected tightly and interact more frequently than ever before. The success of a company doesn't only rely on its own products and services, but also greatly depends on the business community it is in [23]. In 1993, James F. Moore [24] introduced the concept of ecosystem into business research and discussed the 4 steps in the business ecosystem life cycle, i.e. birth, expansion, leadership and self-renewal .Then in the work of 1996[25] he defined business ecosystem as follows: the business ecosystem is "an economic community supported by a foundation of interacting organizations and individuals – the organisms of the business world".

The concept of service ecosystem emerges while the traditional business mode evolved adopting the idea of SOA. And the new defined service system resembles the concept of business ecosystem largely. A service system is a value-coproduction configuration of people, technology, and other internal and external service systems [26]. In the system, the components share information and changes. With similar definition of basic components, the difference between service industry and traditional industries reveal the main distinction of service ecosystem. Service is the co-value creation process and it is the action taking place between people, which is not seen in production [27]. The service ecosystem is defined customer centric and evolves with more dynamic factors. So far, there is not commonly adopted definition for service ecosystem. G. Scheithauer [28] thinks "service ecosystems are electronic market places and emerge as a result of the shift toward service economies. The aim of service ecosystems is to trade services over the internet". In this paper, we consider service ecosystem as a community of services, consumers, service vendors, service platform operators and the environmental influences around them; these basic units interact with each other through service compose and invoke. In our definition, services in the ecosystem are not restricted to the online services; the offline services are also included.

B. Structure

Broadly speaking, the service ecosystem contains four types of crucial factors: services (service vendors), service platform operators, consumers and environmental influences. Each of the factors plays a different role in the system and desires for the health of the whole system from distinct perspectives.

Services (Service Vendors): Services are produced and delivered by service vendors to customers. In this co-value creating process, the basic function of service ecosystem is accomplished. Services are the most important factors in a service ecosystem; without the existence of service or if there are not enough services to satisfy the needs of consumers, the entire system will gradually lose the consumers and go declining.

Services in this article can be real world services and virtual services functioning as software. There are communication services, airline services, health-care services, and banking services, for example. In a highly developed service system, a service focuses on just one domain and cooperates with other services to compose more functional complex service groups and achieve sophisticated goal (The service composite process is also called *Mashup* in open API cooperation). A service vendor can supply several kinds of services, but a service can only be presented by one vendor.

Generally, function and quality of service (QoS) are two main metrics used to describe and differentiate services. Services with the same function can be considered as a cluster of individuals and called service population [7]. Functionally different service populations can cooperate with each other and organize themselves as service community [17] [7].

Service vendors represent the people or the group which produce and operate the service. So according to the changes of consumer needs and market situation, the vendors can adopt several kinds of different actions to fit the changed environment, including adjusting function, improving QoS or advertising to attract consumers [8] etc. Most of these changes can bring dynamic factors to the whole ecosystem and spread through the connections in the system (see details in section III).

Services Platform Operators: Virtual services and services trading on the internet are published on the service platform by service vendors. The service platform is built by the platform operators to provide all kinds of services to the consumers. The operators are the actual controllers and managers of the ecosystems. They have to provide clear technical standards and guidance to the service vendors. Also as the enablers between service vendors and customers, the operators gain profits relying on a prosperous, stable, robust and productive service system. Examples are the App Store of Apple Inc., Programmable Web and SalesForce [29].

As an open system, the dynamism is inevitable on the platform. Thus, it is extremely important for the operators to predict the evolution brought by dynamic factors: Realizing which direction the system is going to is the base of keeping the platform stable under dynamic factors (key services exit, QoS fluctuates etc.); Also, adopting controlling policy to encourage services innovation to continuously attract users is crucial for the platform operators when faced with the emerging demands of customers.

Consumers: In service value network (similar description for Service Ecosystem), value creation processes are started and completed when a request from consumers is raised and accomplished. As a consumer centric system, the requests of consumers decide where the whole system is going and the dynamic needs bring about evolution. For consumers, predicting the evolution result of service ecosystem makes it possible to get prepared to latent changes in the system [9].

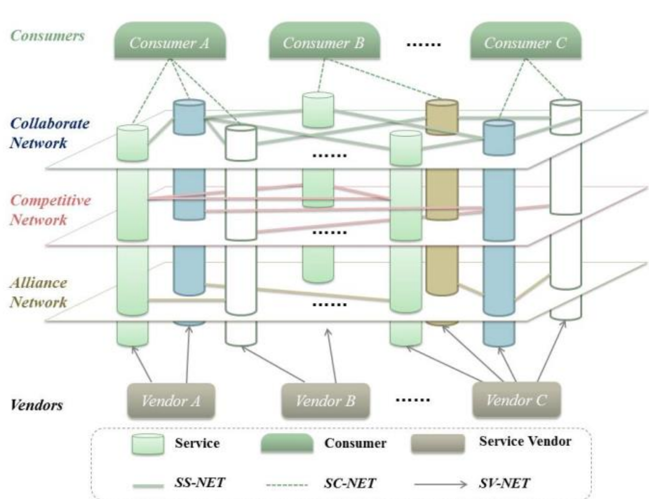
Environmental Influences: Undoubtedly, all the service ecosystems act in the context of society, culture, economy, technologies and politics [6]. The emergence of smartphone makes App store possible, and distributed computing accelerates the development of SaaS. Furthermore, while the whole global service ecosystem cannot be strictly divided, we can separate it to several sub-systems by function or platform. Thus, a service ecosystem can also by influenced by the other service ecosystems with similar function.

III. CORRELATIONS IN SERVICE ECOSYSTEM

According to the definition of service ecosystem, the services factors and their connections compose the highly connected system. Resulting from the connections, the service ecosystem becomes a complex network, which is definitely a nonlinear system. Realizing the dynamic factors spread through the ecosystem with the help of correlations, we build a stereo network model among services, service vendors and consumers.

Our network model is structured as a three-layer one, in which service-service, service-vendor and service (service composition)-consumer correlations are adopted [7]. (Shown in figure 1)

Figure 1. Service Network Model



Service-service correlations (SS-NET): Services are logically connected by their similarity in input and output parameters [34]. Services with the same inputs and outputs, and play the same role in service ecosystem are considered as competitive services. Services with matched input and output parameters can collaborate with each other and compose to satisfy complex demands.

Service-service correlations can be analyzed as three networks: the services connect with their collaborative ones connect as a ***collaborative network (cl-NET)***; connect to their competitors to compose a ***competitive network (cp-NET)***; the alliances between services connect them to be an ***alliance network (al-NET)***. In all of the three networks, services are denoted as nodes and the edges depict the relation of collaborating, competing and allying between services.

Service (service composition)-consumer correlations (SC-NET): when services or service compositions are invoked by users, the connections are established. The more the consumers invoke services, the stronger the connections become.

Service-vendor correlations (SV-NET): the services are delivered by different vendors. In this correlation, connections tie service and its vendor together. Dynamic factors spread through service network and influence vendors by service-vendor correlations, while the activities of vendor may impact the service networks in return.

IV. SERVICE DYNAMIC FACTORS

Services in the system keep altering nearly though their entire life cycle. In traditional research area, service evolution is very close to the concept of Software Evolution, used to describe activities including the introduction of new function, the modification of already existing function [30] etc.. While in real systems, these changes lead to continuous renew of systems, it is an important issue to manage the effects accompanied with the evolution. In [19], an approach for recognizing the evolution of web service with WSDL is proposed. Vasilios Andrikopoulos et al [30] demonstrated a unifying theoretical framework for controlling the evolution of services, which can deal with structural, behavioral and QoS level-induced service changes in software system. An impact analysis model based on service dependency are described by Shuying Wang[18] and they used dependency matrix to calculate the impacts on the original services compositions. Most of the work just considered the technical changes of the web services, none of the real world services and their complex intelligent activities are taken into consideration. Furthermore, little of the previous researchers did work on the spread effects on the whole ecosystem, which can be dramatically different from those on the composed services, as some of them have researched.

On synthesizing the previous work on service evolution and business evolution, we conclude services' activities which can possibly affect the whole system. Four kinds of evolution and activities of services are demonstrated as follows, i.e. structural changes, functional changes, QoS changes and intelligent activities.

A. Structural Changes

Structural changes are used to describe service activities affect the structure of the service populations directly, including ***service emergence and extinction***. After services emerge or disappear in the ecosystem, some new connections between services and service populations appear or disappear and some service populations can emerge or extinct at the same time. These changes can be very crucial changes to the system.

B. Functional Changes

Sometimes, service evolves by altering their functions. For real-world services, the functional changes can be judged by the parameters or actions they need to accomplish the service goal. As for web services, functional changes are judged by recognizing the WSDL documents [19].

Functional changes for web services can be sorted according the magnitude of altering, which can be ***functional changes*** (the changes of function descriptions), ***operation changes*** (the changes on the Web Service operations) and ***parameter changes***. For each kind of changes, the alternation can be adding, deleting or just modifying. Each of the changes may affect the other services cooperating or competing with them in service ecosystems.

C. QoS Changes

Quality is one of the most important key indicators in service science. QoS is defined as a set of indicators which stand for the nonfunctional performance from difference perspectives [20, 21, 31]. Each of the indicators can become shorter or longer, higher or lower.

Response time is the time between sending the service request and getting response from the service. Shorter response time means higher quality of services. It can alter longer or shorter according to the environment factors and the natural property of the service itself.

Execution time is an indicator more useful in online service evaluation. It is used to measure the required time for service execution. Shorter execution time means better performance.

Cost is used to present the money a service consumer needs to pay when invoking a service. Lower cost makes a service more competitive.

Concurrency number means the number of invoking requests the service can respond to at the same time. The more a service can deal concurrently, its performance will be better.

The above QoS indicators are the main ones to judge the nonfunctional performance of services, but alternation in other QoS may also influent the other services.

D. Intelligent Activities

Service individuals behave as intelligent units with service vendors behind them. Thus, when considering the dynamism brought by the services, these intelligent activities cannot be omitted.

Advertising [12]: In service ecosystems, there can be several services which offer the same function to customers and compete with each other to get more customers. Some service vendors may advertise to attract more users, and then this activity can affect the market share in the service population and influent the whole ecosystem afterwards.

Alliance [32]: Service vendors can ally with others present services which can cooperate with those offered by former ones, i.e. when users invoke the allied services together, the QoS of composite services can be high. For instance, when booking hotel and calling taxi with services from vendor A and vendor B, the cost of invoking Hotel Booking service offered by vendor A will be 75% of that when invoking the service separately. Service alliance formation and decompose will affect the invoking chance of the allied services and thus affect the services beside them.

V. SERVICE ECOSYSTEM INDICATORS

Although a lot of work has been done on the topic of service ecosystem, there is rare work on the metrics of comprehensive evaluation. When discussing the effects of dynamic service factors on services ecosystem, it is important to use specific metrics to evaluate how the system is and will become. Thus, a systematic indicator set for service ecosystem is presented as follows.

While the consumer-centric ecosystem runs aiming at meeting the requests of consumers, the indicators are also presented according to the service quality of service ecosystem. Roughly, we classify the indicators as Current Service Indicators, Sustainable Service Indicators and Stability Indicators.

A. Current Service Indicators

Current service indicators are used to evaluate the current service ability of the ecosystem, consisting of indicators as follows.

Number of Services (#S): the number of services in the service ecosystem.

Number of Service Populations (#SP): the number of service population in the service ecosystem. A service population is composed of service with similar function. This indicator shows the diversity of service ecosystem.

Number of Users (#U): the number of users who invoke services in the ecosystem in the past.

Number of Service Compositions (#SC): the number of historical service compositions in the ecosystem, which shows the ability of ecosystem to satisfy complicated demands.

Average Size of Service Compositions (SizeSC): average number of the historical composition length of all the service compositions, which shows the cooperating ability of services in the ecosystem.

Average QoS of Services (QoSS): average QoS of all the services, which shows the quality level of services in the ecosystem.

Proportion of Active Services (%AS): proportion of active services out of all the services in the ecosystem, which indicates the vitality of the whole system. The larger the indicator is, the more lively the ecosystem behaves.

Concentration Rate of Services Compositions (CRSC): indicates the heterogeneity of the number of compositions per service, the Herfindahl-Hirschman indicator (HHI) and

Pareto indicator (PI) can be used to give quantitative description.

Concentration Rate of Service Collaborations (CRS): this indicator depicts the heterogeneity of service correlations. The services having more edges in cl-NET owns larger place in correlations. The HHI and PI method can be used to give quantitative evaluation.

B. Sustainable Service Indicators

Different from the current service indicators, the sustainable indicators show the ability of continuously creating value.

Proportion of Service Emergence (%SE): the number of services appeared in a period of time out of the total number of services.

Proportion of Service Population Emergence (%SPE): the number of service population with new function appeared in a period of time out of the total number of service populations.

Proportion of Service Extinction (%SPEx): the number of services extinct in a period of time out of the total number of services.

Proportion of Service Population Extinction (%SPEx): the number of service population extinct in a period of time out of the total number of services.

C. Stability Indicators

Stability is used to demonstrate the robustness of the entire system, i.e. when several services are removed from the service network, how the function will be influenced. In this part, error tolerance and attack survivability are used as main indicators [30].

Fault Tolerance (FT): fault tolerance is used to address the service networks' stability when facing stochastic faults. This indicator measures the changes in the number of service compositions, number of service populations and the average composite length of typical composition when a small fraction f of the nodes is stochastically removed.

Attack Survivability (AS): attack survivability is used to address the service networks' stability when encountering with intentional attack. This indicator measures the same changes of indicators as Error Tolerance while this changes are detected after the fraction f of the most important services (e.g. the most connected services in the network) are removed from the service internet.

VI. RESEARCH FRAMEWORK FOR THE DYNAMIC SERVICES

With what we discussed in section III, IV and V, a research framework for the effects of dynamic services on the whole service ecosystem can be set up. Before working out the solution of this problem, three questions have to be answered firstly:

1) What kind of dynamic services can influence the ecosystem;

2) How are the dynamic factors spread in the ecosystem;

3) What changes will happen after the dynamic factors are introduces.

To structure the spreading skeleton of dynamic factors, the correlations in service ecosystem are discussed and a stereo network model is built. Then in section IV, important service dynamic activities are analyzed in detail, which offers answer to the first question and finds the start point for the whole topic. By spreading in the complex network, the dynamic factors can affect the ecosystem. In section V, an indicator system for service ecosystem is built and the indicators reveal the changes we could focus when studying the effects of dynamic services.

Not all of the effects can spread in the ecosystem through all the correlations and impact all the indicators. The relevance of service dynamic activities, correlations and ecosystem indicators are listed below.

TABLE I. RELAVENCY OF FACTORS IN THE FRAMEWORK

Dynamic Factors		**Network**	**Relevant Indicators**
Service Emergence and Extinction		All	All
Structural Changes	***functional changes***	cl-NET,al-NET,cp-NET	#SP,#U,#SC,SizeSC,CRSC,CRS,FT,AS
	operation changes	cl-NET,al-NET,cp-NET	#SP,#U,#SC,SizeSC,CRSC,CRS,FT,AS
	parameter changes	cl-NET,al-NET,cp-NET	#SP,#U,#SC,SizeSC,CRSC,CRS,FT,AS
QoS Changes	***Response time***	cl-NET,al-NET,cp-NET	#U,QoSSC,CRSC,CRS
	Execution time	cl-NET,al-NET,cp-NET	#U,QoSSC,CRSC,CRS
	Cost	cl-NET,al-NET,cp-NET	#U,QoSSC,CRSC,CRS
	Concurrency number	cl-NET,al-NET,cp-NET	#U,QoSSC,CRSC,CRS
Intelligent Activities	***Advertising***	All	%AS,%SE,CRSC,CRS
	Alliance	All	%AS,%SE,QoSSC,CRSC,CRS

VII. CONCLUSION AND FUTURE WORKS

With the widely adopting of SOA and cloud computing, traditional industries are on their way of transforming to service based business, including software industry and other offline industries. As the users' needs become more specific and complex than ever before, it is a must for services to interact with each other to exchange control data and information. The services and their correlations can be treated as a complex system with self-organize and continuous co-evolution properties, which is called service ecosystem. In service ecosystems, dynamic factors are general and may affect the performance of the whole system by spreading through the correlations.

There is little systematic research on the effects of dynamic services while this topic plays a crucial role in the managing and controlling of service ecosystems. So in this paper, we designed a research framework for researching the dynamic factors in service ecosystems. Firstly, the definition of service ecosystems is clarified, and the structure is demonstrated. While realizing the dissemination of dynamic factors depend on the service correlations, a stereo network among services, service vendors and consumers are set up to structure the spreading framework of dynamic factors. Also, the main service dynamic factors are discussed, which reveal the start point of the research. Then, we sum up the most important indicators for evaluating service system, which can be sorted as current service indicators, sustainable service indicators and stability indicators. Each of the indicators can be applied to describe the ability of system to create value at present, in future or when encountering errors and attacks. We use these indicators to demonstrate the state and state change of service ecosystem. Finally, a research framework is presented based on the ecosystem indicators, service dynamic factors and service network. In the framework, we list possible affection of these service dynamic factors.

Since we have built the framework for investigating the dynamic effects in service ecosystem, in the future we will set up more detailed numeric model and do theoretic deduction on the topic. Also, as the dynamic factors vary in the system, more factors including changes of platforms and environment can be discussed. On comprehending the evolutionary mechanism, the controlling and inducing strategies can be designed.

ACKNOWLEDGMENT

This work is supported by the National High-Tech. R&D Program, China(No. 2012AA040915), China Engineering Academy Member Workstation Project at Zhenjiang Zhongmei Co.

REFERENCES

[1] B. Blau, J. Kramer, T. Conte, and C. Van Dinther, Service value networks, IEEE Conference on Commerce and Enterprise Computing, pp. 194-201.

[2] A.P. Barros, and M. Dumas, The rise of web service ecosystems, IT professional, vol. 8, no. 5, 2006, pp. 31-37.

[3] A.P. Barros, M. Dumas, and P.D. Bruza, The move to Web service ecosystems, BPTrends, vol. 3, no. 3, 2005.

[4] R. Fischer, U. Scholten, S. Scholten, and S. Tai, Information-based control of service-enabling ecosystems, the Second International Workshop on Enabling Service Business Ecosystems, pp. 1-14.

[5] I.S. Razo-Zapata, P. De Leenheer, J. Gordijn, and H. Akkermans, Service value networks for competency-driven educational services: A case study, 6th International BUSITAL Workshop.

[6] R.C. Basole, and W.B. Rouse, Complexity of service value networks: conceptualization and empirical investigation, Ibm Systems Journal, vol. 47, no. 1, 2008, pp. 53-70.

[7] K. Huang, Y. Fan, and W. Tan, BSNet: A Three-Layer Business Service Correlation Network Model, 2011 IEEE Ninth International Conference on Dependable, Autonomic and Secure Computing (DASC), pp. 1117-1124.

[8] F. Li, C. Tian, R. Cao, and S. Jiang, Value network model for service ecosystem in business environment, pp. 955-958.

[9] P. Liu, and G. Nie, Research on Service Ecosystems: State of the Art, pp. 1-4.

[10] S. Li, and Y. Fan, Research on the service-oriented business ecosystem, 2011 3rd International Conference on Advanced Computer Control (ICACC), pp. 502-505.

[11] Y. Sawatani, Research in service ecosystems, Portland International Center for Management of Engineering and Technology, pp. 2763-2768.

[12] F. Li, C. Tian, R. Cao, and S. Jiang, Value network model for service ecosystem in business environment, IEEE Network Operations and Management Symposium, pp. 955-958.

[13] W. Jiang, S. Hu, D. Lee, S. Gong, and Z. Liu, Continuous query for QoS-aware automatic service composition, 2012 IEEE 19th International Conference on Web Services (ICWS), pp. 50-57.

[14] Z. Maamar, L.K. Wives, Y. Badr, S. Elnaffar, K. Boukadi, and N. Faci, LinkedWS: A novel Web services discovery model based on the Metaphor of “social networks”, Simulation Modelling Practice and Theory, vol. 19, no. 1, 2011, pp. 121-132.

[15] J. Zhang, W. Tan, J. Alexander, I. Foster, and R. Madduri, Recommend-As-You-Go: A Novel Approach Supporting Services-Oriented Scientific Workflow Reuse,, 2011.

[16] K. Huang, Y. Fan, and W. Tan, An Empirical Study of Programmable Web: A Network Analysis on a Service-Mashup System, 2012 IEEE 19th International Conference on Web Services (ICWS), pp. 552-559.

[17] T. Mo, X. Xu, and Z. Wang, A service system theory frame based on ecosystem theory, pp. 3184-3187.

[18] S. Wang, and M.A.M. Capretz, A dependency impact analysis model for web services evolution, pp. 359-365.

[19] M. Fokaefs, R. Mikhaiel, N. Tsantalis, E. Stroulia, and A. Lau, An empirical study on web service evolution, pp. 49-56.

[20] D. Schuller, U. Lampe, J. Eckert, R. Steinmetz, and S. Schulte, Cost-driven Optimization of Complex Service-based Workflows for Stochastic QoS Parameters, pp. 66-73.

[21] A. Amin, A. Colman, and L. Grunske, An Approach to Forecasting QoS Attributes of Web Services Based on ARIMA and GARCH Models, pp. 74-81.

[22] A. Kattepur, A. Benveniste, and C. Jard, Negotiation Strategies for Probabilistic Contracts in Web Services Orchestrations, pp. 106-113.

[23] M. Iansiti, and R. Levien, The Keystone Advantage: What the New Dynamics of Business Ecosystems Mean for Strategy, Innovation, and Sustainability, Harvard Business School Press, 2004.

[24] J.F. Moore, Predators and prey: a new ecology of competition, Harvard business review, vol. 71, 1993, pp. 75.

[25] J.F. Moore, The Death of Competition : Leadership and Strategy in the Age of Business Ecosystems, Harper Business, 1996, pp. 297.

[26] J. Spohrer, P.P. Maglio, J. Bailey, and D. Gruhl, Steps Toward a Science of Service Systems, IEEE Computer Society, 2007, pp. 71-77.

[27] T.P. Hill, On goods and services, Review of income and wealth, vol. 23, no. 4, 2005, pp. 315-338.

[28] G. Scheithauer, S. Augustin, and G. Wirtz, Describing Services for Service Ecosystems, pp. 242-255.

[29] R. Fischer, U. Scholten, and S. Scholten, A reference architecture for feedback-based control of service ecosystems.

[30] V. Andrikopoulos, S. Benbernou, and M.P. Papazoglou, On the evolution of services, EEE Transactions on Software Engineering, vol. 3, no. 38, 2012, pp. 609-628.

[31] J. Zhang, Z. Huang, and K.J. Lin, A Hybrid Diagnosis Approach for QoS Management in Service-Oriented Architecture, pp. 82-89.

[32] L. Barakat, S. Miles, and M. Luck, Efficient Correlation-Aware Service Selection, pp. 1-8.