SERVICE SCIENCE
Introducing Service Networks Performance Analytics

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Keywords: Service science, Service network, Actor network theory, Performance analytics.

Abstract: Although services are delivered across dispersed complex service eco-systems, monitoring performance becomes a difficult task. This paper explores a number of areas to support the development of service performance analytics within the discipline of service science. The paper provides a comprehensive account for the need to introduce modelling techniques to address the significant research void and explains how actor network theory (ANT) can be introduced as one of the core theories to examine service operations and performance. ANT sets out to develop an understanding on both how and why networks exist and to understand processes co-creation between human and non-human actors. By examining performance, this paper draws our attention towards the need to formulate methods to examine service network key performance indicators and the need to model service interaction, structure, and behaviour which impact on performance and consequently on service evolution.

1 INTRODUCTION

Nowadays, organisations are becoming increasingly interested in understanding the operations of service networks as a means to adapt to the ever-changing business environment. However, as services are delivered across dispersed complex service eco-systems, monitoring performance becomes a difficult task. Management must attempt to develop a greater understanding of service processes to identify where improvements may be made by employing business process management (BPM). We are often led to believe that we live in a 'global service network', surrounded by networks of power, influence, and relationships (for example, Law, 1999). Therefore, we can view a network as a specific set of linkages among a defined set of actors, whose properties can characterise the linkages which influence service behaviour. The critical problem here is the lack of research to bridge service computing and service management developments, for example, modelling service operations and analytics to enhance service requirements. The interaction patterns exhibited within service environments (physical and virtual) are of critical importance to performance analytics. We adopt actor network theory (ANT) as one of core theories upon which we can examine service relations and their effects on service performance between service actors (for example, people, organisations, and IS). ANT was originally created to understand processes of technological innovation and scientific knowledge-creation between human and non-human actors (Latour, 2005; Callon, 1986). ANT is not typically concerned with why a particular network exists but rather the infrastructure which supports the network and understanding its evolution, i.e. how the network exists. We discuss how ANT offers us a scientific lens to view service performance and supports our quest to develop service performance analytics.

2 THE SERVICE ENVIRONMENT

The service environment is comprised of complex

Carroll N., Richardson I. and Whelan E..
SERVICE SCIENCE - Introducing Service Networks Performance Analytics.
DOI: 10.5220/0003357002530259
In *Proceedings of the 1st International Conference on Cloud Computing and Services Science* (CLOSER-2011), pages 253-259
ISBN: 978-989-8425-52-2

business interactions often influenced by the affordance of technology. The growth in '*service science*' as a discipline has underscored the need to investigate the contributory value of business processes and its influence on service performance. Within organisational and technological management theory, understanding and measuring value (i.e. *application of competences*) of service networks is considered one of the key problems which prevent the sustainability of service growth. Service science explores the value *co-creation* of interactions between service systems (Vargo et al., 2008). Modern service systems have become very complex. Technological advances continue to act as a driving force for '*making new patterns and a new elevated level of value creation possible'* (Normann, 2001; p. 8), which places greater emphasis on the need to understand how process patterns influence service performance.

3 DEFINING SERVICE SCIENCE

Service science is an attempt to "*study the application of the resources of one or more systems for the benefit of another system in economic exchange*" (Spohrer et al., 2007, p. 2). One of the fundamental objectives of service science is to understand the mechanics of service networks and define how and why they generate value. As service science undergoes numerous theoretical developments it may be premature to expect that we can define service science. However, Spohrer et al., (2007) identifies four key observations about these disciplines:

1. Heavily resource dependent.
2. Tend to integrate or coordinate resources.
3. Measuring performance is very important.
4. Disciplines incorporate the word "service", e.g. service engineering.

Broadly speaking, services science may be described as a discipline which sets out to develop methods to extend the availability and accessibility of business processes. It is also concerned with improving manager's ability to predict risk, estimate their effects, and reduce uncertainty through modelling the value-exchange which results from provider and client interaction during intellectual, behavioural, economic, and/or social activities.

3.1 Complexity of Service Networks

Technology is often referred to as the backbone to many of the service providers. In addition, the Internet has fuelled the expansion of a plethora of services and service networks, for example, service clouds. As the number of services and variety of services continue to increase, so too will their complex environments. However, the problem here is understanding the dynamics and complexity of service science: "*powerful dynamics are in play around the world when it comes to applying resources effectively to solve problems and create value*" (Spohrer et al., 2007; p. 10). Therefore, understanding the complexity of network structures, process patterns, and methods to improve network performance is critical to the success of service eco-systems, for both the service provider and client. Spohrer et al., (2007) identify five main criteria within a service (summarised in table 1 below):

Table 1: Main Criteria within a Service.

Criteria	Explanation
Resource	Value of resources and how service interaction behaviour influences value.
Entity	The service system (or an actor; person, organisation, information and technology or the configuration of all four). It must dynamically adapt the value proposition and evolve over time.
Service	One or more entities must perform the application of competencies and one or more entities must receive the benefit and co-create value.
Interaction	Interactions generate an outcome. Value is determined whether it has been added or destroyed through unique frames of reference. Four main outcomes from interaction: Win-win value co-creation Lose-lose value co-destruction One entity judges that value is created One entity judges that value is destroyed Assessment of value depends on the frame of reference of the service system which may judge on historical performance as well as expectations (goals), quality, satisfaction of customer experience, improved value, and agility.
Success criteria	What constitutes success? *Calls for a rigorous theory of service systems to explore how entities interact, how they persist, what value they co-create.*

As identified above, service science plays a central role in supporting our quest to learn how service network and service exchange influence service performance. We suggest that the application of actor network theory (ANT) as a suitable theory to understand the dynamics of service networks and consequently, service network performance analytics.

4 ADOPTING ANT

Modern organisational structures promote flat hierarchies and more flexible structures, which are fundamental characteristics of the modern organisational architecture. To explore such network architectures, there is a growing body of evidence which suggests that actor network theory (ANT) may assist us to gain a greater understanding of networks within the IS discipline. ANT can provide a deeper understanding about how and why processes of '*technological innovation and scientific knowledge-creation*' and is not concerned with the network per se, but rather the infrastructure which supports the network's evolution (Monteiro, 2000). It examines the performance of network relations and explores the influence of objects towards those relations (Law, 1999; p. 7). ANT research examines socio-technical influences and relational effects of actor (i.e. human and non-human) interaction within networks which support, for example, people, organisations, and technology. ANT is based upon three main principles. These are; agnosticism, generalised symmetry, and free association (Callon, 1986):

1. *Agnosticism*: analytically impartiality is demanded towards all the actors involved in the network.
2. *Generalised symmetry*: explains the conflicting viewpoints of different actors in same terms by use of an abstract and neutral vocabulary.
3. *Free association*: requires the elimination and abandonment of all priori distinctions between the technological, natural, and social factors.

ANT directs out attention towards networks, links, interactions, assemblages, and associations and presents questions such as, are the associations weak or strong?; Is the network stable or unstable?; What elements, if changed, would create new entities, and both how and why are these created and supported?

4.1 Applying ANT to Service Networks

Service actors (organisations, people, IS) may be viewed as representations of a networked effort to deliver a service, while unfolding the meaning (or value) of influential service actors. ANT may be adopted as a research method for a soft case study approach to examine the trajectories of service networks and service actor interaction. The effects of such interactions are of significant interest when we examine service network interaction performance or outcomes. Law (1999) refers to these interactions as *relational materiality* and *performativity* which examines the "consequence of the relations in which they are located" (p. 4). Thus, ANT provides and alternative view from management literature of service management with a view to understand how service systems and business strategies align. ANT also presents a lens or a framework which provides a detailed description of the underlying mechanics and its infrastructure which support dynamic networks and the unbiased viewpoint of the network actors (Monteiro, 2000).

4.2 ANT and Service Analytics

ANT is essentially concerned with a bottom-up concept of alignment and strategy formation, while alignment is traditionally more concerned with a top-down view on planning and decision-making processes. Therefore ANT provides a theoretical platform upon which we can begin to analyse the implications of service relational structures on performance analytics. This allows managers to establish clearer facts, effects, beliefs or technological solutions within service networks and learn how IT enables and inhibits service performance. Networks are considered to be "processual, built activities, performed by the actants out of which they are composed" (Crawford, 2005; p. 1). To summarise, the following list summarises some of the key concepts within ANT (Monteiro, 2000):

- ***Actor/Actant:*** any element (human or non-human – 'black box') that performs actions and influences other elements it interacts with and whose patterns are known as inscriptions.
- ***Inscription:*** the behavioural pattern between the actant and another element in the network, i.e. interests are inscribed in written material (e.g. service level agreements or SLA).
- ***Translation:*** the process of aligning actors across a specific network through the adaptation of the inscriptions when a new actor is created.
- ***Enrolment:*** process of becoming a member of a stable network.
- ***Alignment:*** result of the enrolment process when a network becomes stable and unified through the process of translation. Alignment must also ensure the all inscriptions are agreed upon during the process of enrolment.
- ***Irreversibility:*** measures how difficult it is to undo a decision and how to determine the subsequent measures.
- ***Black Boxing:*** an approach to analyse an ANT network through the simplification of a network by removing identities from actors. Black boxes may always be reopened as networks demand continual maintenance to order.

As the list above suggests, actors are therefore responsible for an *action* which supports the evolution of a network. Therefore ANT provides a theoretical platform upon which we can begin to analyse the implications of service relational structures on performance analytics.

5 VALUE OF SERVICE NETWORKS

Reporting on the value of service network relationships, especially from a business perspective can prove to be extremely beneficial (Carroll et al., 2010). In this sense, value may be referred to as "the adaptability and survivability of the beneficiary system" (Vargo et al., 2008; p.148). Service value also refers to the relational exchanges and examines how network interaction generates a value to satisfy a service client's need (i.e. value exchange). Thus, the value of a service network is "a spontaneously sensing and responding spatial and temporal structure of largely loosely coupled value proposing social and economic actors interacting through institutions and technology, to: (1) *co-produce service offerings*, (2) *exchange service offerings*, and (3) *co-create value*" (Lusch et al., 2010). Within service systems there is a large element of barter (method of exchange) involved in the transactions and it is often difficult to examine the 'complementary resources' which are exchanged within a service system, for example, information resources.

5.1 Our Approach towards Service Analytics

We propose that one solution towards modelling service performance analytics is to examine the relational structures to support service networks. Despite the volume of research which concentrates on complex business applications and modelling processes there are no research efforts to explore the implications of relational structures on service network performance. Thus the relational structure of service networks shared amongst organisations to support business operations may prove to be the key to modelling service networks and their performance. We identify the need to visualise and understand the relational contributions of service structures to further enhance decision making tasks while restructuring service network business processes (Carroll et al., 2010). We posit that the implications of relational structures and service behaviour allow us to develop service network performance analytics.

6 PERFORMANCE ANALYTICS

A service network is a complex system which relies on the harmonisation of numerous actors. Service performance is often influence by external entities causing structural variability across a service eco-system which impacts of the networks characteristics and ultimately, its performance. Therefore, it is critical that we gain a thorough understanding of what influence service performance for two main reasons; firstly to enhance service management decision-making tasks (*service management*), and secondly, to feed this information into service requirements engineering (*service computing*). This is appropriate as the relationship between service computing and service management relies on the exchange of service resources to support several key factors of service orientation: organisation, people, and software. This view unites two main disciplines of service computing and service management. Figure 1 below illustrates six main types of service relationships (Zhao et al., 2008) where service computing is largely concerned with software components, while service management is mainly concerned with the people although both service computing and management are required to successfully deliver a service.

Figure 1 also illustrates the unification of these broad concepts which makes communication between engineers and managers more effective.

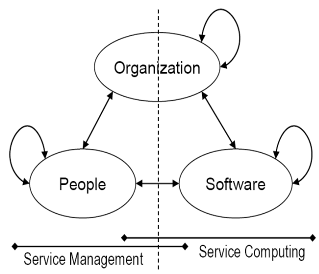

Figure 1: Service Orientation (Zhao et al., 2008).

Across business and IS research, there is a significant gap in our ability to bridge and advance our understanding of technology and management in this so called 'service-dominant' business environment (Normann, 2001).

Figure 2 above illustrates the five tiers which form the service network anatomy; the human and software infrastructure and the software and human services governed by SLA and Quality of Service (QoS); the atomic services monitored controlled by process metrics; the service processes managed by participant metrics; and the business transactions managed by network key performance indicators (KPIs).

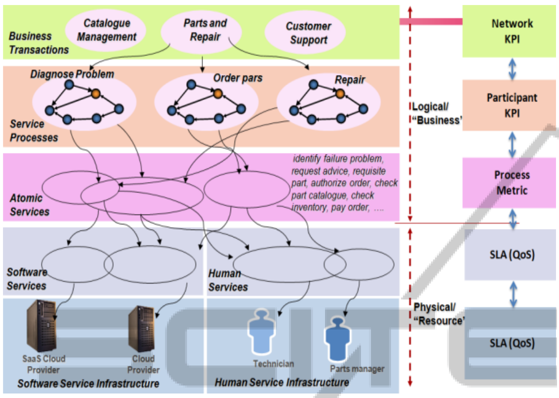

Figure 2: Service Network Anatomy (S-Cube, 2009).

Before we attempt to measure service network though performance analytics, we are reminded of Hubbard's (2007) advice to first question how and what gets measured as it has some conceivable effect on decisions and behaviour (p. 43):

1. What decision is this supporting?
2. What really is the thing being measured?
3. Why does this thing matter to the decision being asked?
4. What do you know about it now?
5. What is the value to measuring it further?

Managers must rethink (design, innovate, deliver, and support) new strategies and possible structures to transcend their competencies across service networks. This includes technology, network topology, human behaviour, business strategy, service design, and economics. More specifically, managers must pay close attention to how service management is conceptualised (capabilities, structures, and processes) and how behaviour is orchestrated to interact and innovate service development.

Applying this business logic the service actors and service competencies draws our attention towards the relationship or tie which determines the exchange patterns within a service network. Therefore, service (actor) interaction patterns should be possible to model and provide insight on how specific actor relations enable or inhibit service business processes. We can also categorise the type of relationship within performance analytics and KPIs. It can also provide greater insight within the service exchange process and the 'value' of the exchange, for example, information and financial data. For example, there are three main types of performance measures (table 2):

Table 2: Main Types of Performance Measures.

Performance Measure	**Explanation**
Key Result Indicators (KRIs)	Determine how service has performed in the past, for example, sales last month.
Performance indicators (PIs)	Inform what you ought to do.
Key Performance Indicators (KPIs)	Prescribes what you ought to do to increase performance.

As summarised above, performance measures (KRIs, PIs, and KPIs) analyse how key activities influence service performance e. Service delivery systems also distinguish five main factors which are invariably influenced by the physical setting of technical tools to deliver a service: cost rationalisation, quality enhancement, beneficial customer linkages, behavioural implications, and technology adaption.

The first question is *where do you want to be* which suggests that organisation must be committed to service transformation and cooperated to meet the business objectives, mission, and vision. The second question, "*where are we now?*" may be a difficult question to answer but managers must identify where changes are needed, for example, people, process, practice, technology/technical infrastructure, and data (i.e. metrics) to steer the service towards the service vision. The third question asks, "*how do we get to where we want to be?"* which requires a more detailed plan including a top-down (process-orientated technical infrastructure) and bottom-up (influence the development of processes) of a service system The fourth and final question is "*how do we know when we have arrived?"* This is a critical question as it determines the success criteria (which are a major factor within service science). One of the greatest concerns within today's service network landscape is the inability of business models to cater for the pace and dynamics of business. Failing to examine the service network value increases the chances of ignoring the spatial and temporal structure of largely loosely coupled value proposing actors which dynamically interact through 'institutions and technology' offers little insights on service performance (Lusch et al., 2010).

6.1 Key Performance Indicators

Key performance indicators (KPIs) are quantifiable measures of organisations' progress to meet specific goals. KPIs also assist managers in decision making to determine the right course of action. The level of dimensional support across the process structures is expressed in several forms including, structural, functional, compositional, and behavioural. Often these dimensions are taken for granted and overlooked although this information provides both tangible and intangible metrics on service network performance. There are several reasons why service metrics often fail, for example, service networks may use incorrect metrics which do not measure the business value of the network. Incorrect metrics may also mean that the performance findings are not actionable as probing for a complete analysis of the network is more difficult to collect data. In other cases, managers may set poor performance targets and fail to implement incentives or penalties to enhance the service performance. Another reason may include the over emphasis on service cost over business benefits.

Many services are exceedingly complex phenomena which can be conceptualised in several different ways. Taking a qualitative perspective and trying to really understand primarily what relational structures mean in service network, how they evolve, and then try and address and look at how they change with the impact of IT and service performance. The relationships which exist between these services can determine the service innovation and operations efficiencies across networks. This will also allow us to identify the critical success factors (CSFs) which enable (KPI) or inhibit business processes. Freeing up resources to develop value-added information is critical to managerial activities (e.g. rapid decision making and execution). To address these issues we must uniquely define the business KPIs. KPIs allow us to measure the success of goal achievement and to generate insight to discover how service performance and value may be enhanced. Characteristically, service network KPIs should be simple for decision making, relevant to unique (service-dominant) business models, present timely results, useful, and instant for actionable insights. Here, one is reminded of services seeking the right balance or requisite variety between *use, usage, and usability* of their resources and processes through service-oriented approaches. We also encapsulate this when we refer to the notion of 'performance analytics' within a service environment (figure 3) as follows:

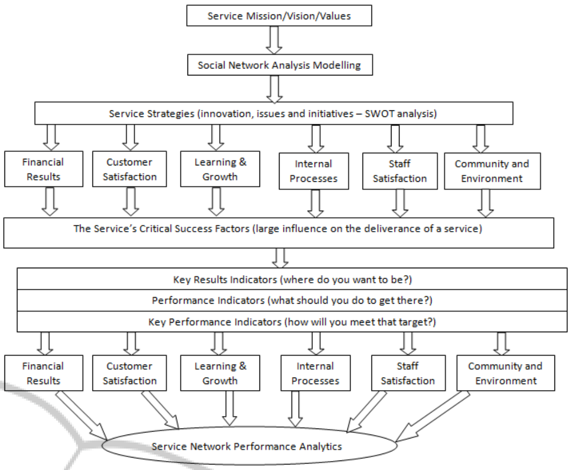

Figure 3: Service Network Performance Analytics.

Within a service environment, it is paramount to begin the process of establishing performance measures using the service mission, vision, and values. Considering services are typically unique in many ways, each service must determine their mission, vision, and values. In addition, managers must develop a vision (often an intangible or philosophical view) on what they must achieve in order to successfully meet their goals. Services must also devise strategies to achieve their visions. Within the service environment, managers need to identify areas to introduce service innovation, service initiatives, and identify issues which may present opportunities or threaten service sustainability. This may be achieved through a SWOT-like analysis (strength, weaknesses, opportunities, and threats) of the service environment while adopting the balanced scorecard critical success factors; financial results, customer satisfaction, learning and growth, internal processes, staff satisfaction, and community and environment. These may be adapted to suit a service environment and identify KPIs to examine service competencies, relations, and resource exchange. Freeing up resources to develop value-added information is critical to managerial activities (e.g. rapid decision making and execution).

7 CONCLUSIONS

This paper presents a platform which introduces the need to explore service network performance analytics though the application of ANT. The focus on service network relational structures acknowledges the fundamental role on the generation of value through the sustainability of service network relationships and performance. As part of other research work, we have incorporated the use of social network analysis (SNA) to model service performance and borrow SNA metrics (Carroll et al., 2010) to examine service performance analytics.

ACKNOWLEDGEMENTS

The research leading to these results has received funding from the European Communities Seventh Framework Programme FP7/2007-2013 under grant agreement 215483 (S-Cube). For further information please visit: http://www.s-cube-network.eu/. This work was supported, in part, by Science Foundation Ireland grant 03/CE2/I303_1 to Lero - the Irish Software Engineering Research Centre (www.lero.ie).

REFERENCES

Callon, M., 1986. Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St Brieuc Bay. In *John Law (ed.), Power, Action and Belief: A New Sociology of Knowledge. London*: Routledge & Kegan Paul.

Carroll, N., Whelan, E. and Richardson, I., 2010. Applying Social Network Analysis to Discover Service Innovation within Agile Service Networks, *Service Science, Volume 2*, Number 4, pp 225-244.

Crawford, 2005.

Latour, B., 2005. Reassembling the Social: An Introduction to Actor-Network-Theory (*Oxford: Oxford University Press).*

Law, J., 1999. After ANT: complexity, naming and topology. In J. Law and J. Hassard (eds.), Actor network theory and after, *Blackwell publisher, pp. 1-14.*

Lusch, R. F., Vargo, S. L., and Tanniru, M., 2010. Service, value networks and learning. *Journal of the Academy of Marketing Science, Volume 38*, pp. 19-31.

Monteiro, E., 2000. "Actor-Network Theory and Information Infrastructure," in: From Control to Drift, C. U. Ciborra (ed.), *Oxford University Press,* Oxford, pp.71-86.

Normann, R., 2001. Reframing business: when the map changes the landscape. *Chichester*, New Sussex: Wiley.

S-Cube, 2009. Documents available from Website: http://www.s-cube-network.eu/

Spohrer, J., Maglio, P. P., Bailey, J., and Gruhl, D., 2007. ‘‘Steps Toward a Science of Service Systems,’’ *IEEE Computer, Volume 40*, Number 1, pp. 71-77.

Vargo, S. L., Maglio, P. P. and Akaka, M. A., 2008. On value and value co-creation: A service systems and service logic perspective. *European Management Journal, Volume 26*, pp. 145-152.

Zhao, J. L., Hsu, C., Jain, H. K., Spohrer, J. C., Tanniru, M. And Wang, H. J. 2008 "ICIS 2007 panel report: bridging service computing and service management: How MIS contributes to service orientation", *Communications of the Association for Information Systems, 22*, 413-428.