Towards SOA Implementation Complexity Measurement Enlightened by Organization Theory

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ABSTRACT

When implementing information infrastructures to support business, Service-Oriented Architecture (SOA) based systems are inevitably more complex than traditional architecture based systems. Therefore, it is essential to measure the implementation complexity to avoid development that is unworthy of adopting SOA. However, there is little work that covers the SOA implementation complexity measurement with comprehensive analysis. By adopting existing work related to organizational complexity, this paper proposes a framework for comprehending and measuring the organizational complexity of SOA implementation, which comprises four dimensions: Structure, Environment, Business and Resource. Along each dimension, some SOA-compatible metrics have been extracted from the corresponding research on organizational complexity. More importantly, this proposed framework can be used for future work in proposing metrics for integrally and quantitatively calculating the complexity of implementing SOA.

Categories and Subject Descriptors

D.2.8 [**Software Engineering**]: Metrics – *complexity measures.* D.2.9 [**Software Engineering**]: Management – *cost estimation.* F.1.3 [**Computation by Abstract Devices**]: Complexity Measures and Classes – *relations among complexity classes.* H.5.3 [**Information Interfaces and Presentation**]: Group and Organization Interfaces – *organizational design.*

General Terms

Measurement, Design, Theory

Keywords

Service-Oriented Architecture (SOA), Organization Theory, Organizational Complexity, SOA Implementation Complexity, Measurement.

1. INTRODUCTION

Service-Oriented Architecture (SOA) has become a widely accepted and adopted architectural style that provides the benefits of agility, flexibility and adaptability for dynamic businesses. However, the loosely coupled asynchronous SOA systems are inherently more complex than the traditional architecture based systems. Josuttis [16] has pointed out that distributed processing would be inevitably more complicated than non-distributed processing, and any form of loose coupling increases complexity. In practice, building a true heterogeneous SOA for a wide range of operating environments may take years of development time if the company does not have sufficient SOA experience and expertise [15]. Since the more complexity involved in a system, the more difficulty the designers or engineers have to understand the implementation process and thus the system itself [17], these companies should adopt SOA only when its benefits outweigh any extra costs due to the increased complexity. Therefore, it is vital to measure implementation complexity before starting an SOA project.

Unfortunately, little discussion related to the complexity measurement for SOA implementation can be found in existing literature. Norfolk [19] wonders "We do already have accepted complexity metrics, but are they adequate in an SOA world?" without giving any measurement suggestions. Linthicum [18] lists several kinds of complexity when calculating the cost of SOA projects, such as complexity of data storage technology, system complexity, service complexity, and process complexity. Jiao, et al. [20] propose a complexity metric based on Service Component Architecture (SCA) specification. Hirzalla, et al. [6] introduce an SOA metrics framework that comprises both service level and SOA-wide metrics to measure design and runtime qualities of an SOA implementation. Nevertheless, to the best of our knowledge, none of the existing work reflects all of the facets when implementing SOA.

This paper views SOA from an organizational perspective, and regards the SOA implementation as an organizational activity. In fact, thinking of SOA organizationally is possible and reasonable based on the traditional consensus of the organization concept. Benefiting from the mature organization theory research, we have identified four complexity dimensions for SOA implementation by adapting existing research on organizational complexity. According to our current work of analyzing characteristics of SOA implementation, these four dimensions that are Structure, Environment, Business and Resource can reflect the most

influential complexity aspects of SOA implementation. On the other hand, the identification of complexity dimensions tries to avoid dealing with the excessively detailed and trivial issues. For example, we ignore the technical factor of implementation to maintain the general service concept in SOA. Furthermore, this paper extracts SOA-compatible metrics from the organizational complexity area, and also suggests potential measurement metrics for each complexity dimension.

The remainder of the paper is organized as follows. Section 2 justifies thinking of SOA from the organizational perspective. Section 3 introduces the complexity measurement framework that comprises four dimensions for SOA implementation. Conclusions are drawn and some future work is proposed in section 4.

2. THINK OF SOA FROM THE ORGANIZATIONAL PERSPECTIVE

Organizations emerged as early as ancient civilizations appeared. Today, organizations have become indispensable and pervasive components of human beings' society, for example, from schools to hospitals and from armies to governments. However, there is no single agreed definition of an organization. Fierce debates about the organization concept are still underway, although theorists have traditionally consented that organizations are collectivities of people who are socially arranged to pursue specific purposes and achieve explicit goals [1]. This traditional consensus already makes it possible and proper to think of SOA using the organizational perspective, which is mainly based on two reasons.

On the one hand, it is suitable to think of SOA as a form of organization architecture. The Organization for the Advancement of Structured Information Standards (OASIS) [2] defines SOA as "a paradigm for organizing and utilizing distributed capabilities that may be under the control of different ownership domains. It provides a uniform means to offer, discover, interact with and use capabilities to produce desired effects consistent with measurable preconditions and expectations." When it comes to implementation, SOA is used to build up a collection of independent services that can be quickly and easily integrated into different, high-level business services and business processes to create business value and achieve business strategies [3]. To summarize, SOA both in theory and in practice is proposed for organizing services to attain some particular goals. Therefore, SOA can be set under the umbrella of organization theory following the suggestion of traditional organization concept: if the process of organizing is about goal attainment, the organization theory could be followed to conceptualize, explain and ultimately guide individuals' activities that should be united together to achieve desirable, common organizational goals [1].

On the other hand, it is secure to think of SOA from the organizational perspective. Within SOA systems, a service is a well-defined unit of functionality realized by a service interface and a service implementation [4]. A service interface identifies a service and exposes the semantic description of the service's invocation. A service implementation realizes the work that the service is designed to perform. Unlike people in social organizations, services in SOA do not have mental or psychological attributes. Consequently, services will always obey the control from "senior manager" of the whole SOA system, and may even not be aware of the "organizational goal". When thinking about SOA organizationally, the blind obedience characteristic of services can naturally avoid the dangers of defining organizations in terms of having a goal while not all members freely agree to that goal [5].

Thinking of SOA from the organizational perspective can bring interdisciplinary research opportunities. For example, the current research achievement relating to organizational complexity might be applied to the complexity measurement of SOA implementation.

3. COMPLEXITY MEASUREMENT FRAMEWORK FOR SOA IMPLEMENTATION

Based on the definition of organizational complexity [8], it is not difficult to reformulate the concept of complexity of SOA implementation as *the amount of differentiation that exists within different facets affecting the SOA implementation*. Scherrer-Rathje, et al. [7] have revealed that different facets of complexity need to be analyzed differently. Inspired by the existing research into organizational complexity [8-14], we can identify four different dimensions that should be analyzed separately when measuring the complexity of SOA implementation: Structure, Environment, Business and Resource. The four dimensions then constitute a framework for the complexity measurement of SOA implementation, as illustrated in Figure 1.

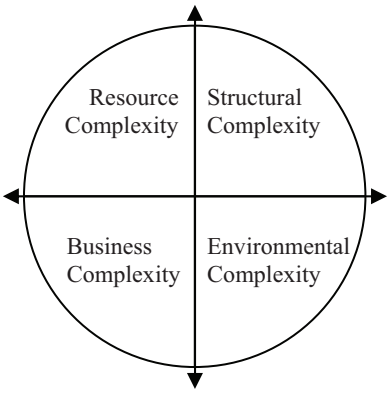

Figure 1. Complexity Measurement Framework for SOA Implementation.

3.1 Structural Complexity

Structure is the fundamental content when understanding any type of system, including organizations and SOA systems. Goold and Campbell [9] suggest that the organization is a structured network that has features of both network and structure. The network is woven by using largely self-managing units, and meanwhile sufficient structure and hierarchy are necessary to ensure that the responsibilities and relationships are clear, and that the collaborations among units are successful. Similarly, SOA is supposed to adopt coarse-grained and self-contained services to build structural and hierarchical business processes. Therefore,

structural complexity is the first and important facet that influences SOA implementation.

Generally, structural complexity is closely related to the elements within the structure and the interconnections among the elements. The density of interconnections depends on the number of elements and their diversity, while the number of elements also drives the diversity to some extent [8]. In other words, the more the elements and their types, the more complicated the interconnections, and the more complex the structure. For SOA systems, more complex structures inevitably require more effort on cooperation and collaboration among services. For instance, an SOA-based online shopping platform is more complex than one online shop on the platform, because the shop only needs to invoke part of services provided by the platform while the platform is constituted through interconnecting more services and more types of services. Measuring the structural complexity of SOA implementation can borrow Hornby's proposal [10] that takes into account modularity, reuse and hierarchy characteristics when measuring the structural complexity of evolutionary design systems.

3.2 Environmental Complexity

As mentioned previously, both an SOA system and organization are systems sharing some common features, and both cannot be isolated from external environment. The environment is the surroundings of a system, and the system and its environment may impact on each other. In reality, the system's environment will always be more complex than the system itself. However, the system's complexity can be considered as a response to the complexity of the environment, and be measured through differentiation [8]. In fact, SOA emerged from the requirement of satisfying the increasingly changing business environment, such as expanded market, growing competitors, and switched government policies. The complex environment normally requires complex SOA systems within the business institutions, which unavoidably results in complex SOA implementations. For example, the SOA implementation for some international business will be more complex than that for the same scale of local business, because different social, cultural, political and information infrastructural factors must be also taken into account when implementing SOA for international business. On the other hand, the robust adaptability of the SOA systems should be emphasized when facing frequently and rapidly changing environment, which also contributes complexity to the SOA implementation.

Peng, et al. [11] summarize five environment variations that differently impact on the organizational change, containing asymptotic variation, interfering variation, periodic variation, phase-transition variation, and random variation, which can also be used to inspire the research into environmental complexity of SOA implementation.

3.3 Business Complexity

The 'business' here implies not only commercial processes but also non-profit routines that constitute organizational actions and that can be supported by corresponding SOA systems. Dooley [8] treats business as an internal environment that makes organizations internally differ in complexity. Similarly, the business radically determines the implementation complexity of the corresponding SOA system. For example, building a stock transaction system will be absolutely more complex than establishing an online pizza-order system, because the stock trade requires more sophisticated calculation, more complicated procedure and more trading rules than ordering food.

Business complexity is closely associated with the structure of the business. There is no denying that increasing calculation brings increasing data flows, complicated procedure implies large-scale business process, and more rules result in more control flows. Therefore, there is a tight correlation between business complexity and structural complexity within an SOA implementation. The measurement for structural complexity can be switched to satisfy the measurement of business complexity. Furthermore, different implementation strategies for the same business may lead to varying structural complexities. Holding constant business complexity, adopting coarser grained services will reduce the number of services and interconnections when implementing SOA, which can correspondingly decrease the structural complexity. However, we cannot infinitely reduce the structural complexity by continuously scaling up services, because in turn the larger scale services may spoil the flexibility of SOA system when experiencing dramatic environment changes.

3.4 Resource Complexity

Resources are essential components and play significant roles in organizations. The management research field has emerged one key development that is to look at organizations in the Resource-Based View (RBV) [12]. In RBV, the organizations are viewed as a bundle of assets and resources that can create competitive advantages if the resources are employed in proper ways. By separating workers from the general resource concept, Siahpush [13] suggests that the organizations are composed by resources (or vulnerabilities) and actors including employees and employers. Although the resource concept is broad and may be intangible in RBV, the suggestion of composite organization can be migrated to view SOA systems as combinations of resources and services from the organizational perspective. Inspired by Efstathiou, et al.'s work [14], we can use tangible resource related metrics to entropically measure the complexity of SOA implementations. To simplify the calculation, the resource complexity can be quantitatively measured with the amount of resource requisitions when implementing SOA, for example, the external storage capacity, the response time of transaction, and the message size of communication. External storage for example due to data backup will incur manipulating data synchronization and employing more facilities; the limit of response time requires stable network and fast calculation; large message size may result in additional CPU load and peak memory utilization. Moreover, the involved personnel that are treated as actors in organizations can be also viewed as resource in the SOA environments, because services will play actors' roles when organizationally observing SOA.

4. CONCLUSION

Compared with systems based on traditional architecture, SOA systems are inherently more complicated. Therefore, before starting a new SOA project, it is necessary to measure the implementation complexity so as to estimate the ratio of the resulting benefits to the increased complexity costs. To inspire research into measuring SOA implementation complexity, this

paper presents an organization-based view to comprehend SOA, and treats SOA implementations as organizational activities. Enlightened by existing work of organizational complexity in the organization theory domain, we have identified four dimensions – Structure, Environment, Business and Resource – to measure the complexity of SOA implementation. Based on our current work, we believe that these four dimensions have covered the most influential aspects when implementing SOA. Consequently, we can use a framework that is composed by these four dimensions to portray a relatively full scope of complexity measurement for SOA implementation. After a systematic review of existing work for measuring organizational complexity, the future work will be to propose computational complexity metrics within different measurement dimensions. By adopting there proposed metrics, the SOA implementation complexity would be quantitatively measurable, and then facilitate the cost estimation and decision making for new SOA projects.

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