Toward SOA Implementation Complexity Measurement Enlightened by Organization Theory

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ABSTRACT
When implementing information infrastructures to support business, the Service-Oriented Architecture (SOA) based systems are inevitably more complex than the traditional architecture based systems. Therefore, it is essential to measure the implementation complexity to avoid the development un-worthy of adopting SOA. However, there are few works that can cover the full scope of complexity measurement for SOA implementation. Through organizationally comprehending SOA and borrowing existing work related to organizational complexity, this paper proposes a framework for measuring the complexity of SOA implementation, which comprises four dimensions: Structure, Environment, Business and Resource. This framework can then instruct the future work of proposing metrics for integrally and quantitatively calculating the complexity when 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.
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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 increasingly become a widely accepted architectural style that provides the benefits of agility, flexibility and adaptability when facing 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 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], the companies should adopt SOA only when its benefits outweigh any increased complexity costs. Therefore, it is significant to measure the implementation complexity before starting an SOA project.

Unfortunately, little discussion related to the full scope of complexity measurement for SOA implementation can be found throughout the 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 a SOA metrics framework that comprises both service level and SOA-wide metrics to measure design and runtime qualities of an SOA implementation. Nevertheless, none of the existing work reflects all of the facets when implementing SOA.

This paper views SOA in the organizational perspective, and regards the SOA implementation as an organizational activity. In fact, organizationally thinking SOA is possible and safe based on the traditional consensus of the organization concept. Benefiting from the fruitful achievements in the organization theory domain, we have identified four complexity dimensions for SOA implementation by borrowing ideas from existing research into organizational complexity. These four dimensions cover structural, environmental, business-related and resource-related complexity aspects of SOA implementation, while ignore the technical factor to maintain the general service concept in SOA. Furthermore, this paper extracts SOA-compatible metrics from organizational...
complexity area, and also suggests potential measurement metrics for every complexity dimension.

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

2. THINK SOA IN THE ORGANIZATION PERSPECTIVE
Organizations emerged as early as ancient civilizations appeared. In current world, organizations have become indispensable and pervasive components of human beings’ society, for example, from school to hospital and from army to government. However, there is not a concrete definition of 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]. Fortunately, this traditional consensus already makes it possible and proper to think SOA in the organizational perspective, which is mainly based on a twofold reason.

On the one hand, it is suitable for thinking SOA as a way of organization. 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 safe to think SOA in 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]. Service interface identifies a service and exposes the semantic description of the service’s invocation. 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 be not aware of the “organizational goal”. When organizationally thinking SOA, 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 SOA in the organizational perspective can bring interdisciplinary research opportunities. For example, the existing research achievement about organizational complexity can be lent to the complexity measurement of SOA implementation.

3. COMPLEXITY MEASUREMENT FRAMEWORK FOR SOA IMPLEMENTATION
Following the definition of organizational complexity [8], we can define the 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 clockwise illustrated in Figure 1.

3.1 Structure Complexity
Structure is the fundamental content when understanding any type of systems, including organization and SOA system. 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 insure that the responsibilities and relationships are clear, and that the collaborations among units are successful. Similarly, SOA is supposed to adopt course grained and self-contained services to build structural and hierarchical business processes. Therefore, structure complexity is the first and important facet that influences the SOA implementation.

Generally, structure complexity is closely related to the elements within the structure and the interconnections among the elements. The ability 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 harder the interconnections, and the more complex the structure. For SOA systems, more complex
structures inevitably require more efforts for the purpose of 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 structure complexity of SOA implementation can borrow Hornby’s proposal [10] that takes into account the modularity, reuse and hierarchy characteristics when measuring the structure complexity of evolutionary design systems.

3.2 Environment Complexity
As mentioned previously, both SOA system and organization are systems with similar features, and both cannot exist without external environment. 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 complexity within the environment, and be measured through the differentiation [8]. In fact, SOA indeed 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 implementation. 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 environment changing, 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 environment complexity of SOA implementation.

3.3 Business Complexity
The ‘business’ here covers 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 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.

The 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 close relationship between business complexity and structure complexity within an SOA implementation. The measurement for structure complexity can then be switched to satisfy the measurement of business complexity. Furthermore, different implementation strategies for the same business may have different structure 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 structure complexity. However, we cannot infinitely reduce the structure complexity by continuously enlarging the scale of services, because in turn the larger services will spoil the flexibility of SOA system when encountering dynamic environment.

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. Following this suggestion, SOA systems can be viewed as combinations of resources and services in the organizational perspective. Inspiring by Efstathiou et al.’s work [14], we can use resource related metrics to entropically measure the complexity of SOA implementations. To simplify the calculation, the resource complexity can be quantitatively measured through 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 persons that are treated as actors in organizations can be still viewed as resource in the SOA environment, because services will play the role of actors when organizationally observing SOA.

4. CONCLUSION
Comparing with the systems based on traditional architecture, SOA systems are inherently more complicated. Therefore, before starting a new SOA project, it is essential to measure the implementation complexity so as to estimate the ratio of the resulting benefits to the increased complexity costs. To inspire the research into SOA implementation complexity, this paper uses 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. These four dimensions then compose a framework that instructs a relatively full scope of complexity measurement for implementing SOA. The future work is to propose computational complexity metrics within different measurement dimensions. Benefiting from the proposed metrics, the SOA implementation complexity will be quantitatively measured.
calculated, and then facilitate the cost estimation work for new SOA projects.

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6. REFERENCES