The Dynamics of Service Oriented Architecture (SOA) Implementation

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Abstract

Despite the increasing popularity of Service-Oriented Architecture (SOA), mixed outcomes about SOA implementation have often been reported. The key research question to be answered in this study is how various factors, while interacting with each other over time, affect the dynamics of the SOA implementation and certain organizational challenges may occur in the implementation process. To develop plausible explanations for the organizational challenges to SOA implementation, this study builds a system dynamics model from a process research perspective which is missing in the extant literature on SOA. In particular, the relationship between the duration (rather than just the strength) of top management normative commitment and the time delay of technology learning, which is critical to the success of SOA implementation but ignored in extant literature, is uncovered and the critical effects on the success of SOA implementation is demonstrated through experimental simulations. The simulations show that reducing a seemingly short period of duration of normative commitment may cause dramatically unexpected and usually negative outcomes of SOA implementation. The implications are that when providing normative commitment on SOA implementation, managers should consider the time delay of SOA technology learning in their organization and carefully decide appropriate duration of their normative commitment.

1. Introduction

It is important for an organization to be able to adapt its IT systems and quickly respond to changing business conditions. Such ability is defined as the organization's information systems (IS) agility (Choi et al. 2010) and has been considered as a key facilitator to enhance competitive advantages (Luthria and Rabhi 2009). Service-oriented architecture (SOA) is an important technology that has been advocated as a new computing paradigm to build IT systems and enhance the IS agility of organizations. However, mixed outcomes about SOA implementation have been reported: some successes and some failures[1]. Given the growing significance and risk of SOA, it is surprising that there is a scarcity of academic research addressing the paradox. The key research question to be answered in this study is how various factors, while interacting with each other over time, affect the dynamics of the SOA implementation and certain organizational challenges may occur in the implementation process. Particularly, the relationship between the duration (rather than just the strength) of top management normative commitment and the time delay of technology learning, which is critical to the success of SOA implementation but ignored in extant literature (Choi et al. 2010; Luthria and Rabhi 2009), is uncovered and the critical effects on the success of SOA implementation is demonstrated.

Mohr (1982) identifies two different perspectives: variance and process. The variance

[1] A positive survey on SOA is found at http://www.zdnet.com/blog/service-oriented/so-far-soa-failures-are-few-and-far-between-survey-says/1247, while a negative survey on SOA is found at http://www.infoq.com/news/2008/08/survey-soa-failure.

research seeks to explain variation in outcome variables by associating those outcomes with antecedent conditions and predictor variables. The process research seeks to explain outcomes by examining sequences of events over time. To date, prior academic research on SOA has largely adopted the variance perspective. Specifically, prior research on SOA has claimed potential benefits and business value of SOA (Mueller et al. 2010). Nevertheless, organizations implementing SOA often encounter challenges in their efforts. To address those challenges, some recent works have turned aspects of critical success factor (CSF) that potentially affect SOA implementation. Research in this stream tends to enumerate a number of factors that potentially facilitate or impede the intended benefits of SOA. Such research, however, has failed to explore the causal relationships among those critical factors. More importantly, none investigated how those factors interact with each other during the dynamics of the multi-month/year process of SOA implementation. This paper seeks to fill in the literature gap at those aspects.

The research presented in this paper suggests that we may be able to make some sense of the mixed outcomes by shifting the focus away from the variance perspective to the process perspective (Mohr 1982). The process perspective focuses on explaining how change emerges, develops and diminishes by examining the implementation process of SOA over time (Robey et al. 2002). As demonstrated in this paper, the process perspective is appropriate to study the micro-processes of capability-enhancing organizational change (Repenning and Sterman 2002) and thus allow us to explain different experiences that can account for the SOA implementation paradox.

This research makes two important contributions to the literature on the implementation of information systems. First, the theoretical contribution provides insights about the association between duration of normative management commitment and delay time of learning new technology during SOA implementation. Extant literature on SOA (Choi et al. 2010; Luthria and Rabhi 2009) has not discussed the dynamics of these effects on the success or failure of SOA implementation. Second, the empirical contribution provides meaningful qualitative data, indicating the inherent tradeoffs of SOA implementation between short-term performance drop and potential long-term benefits and between local project needs and organization-wide IS agility.

2. Research Methodology

We use system dynamics modeling as the main research methodology (Sterman 2000). System dynamics has been proved to be a powerful modeling tools (Repenning and Sterman 2002; Sterman 2000) and has received increasing attention for IS research (Abdel-Hamid and Madnick 1991; Cao et al. 2010; Choi et al. 2010; Georgantzas and Katsamakas 2008).

We followed the standard method of data collection and analysis that was used in Abdel-Hamid and Madnick's works on software project management (Abdel-Hamid and Madnick 1991). First, an initial series of 10 semi-structured interviews were conducted with 14 different managers and developers. Interviews lasted between 60 and 90 minutes. After the purpose of the research was explained, informants began by describing their professional background. They were then asked to share their experience associated with SOA implementation efforts in the organization. Finally, they were asked to speculate on the potential key challenges and factors that

facilitate or impede those SOA implementation efforts. Second, after a "skeleton" model was built based on the information collected at the first phase, an extensive review of the literature was conducted. The "skeleton" model served as a useful guideline for the literature review. The literature review filled in many gaps of the "skeleton" model and led to a more detailed version of the model. Also, each causal link in the model was justified by the supportive evidence from qualitative data we gathered and/or the literature review. Third, another series of 12 interviews were conducted with 15 informants. Since data collection, coding and analysis proceeded iteratively, the interviews of this phase became more structured than that in the first phase.

It is also worth noting that this research intentionally avoided replicating the context of a specific organization; we removed the details that were merely applied to a specific organization. The model and theory building aim to generate insights and implications in a broad organizational context.

3. Model

The system dynamics model shown in Figure 1 includes two balancing loops and three positive loops. The balancing loop B1 indicates developers invest part of their work hours to implement SOA-based IT systems. There are two kinds of pressures that affect the tradeoff decision of IT developers and managers: one is the pressure to deliver the immediate functionalities of IT systems (usually viewed as done faster by not incorporating new technologies, such as SOA) on schedule, and the other is the pressure to use SOA for long-term benefits. The balancing loop B1 operates to close IS agility gap over time by investing in SOA. The balancing loop B2 represents the decision that developers might make to "work harder" to get the functional development done on schedule. This decision actually shifts part of their work hours to the functional development and under-invests in SOA. B2 indicates that the tendency of developers to put high priority on delivering functionalities to end users on schedule, which was confirmed by many managers that we interviewed. B2 operates to close the delivery rate gap and release the schedule pressure. It is worth noting that there is relatively shorter delay within B2 than the delay within B1. In case of a big delivery rate gap (e.g., urgent IT functionalities are requested by end users from business units), it is very likely for the IT managers and developers to make the decision that bypasses the SOA requirements and accelerates the development of functionalities.

The reinforcing loop R1 represents the fact that developers' productivity increases over time with more and more SOA systems installed in the organization, releasing the `Pressure to Deliver on Schedule`. Under less intense schedule pressure, it is more likely for IT managers and developers to invest more of their work hours in SOA implementation. However, developers cannot immediately acquire the knowledge and skill of SOA considering its technical complexity (Choi et al. 2010) and thus cannot increase their development productivity in a short period. The substantial delay in R1 has important effects on the decisions of IT managers and developers.

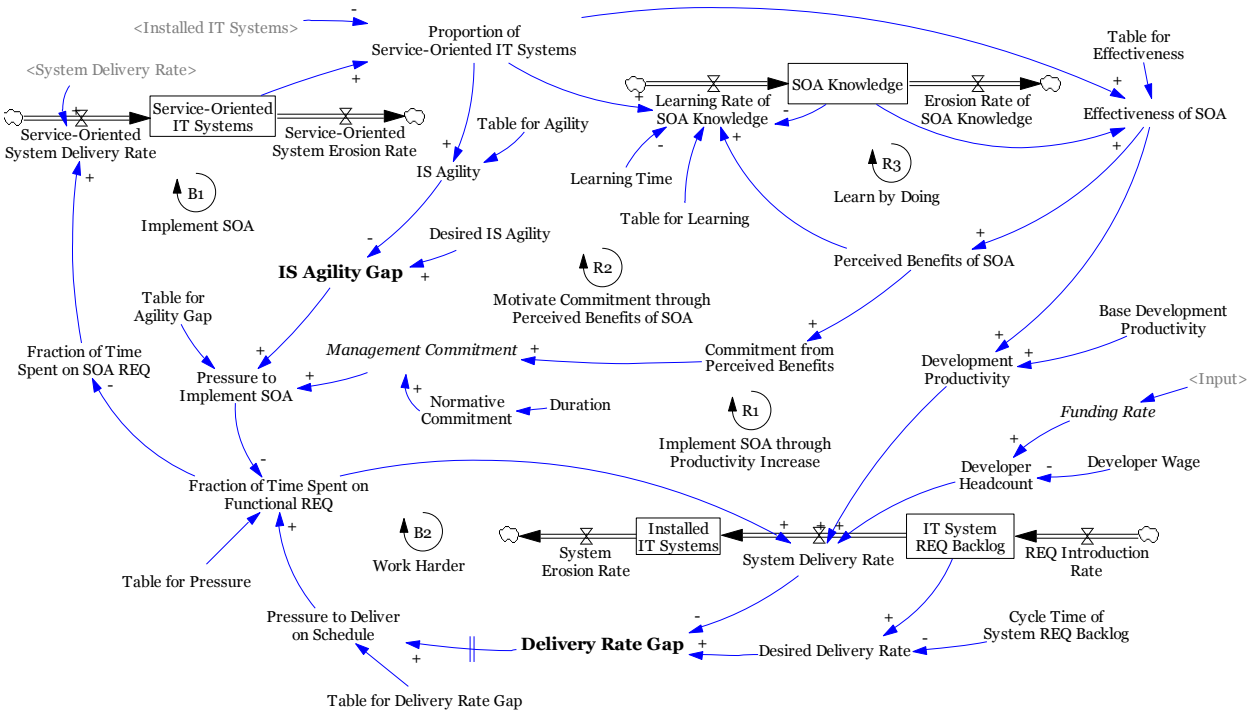

Figure 1. System dynamic model of SOA implementation process

The reinforcing loop R2 represents the fact that an organization perceives more benefits from SOA implementation when the development productivity is being improved over time. The perceived benefits of SOA increases the management commitment and promotes the SOA implementation further, resulting in more perceived benefits. Similar to R1, R2 is also subject to the substantial delay between attaining higher SOA penetration and the perceived benefits of SOA. Yet the substantial delay in R2 has a very important effect that is different from the effects of the delay in R1. That is, the substantial delay in R2 largely postpones the recognition of benefits of SOA by the organization. Accordingly, organizations that decide to implement SOA have to be patient enough and tolerate a perhaps long period during which little benefits of SOA are perceived, especially at the early stage of SOA implementation. Thus, much of the management commitment to SOA has to come from normative commitment. In such situations, top management (e.g., CIOs) has to use their leadership to resist possibly unfavorable initial word of mouth about SOA. This normative commitment has to be maintained for long enough before perceived benefits of SOA arrive and enough endogenous commitment is motivated.

The reinforcing loop R3 models the mechanism of the time delay between `Proportion of Service-Oriented IT Systems` and `Effectiveness of SOA`. The time delay is caused by the technology learning process of SOA. That is, it takes time for an organization to acquire SOA knowledge and proficiency by using and building SOA IT systems and SOA design principles.

4. Experimental Simulation

In the experimental simulation, we focus on two key variables: the duration of the normative commitment and the learning time. In the base model, the duration of the normative commitment is set to be 12 months and the learning time is 12 months also. For simplicity, this means that the

normative commitment lasts for 12 months and after that, top management simply removes the normative commitment. The learning time reflects the time delay to increase the technology knowledge about SOA. The settings of the two comparative experimental simulations are given in Table 1. Figure 2 shows the simulation results of the base simulation (blue solid curves) and two comparative experiments (red dotted and green dashed curves).

Table 1. Settings of Experiment Simulations (Unit: Month)

	Base	Experiment 1	Experiment 2
Duration of Normative Commitment	12	9	12
Learning Time	12	12	16

Let's first look at the base simulation (blue solid curves) which has a successful outcome. As shown in Figure 2(a), the organization's IS agility grows gradually during the first 12 months. When the normative commitment is removed at the 12th month, the IS agility drops for a while. But at around the 15th month, the IS agility stops dropping and turns to grow again. Eventually, the organization's IS agility grows and stabilizes at a high level. Thus, this result illustrates a preferable case in which the organization has successfully built up its IS agility through implementing SOA. As shown in Figure 2(b), most of the developers' work hours are spent on functional requirements when the normative commitment is removed suddenly at the 12th month. But since internal commitment has already been motivated through the recognized benefits of SOA, the developers continue to spend a sufficient fraction of their time on implementing SOA. With more benefits of SOA being perceived, developers spend more time on SOA requirements and thus less time on immediate functional requirements. Figure 2(b) shows the fraction of time spent on functional requirements drops gradually after the sudden rise at the 12th month. When the organization builds up sufficient IS agility, developers, with less pressure to implement SOA, can turn to spend more time on immediate functional requirements. Figure 2(c) indicates that when the normative commitment is removed at the 12th month and developers bypass SOA requirements, the entire system delivery rate actually rises suddenly. But in order to implement SOA and build up the IS agility, the organization does suffer from the "worse-before-better" phenomenon, that is, the system delivery rate drops during the 12th to 20th month. Yet after the 20th month, the system delivery rate turns to grow gradually and exceeds the highest point at the 12th month and equilibrates at a higher level. Figure 2(d) shows that the IT system requirement backlog also equilibrates at a certain level.

Let's now look at Experimental Simulation 1, as shown in Figure 2 using red dotted curves. We change the duration of normative commitment from 12 months to 9 months, holding other factors unchanged. That is, we assume the normative commitment is removed at the 9th month, just three months before the base simulation. This simulation allows us to examine how the shorter duration of normative commitment affects the dynamics of the implementation process.

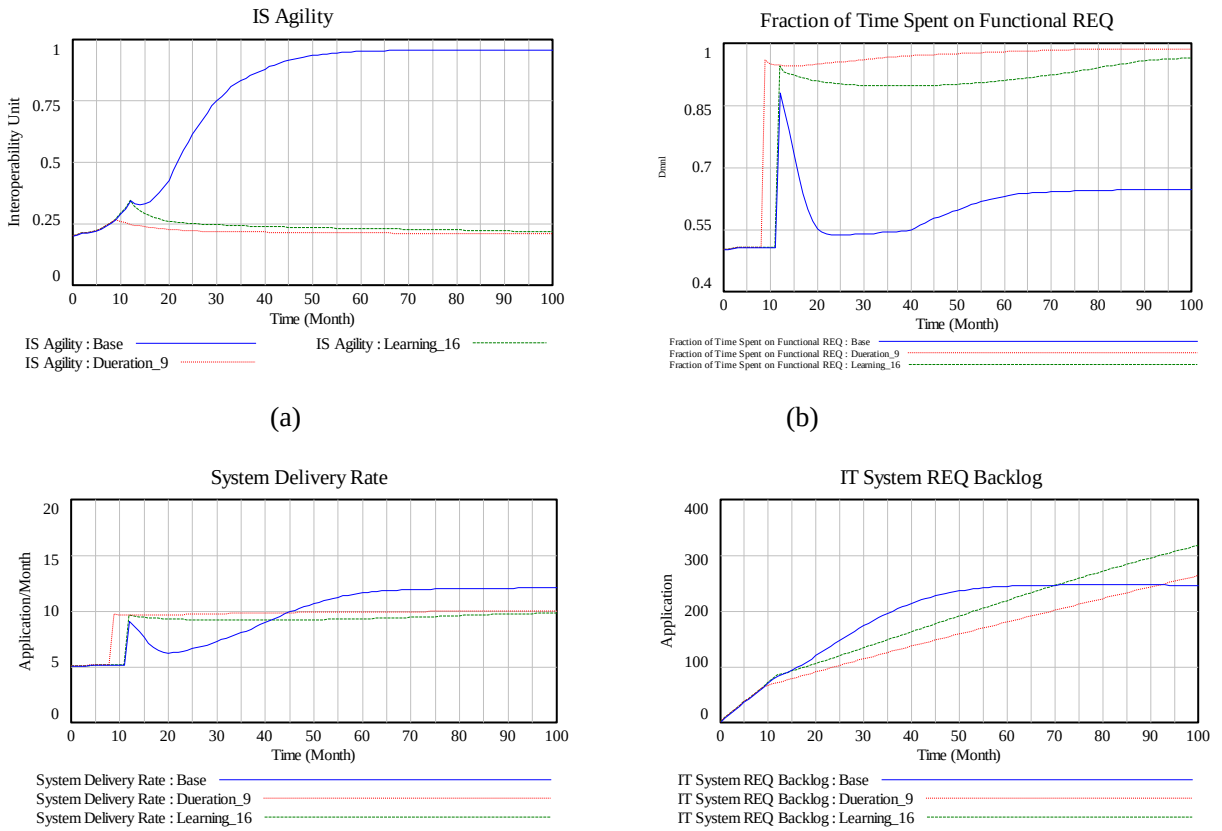

Figure 2. Results of Experimental Simulations

As shown in Figure 2(a), the organization's IS agility turns to decrease after the normative commitment is removed at the 9th month and never increased again. Eventually, the IS agility stays at a low level. This result reveals that little effectiveness of SOA has been realized when the normative commitment is removed at the 9th month. Without realizing the effectiveness of SOA, little benefit of SOA is perceived in the organization, resulting in little internal commitment on SOA. In this case, the organization simply stops implementing SOA. As shown in Figure 2(b), the developers spend most of their work hours on functional requirements and thus little time on SOA requirements. Figure 2(c) indicates that the system delivery rate jumps to a higher level when the normative commitment is removed at the 9th month and developers spend little time on SOA requirements. But the system delivery rate remains at that level which is suboptimal and lower than the case of the base simulation. This means the organization actually loses the opportunity to improve its system delivery rate. Figure 2(d) shows that the IT system requirement backlog always increases, which means the IT department cannot complete the system requirements requested by the business units. In contrast, the IT department was able to accomplish the system requirements in the case of base simulation described earlier.

Finally, let's turn to look at Experimental Simulation 2, using green dashed curves in Figure 2. We change the learning time from 12 months to 16 months, holding the duration of normative commitment as 12 months and all other factors unchanged. That is, we assume the learning time

for the organization to acquire SOA knowledge is 16 months and the normative management commitment is removed at the 12th month as in the base simulation. This allows us to examine how the longer learning time affects the dynamics of the implementation process. As shown, the results of Experimental Simulation 2 generally resemble that of Experimental Simulation 1.

5. Conclusion

This research adopts a process perspective to investigate the dynamics of SOA implementation, contrasting to prior SOA research using only the variance perspective. Specifically, a system dynamic model is built to unfold the significant effects of the duration of normative commitment and time delay of technology learning on the dynamics of the SOA implementation process. Although prior research had identified top management commitment as a critical success factor, this research suggests that it is the duration (rather than just the strength) of normative commitment that may dramatically affect the dynamics. Further, this research suggests that in order to reach a successful SOA implementation, it is important to understand the duration of normative commitment and the technology learning time, i.e., the time to learn SOA technology. The implications are that when providing normative commitment on SOA implementation, managers should consider the time delay of SOA technology learning in their organization and carefully decide appropriate duration of their normative commitment.

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