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A FRAMEWORK TO SUPPORT SERVICE-ORIENTED ARCHITECTURE INVESTMENT DECISION

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Completed Research Paper

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Abstract

Service-oriented architecture (SOA) is a system paradigm that structures business functions as loosely coupled services to enable business agility. SOA requires significant up-front investments, and in return, promises a vast array of benefits. Unfortunately, in contrast to the costs of the investment, monetary benefits associated with SOA are more difficult to measure. For one reason, benefits such as increased agility or improved flexibility are elusive in nature, making it harder to define metrics for their calculation. For another, SOA value is realized in long term under uncertainty, and traditional capital budgeting methods often fail to capture uncertainty when valuing investments. In this paper, we provide a decision framework to analyze the monetary impact of SOA investment in an organization. Combining traditional NPV analysis with option pricing models, our framework accounts for operational and strategic costs and benefits of SOA and proposes an extended investment value to support managerial investment decision.

Keywords: Service-oriented architecture, IT investment, real options, option pricing models

Introduction

Service-oriented architecture (SOA) is a software design paradigm, where software systems are composed of independent, autonomous and loosely coupled services on an IT network. Each service represents a reusable business unit or a task (e.g. customer lookup, credit card validation, sales order query, etc.) that can be published and discovered via standard interfaces. These services can be composed together and reused in different logical flows to support a number of business processes.

Development, composition and use of services are independent of any particular technology. Since SOA is a system design style rather than a system itself, it does not dictate on any specific technology to achieve service orientation (Papazoglou and van den Heuvel 2007). However, a certain infrastructure needs to be in place to build, deploy and manage an SOA implementation. Components of this infrastructure include, but are not limited to, a service repository to store service related data, an enterprise service bus (ESB) to route and transform service messages and an orchestration engine to compose complex business processes from available services. IBM's WebSphere, Oracle's SOA Suite and Sun's Java CAPS are some of the commercial products that provide such components required for the SOA infrastructure – with price tags up to million dollars. According to AMR Research, an average of $1.4 Million on SOA software and services has been spent in 2007 per company that has active SOA initiatives (AMR Research 2008). Upon licensing, installation and training costs, a full SOA implementation can turn out to be a very expensive investment for an organization.

Consistent with its high costs, potential benefits of SOA are also vast, in theory, ranging from reduced maintenance to increased reuse, from business flexibility to application integration and so on. Most importantly, SOA enables organizations to be more responsive to the demands of the markets, because flexible applications can be developed and deployed rapidly to support business agility (Zhao, Tanniru and Zhang 2007).

Unfortunately, in contrast to the costs of the investment, the monetary benefits associated with SOA are more difficult to measure. One problem is that benefits such as increased agility or improved flexibility are elusive in nature, meaning that it is hard to define performance metrics for their accurate calculation. Tsourveloudis and Valavanis (2002) argue that the main trouble of measurement lies in: (1) multidimensional, overlapping characteristics of agility and flexibility and (2) vagueness of the concepts themselves.

A second problem with benefits measurement is the uncertain nature of future events. As an enabler software platform, the core value of SOA is to open up future payoff opportunities that can be realized throughout its lifespan. By capitalizing on such opportunities, managers have the flexibility to alter the benefits obtained from this platform. Unfortunately, traditional capital budgeting methods often fail to capture managerial flexibility when valuing investments (Trigeorgis 2005).

In this research, we study the following question: how to support managerial decision making regarding a specific type of IT investment – the SOA platform? To answer this question, we should be able to measure the actual economic value to be gained by SOA.

Economic value of IT investments is a reasonably studied problem in literature. According to Kumar (2004), IT valuation research can be classified into three main streams: (1) effects of IT investments on organizational financial performance, (2) limitations of traditional methods and the promise of real options theory for IT investment analysis and (3) organizational value of IT investments. Unfortunately, it is difficult to apply the models from these researches onto new cases directly, since different types of IT infrastructures can possess different cost/benefit characteristics.

This is one of the first studies that focus on economic issues related to SOA investments. Building on the three research streams mentioned, we identify nine operational and strategic issues related to SOA and make suggestions on how these issues can be modeled quantitatively. We, then, construct a framework that can be applied to estimate the extended SOA investment value. The extended investment value is a measure for the economic incentive of SOA adoption, and serves as an instrument to support the managerial investment decision.

The structure of paper is as follows: In section two, we discuss the short term, operational issues regarding an SOA implementation in an organization, including what these issues are and how to measure them. In section three, we talk about the long term effects and identify the strategic options occurring after the implementation. In sections four and five, we discuss the framework procedure and demonstrate its implementation in a case study. In section six, we describe the areas of future research and conclude the paper.

Operational Issues in an SOA Project

Operational issues can be reviewed under two categories: (1) Up-front expenditures for SOA implementation, and (2) SOA led changes in IT operations.

Up-front Expenditures

As with many IT infrastructure projects similar in nature, SOA requires significant up-front expenditures during the initiation phase of the project. Up-front expenditures correspond to the negative cash flow at time zero (i.e. until the project roll-out) and include cost of installation, cost of initial development and cost of training.

Specifically, SOA software and hardware purchases (e.g. enterprise service bus, service repository database, etc.) and their setup labor costs are the items to consider during the installation process. After installation of SOA components, initial core services have to be developed and deployed in order to roll-out the SOA implementation. Finally, user training has to be completed before SOA becomes operational in the organization.

It is relatively easy to measure the monetary impact of up-front expenditures. Cost figures regarding software and hardware purchases can be obtained through vendor channels. For effort based items, costs can be defined as a function of labor hours and labor rate. In this calculation, labor rate is a given constant, whereas labor hours required for setup, service development and user training are estimated by management. Equation 1 below is used in our model to compute the up-front expenditures for SOA, where C_u is the total up-front expenditure, c_s is the cost of SOA package and software purchases, c_h is the cost of hardware, L corresponds to the total labor hours spent for installation, development and training and e is the hourly labor rate.

$$C_u = c_s + c_h + (L * e) \tag{1}$$

SOA Led Changes in IT Operations

An SOA implementation represents a major architectural paradigm shift for a company — within both business and IT units (Patrick 2005). The impact of these changes has been subject to recent research from the industry (IBM Global Business Services 2006; IBM Global Technology Services 2008; webMethods 2005) and academia (Beimborn and Joachim 2009; Bieberstein, Bose, Walker and Lynch 2005; Luthria and Rabhi 2008; Maurizio, Sager, Jones, Corbitt and Girolami 2008; Yoon and Carter 2007). In a work by Yoon and Carter (2007), it is argued that changes that organizations experience from SOA implementation can put into two benefit categories: (1) improved business agility and (2) lowered costs. Drawing from the work of Yoon and Carter, Beimborn and Joachim (2009) define the drivers for SOA benefits as: modularization, reuse, reduced complexity, integration potential, virtualization and platform independence. In addition, they also define specific risk and effort factors as the downside impact of SOA. These factors include: organizational change, increased governance efforts and technology risks.

Based on previous literature, we identify three dimensions of changes with the introduction of SOA technology: (1) technical, (2) organizational and (3) managerial, as shown in Figure 1. Technical dimension is driven by changes in application development and maintenance efforts. Organizational dimension focus on how roles and responsibilities in the organizational structure are affected by SOA. Finally, managerial dimension involves changes in IT service management.

Figure 1. Three dimensions of SOA changes in IT Operations
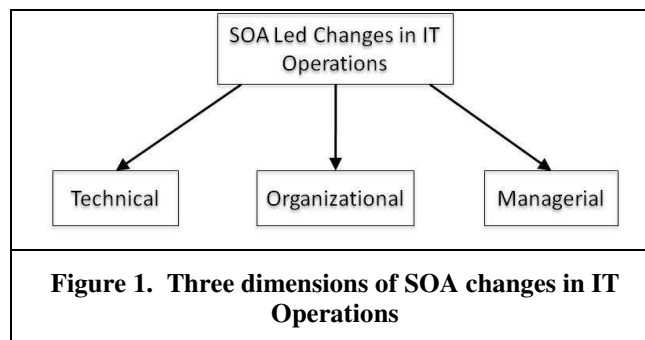
Technical dimension

SOA promotes a shift from writing software to assembling and integrating services. Due to the reuse of functionality, which is encapsulated in services, a service has to be implemented only once but can be used in different business processes (Beimborn and Joachim 2009). This reuse characteristic of SOA has two important technical implications: (1) new applications can be developed in shorter time at lower costs, and (2) existing applications can be maintained more rigorously with less effort.

Application development under SOA is based on service composition mechanism. When applying composition, a new software asset is created by assembling two or more existing assets with custom built code (Postmus and Meijler 2008). The custom code includes integration code that will glue the existing assets together and the new functionality code that is unique to the application. To determine the expenses in SOA based application development, we measure the effort spent on development of custom code. Equation 2, which is adapted from COCOMO 2.0 model (Boehm, Clark, Horowitz, Westland, Madachy and Selby 1995) and Postmus and Meijler (2008) is used for this purpose, in which C_{dK} is the cost of developing a particular application K, s_{inK} and s_{newK} are the total amount of integration and functionality code for K developed in terms of thousands of lines of code (KSLOC) respectively, a_l is the average labor hour to develop one KSLOC, and β is the exponential factor to account for possible economies or diseconomies of scale in writing lines of code.

$$C_{dK} = \left(a_l * \left(s_{inK} + s_{newK} \right)^{\beta} \right) * e \qquad (2)$$

The second impact of SOA reuse is on the maintenance costs of applications. A promise of SOA is to decrease software maintenance by reducing system complexity and function duplication (Beimborn and Joachim 2009). A well accepted economic view on software maintenance is to model it as an economic production process, where maintenance effort (i.e. the input) is converted into corrected software (i.e. the output) (Banker, Datar, Kemerer and Zweig 2002). To model SOA application maintenance costs, we adopt from Banker, Datar, Kemerer and Zweig, (1993) and Banker et al. (2002), where maintenance costs are defined as a function of overall maintenance effort, which is affected by two factors: (1) code complexity, (2) errors in the code.

Code complexity refers to the characteristics of the data structures and procedures within the code that make it difficult to understand and change (Banker, Davis and Slaughter 1998). In the context of software applications, it can be measured by using module size (i.e. average size of application's modules), procedure size (i.e. average size of a module's procedures), and branching (i.e. density of call statements) (Banker et al. 1993). For SOA applications' complexity measurement, we substitute module size with service size while keeping procedure size and branching metrics.

The second issue affecting the maintenance effort is errors in the application code. Variations in error rates are expected to be a function of either the software system itself, or factors in the maintenance environment. We propose to use complexity and system volatility as system factors and maintainer experience as the environment factor in a model of software maintenance effort. Here, system volatility refers to the frequency of changes made to the application software. Systems which undergo frequent modification have higher error rates, because each modification represents an opportunity for new errors to be generated (Banker et al. 2002). And maintainer experience is a measure of maintainers' familiarity with the application. If the programmers maintaining the system are relatively new, their inexperience will increase the chances of errors go undetected. Figure 2 is the representation of this maintenance effort model. In the context of SOA implementation, we expect that as service reuse gets more common through the enterprise; the application complexity ratios will decrease, reducing the overall maintenance

effort. However, error rates in the code are initially expected to go up, because of the programmers' unfamiliarity with the SOA development environment. This will affect maintenance efforts in a negative way.


Figure 2. SOA maintenance effort model
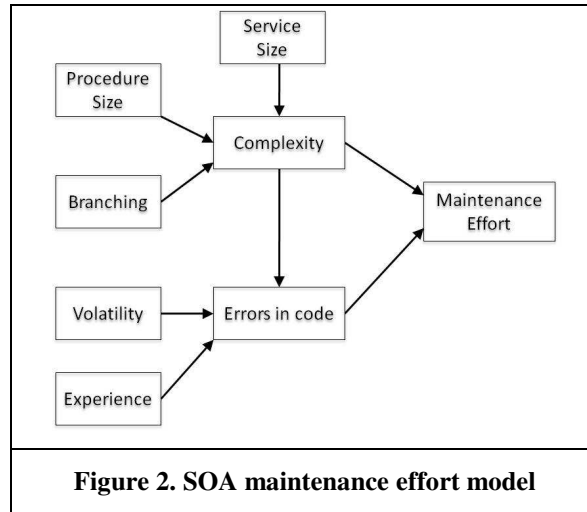
Organizational dimension

SOA enablement is a major transformation for many organizations, requiring effective governance and organizational change. Organizational change impacts how individuals in an organization do their work and how they relate to one another (Bieberstein et al. 2005).

It is necessary to transform traditional software development roles and responsibilities under SOA based environments, mainly due to the increasing alignment between IT and business process management units (Kajko-Mattson, Lewis and Smith 2008). The resulting organizational structure is a one that streamlines cross-business operations, flattens management chains and puts business services at the core of system design (Maurizio et al. 2008; IBM Global Technology Services 2008).

However, adoption to the new organizational structure can be costly. There are two main economic concerns that accompany an SOA based organizational change effort. First of all, SOA implementations introduce new responsibilities for IT professionals. The focus shifts from the implementation of the software system to the understanding of the purpose of the individual components, and their role and cooperation with other services within a combined business process (Kajko-Mattson et al. 2008). Acquiring such new skills and knowledge may require additional tools and training for employees.

Secondly, the organizational workforce can be affected by the changes driven by the SOA implementation. New roles and positions may be created to support SOA specific processes, whereas some existing positions can be eliminated. Proposed by Kajko-Mattson et al. (2008), Figure 3 is a schema for SOA-based system roles that includes new positions such as service developer and service designer and old ones such as traditional back-end support.

Figure 3. SOA based system roles (adapted from Kajko-Mattson et al., 2008)
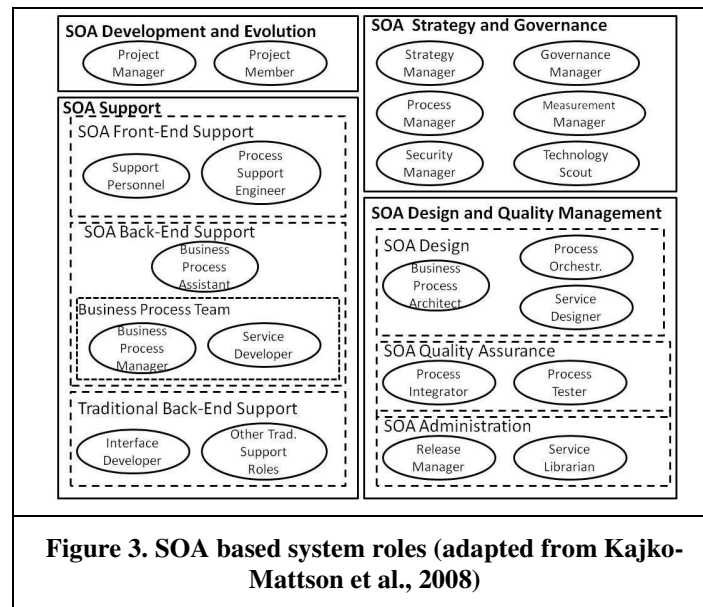
Overall, the company management should consider these two aspects to estimate the effects of SOA implementation on their organizational structure.

Managerial dimension

IT service management (ITSM) is the third area that we can observe changes on with respect to SOA adoption. In broad terms, ITSM refers to the set of processes that deal with the control and monitoring of IT services (Sallé 2004). The most common framework for implementing ITSM is Information Technology Infrastructure Library (ITIL), which can be described as a set of documents consisting of best practices of IT service management. ITIL focuses on two main areas: service support and service delivery (Hochstein, Zarnekow and Brenner 2005).Under service support, five main managerial concerns are addressed: incident management, problem management, change management, release management and configuration management. In addition, service delivery covers the issues related to: service level management, financial management, IT service continuity management, capacity management and availability management (Hochstein et al. 2005).

For many SOA characteristics, the impact on such areas can be both beneficial and costly. For example, while service reuse is a significant benefit for application development and maintenance, the fact that a service can be widely used in many applications throughout the enterprise may create capacity management problems (Bieberstein et al. 2005). For highly reused services, scarce infrastructure resources may cause system overload and affect response times. Eventually, availability of services may be compromised.

In another situation, service composition characteristic of SOA may positively or negatively affect application release times. While applications that are composed of existing services can be developed faster, coordination of such applications with existing IT assets may take more time, thereby delaying the actual release of applications.

Configuration and change management after application implementation may also be affected. Reuse of SOA services in many applications will result in increasing complexity of the configuration of IT assets. Changes to a reused SOA service for one application may also affect other applications using the same service, further complicating change and configuration management aspects under SOA.

In IBM Global Technology Services (2008), the impact of SOA on IT service management of an organization is discussed with respect to three topics: 1. problem identification, 2. service component relationships and 3. performance issues. Studying this work under the context of ITIL framework, we identify the SOA characteristics that affect relevant ITIL sub-areas as shown in Figure 4.

Figure 4. SOA impact on ITIL sub-areas
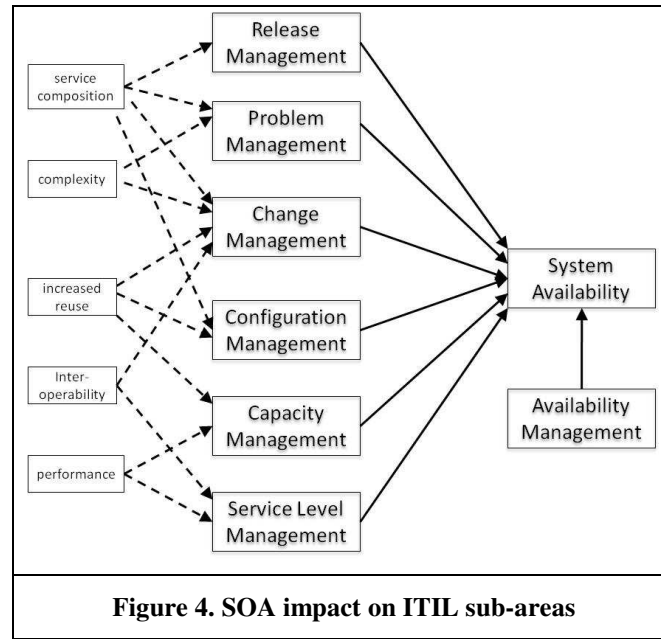
In this model, system availability (i.e. the degree of operational continuity of the system) is directly affected by the changes in the IT service management sub-areas. To measure the impact of SOA on IT service management, system availability values before and after the SOA implementation are compared.

Strategic Options in an SOA Project

According to traditional capital budgeting theory, an investment's net present value (NPV) is the value of its expected future cash flows that is discounted at a rate that reflects the risk factor. Unfortunately, this approach may overlook the strategic opportunities that may occur after the investment has been implemented.

On the other hand, business cases for large scale infrastructure investments such as SOA are increasingly being made on the basis of the flexible and strategic opportunities (Favaro J., Favaro K., and Favaro P. 1998). For example, the ability to delay the commitment of certain resources, to change maintenance schedules, to add and replace additional software components and to initiate follow-on projects are all forms of flexibility that generate additional value for a project (Erdogmus 1999). Lacking a systematic approach to capture this additional value, it would be misleading to estimate the true impact of an IT investment.

A quantitative approach for valuing IT investments with strategic opportunities is based on real options analysis. A project embeds a real option when it offers management the flexibility concerning the structure of IT investments. Using real options, a company can limit its loses / gains through the initial investment while positioning itself to capitalize fully on future opportunities. In such a case, the total value of a flexible IT investment (such as SOA) can be calculated as the value of the initial investment plus the value of options from managerial flexibility (Taudes 1998).

In this research, we propose that the total value of an SOA investment consists of benefits from SOA infrastructure transformation as well as the value of options from future use of SOA. Specifically, we define three options in the strategic context of an SOA implementation: (1) growth options through composite business applications, (2) deferral option through reduced development time, and (3) switch-use option through re-utilization of IT resources.

Growth Options

As an enabling software technology, an SOA investment can be seen as a buy-in for development of new applications with a service-centric approach. Service-centric development refers to the process where reusable services are composed over an orchestration engine and integrated into ESB to create composite business applications. These new applications are opportunities that can be brought into operation at certain implementation points when found beneficial (Taudes 1998).

We define the composite business applications that are developed with SOA functionality as growth options of SOA investment. As shown in Figure 5, growth options provide the management with the flexibility regarding the implementation decision – meaning that management has the right but not the obligation to exercise the option (Dai, Kauffman and March 2007).

Figure 5. Growth option flexibility	Figure 6. Effect of composite application on SOA value
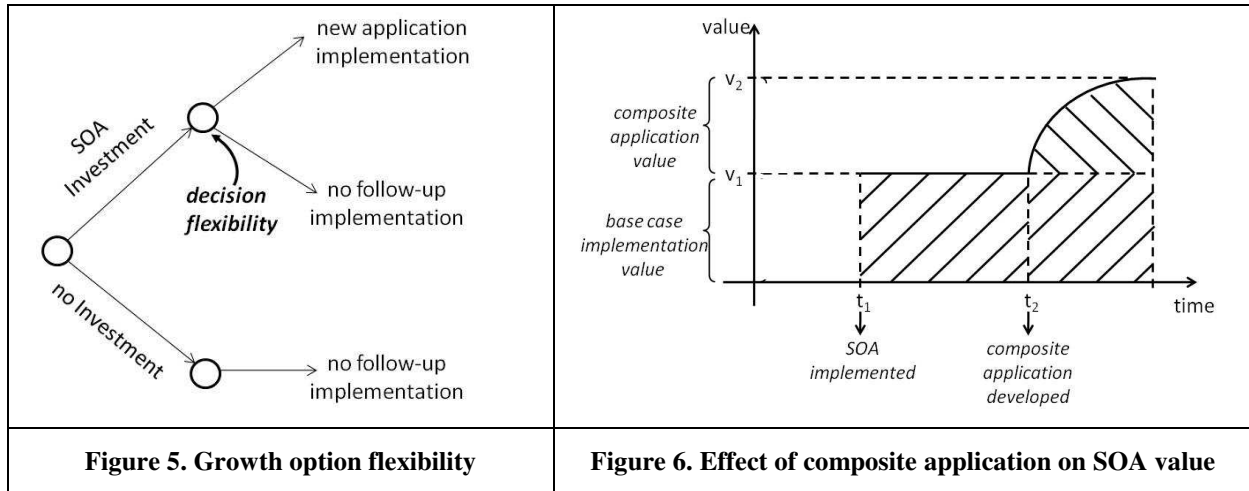
The value of the option comes from the expected benefits of the new application, if the implementation is made. Since a rational decision maker wouldn't exercise an option that has a negative value known at a specific time point, we can be certain that values from implemented applications would be positive and add up to the overall SOA investment value. Figure 6 illustrates this idea, in which the SOA implementation is completed at t_1 and a composite application i is implemented at t_2, bringing the overall investment value to v_2.

However, estimating the expected value of a composite application (i.e. $v_2 - v_1$) may not be trivial, due to uncertainty involved in its future cash flows. According to Dai et al. (2007), stochastic market characteristics in which the option value is realized will significantly affect the value of an option.

To overcome this issue, different option pricing models from finance literature have been employed to value IT growth option opportunities, such as Margrabe's option pricing method, Carr's sequential exchange options model, and Geske's compound options approach (Singh, Shelor, Jiang and Klein 2004). In this paper, we use one of the most common models, the Black-Scholes formulation to compute the value of a composite business application. Due to word limitation, we omit the underlying principles regarding the Black-Scholes model in this paper. However, interested readers can refer to: Black and Scholes (1973) for theoretical background of the model, Benaroch, Shah and Jeffery (2006); Taudes, Feurstein and Mild (2000); Singh et al. (2004) for validity of its assumptions in IT context, and Benaroch and Kauffman (1999); Taudes, Feurstein and Mild (2000) for case studies that employ Black-Scholes to value IT options. In short, the Black-Scholes model is a closed formulation that computes the price of an option (e.g. composite business application k) as;

$$NPV_k = V_0 N(d_1) - Ie^{-rT} N(d_2)$$
$$d_1 = \frac{1}{\sigma\sqrt{t}}\left(\ln\left(\frac{V_0}{I}\right) + \left(r + \frac{1}{2}\sigma^2\right) \times T\right)$$
$$d_2 = d_1 - \sigma\sqrt{T}$$

(3)

where,

NPV_k: Option value of composite business application k

V_0: current value of expected future benefits from application k

I: total cost of ownership for k

T: time period that k is implemented

r: risk free interest rate

σ: volatility of the expected future benefits from k

N(d): cumulative standard normal distribution function

This formula is derived assuming the payoffs of the option can be replicated through a continuously updated portfolio of two assets: a twin security that perfectly replicates value of the underlying asset and a risk free security such as a short-term bond (Erdogmus and Vandergraaf 1999). In SOA investment analysis, we propose to calculate the growth option values of composite business applications using Equation 3 and add these values into the operational NPV value of SOA.
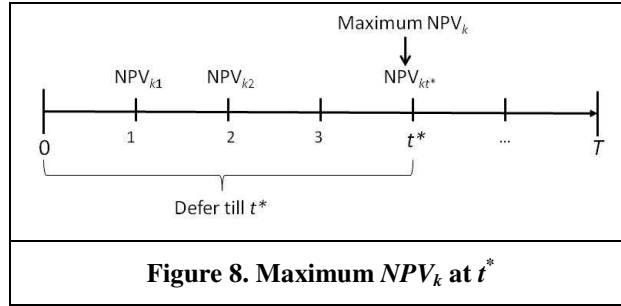
Deferral Option

An impact of service based reuse in SOA is reduced development time of applications. This impact has two significant outcomes. First of all, time-to-market delivery of applications is decreased, resulting organizations to quickly respond to new business demands, and thus achieving greater agility. Second, ability to choose optimal applications from an array of possible projects is increased; because the organization may now wait longer to see market uncertainties to resolve, and yet still develop an application on schedule.

From a real options perspective, reduced development time in SOA enables deferral options for developing and implementing composite business applications. After SOA, the management obtains the flexibility, as shown in Figure 7, to keep the option open (i.e. deferring the development kick-off decision) up to a time point t^*, when the value of the application will reach the highest value. As mentioned before, such flexibility is possible because the organization may now delay the implementation decision as the same amount of reduced development time.

Figure 7. Time flexibility
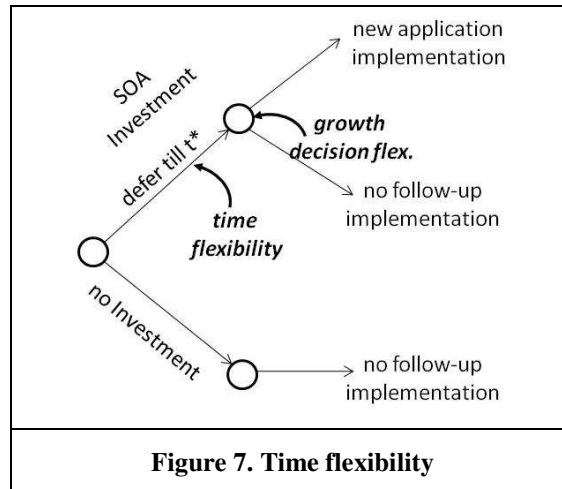
An opportunity to flexibly defer implementation for some time period has a larger expected value than a now-or-never type of investment (Benaroch and Kauffman 1999). In a case where there can be several possible application projects to pursue, but only a few of them could be picked because of development budget constraints, deferral option helps to resolve uncertainties by: (1) learning more about potential returns of each project, and (2) taking possible actions to lower market entry risks. On the other hand, by delaying the implementation, the organization may lose potential revenues from not implemented applications and also lose agility of quick time-to-market delivery.

Depending on the scale of these two competing effects, the option value of an application can increase or decrease. Therefore, the question becomes finding optimal time (i.e. *t**) for implementation, where the growth option value of the application is maximized, as shown in Figure 8.

Figure 8. Maximum NPV_k at t^*

In Benaroch and Kauffman (2000), a decision rule to find the optimal implementation strategy is proposed as following:

Decision Rule: Where the maximum deferral time is *T,* implement the application at time t^*, $0 \leq t^* \leq T$, for which the NPV_{kt^*} takes the maximum value.

$$NPV_{kt^*} = \max_{t=1,...T}(NPV_{kt}) \tag{4}$$

For each time period *t*, NPV_k can be computed using the Black-Scholes formula in Equation 3. However, decision makers should be careful about updating the formula variables and re-applying the decision rule every time new information arrives during the deferral period (Benaroch and Kauffman 2000).

Switch-Use Option

In real options literature, the option to switch-use refers to the managerial flexibility of switching among alternate modes of operations such as projects, machines or technologies (Favaro J. et al. 1998; Trigeorgis 2005). Two basic principles of SOA, *modularity* and *interoperability* are the features that can enable such managerial flexibility in IT infrastructures. As mentioned before, applications under SOA are composed of independent, autonomous and modular software components on an IT network. These modular components include services that encapsulate business functionality as well as IT resources that support application operations such as database systems. Through SOA interoperability, components and applications can integrate seamlessly along the enterprise IT network.

However, at some point in the future, an operational system application can be abandoned permanently, if conditions worsen severely. In that situation, an SOA implementation provides managers with the flexibility to re-utilize modular IT resources in other projects. Eventually, these salvageable resources could be sold or put to different uses, creating additional value for the organization (Benaroch 2002). Figure 9 shows the strategic SOA options including the switch-use flexibility.

Figure 9. Switch-use option flexibility
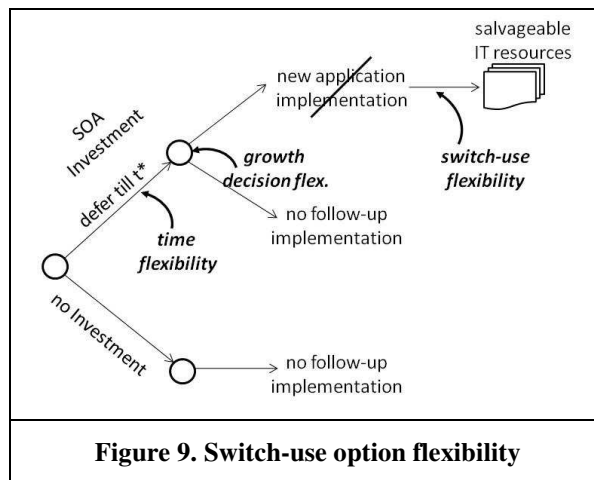
Switch-use options extend the service reusability concept in SOA by also adding the IT resource (e.g. database systems, etc.) dimension into benefits calculation.

To model the switch-use options, we use the formula in Equation 5, in which S_k refers to the salvage value for application k, c_m is the cost of IT resource m under application k's total cost of ownership, and β_m is a management estimate probability of re-utilizing resource m in any other project of the organization.

$$S_k = \sum_{m=1}^{M} c_m * \beta_m \qquad (5)$$

For each application k that consists of IT resources m ($m = 1,2,..,M$), we correct the total cost of ownership I in Equation 3 as $I^* = I_k - S_k$. This correction corresponds to subtracting the expected salvage value of application k from its total cost of ownership. Applying the new I^* into equation 3, we can then find NPV_k^* – the total option value of composite business application k that considers both growth, deferral and switch-use flexibilities.

Decision Support Framework for SOA Investment Analysis

In total, we have identified nine issues related to SOA investments in operational and strategic dimensions. Now, we combine these issues in a framework to support managerial decision making regarding SOA investments. As shown in Figure 10, our framework consists of four steps: (1) defining the up-front investment costs, (2) determining SOA led changes, (3) identifying strategic options, and (4) calculating the extended investment value. Topics to consider for each of these steps are given in the middle columns of the figure, while analysis tools and measures are given in the bottom two columns.

Figure 10. Decision support framework for SOA investment analysis
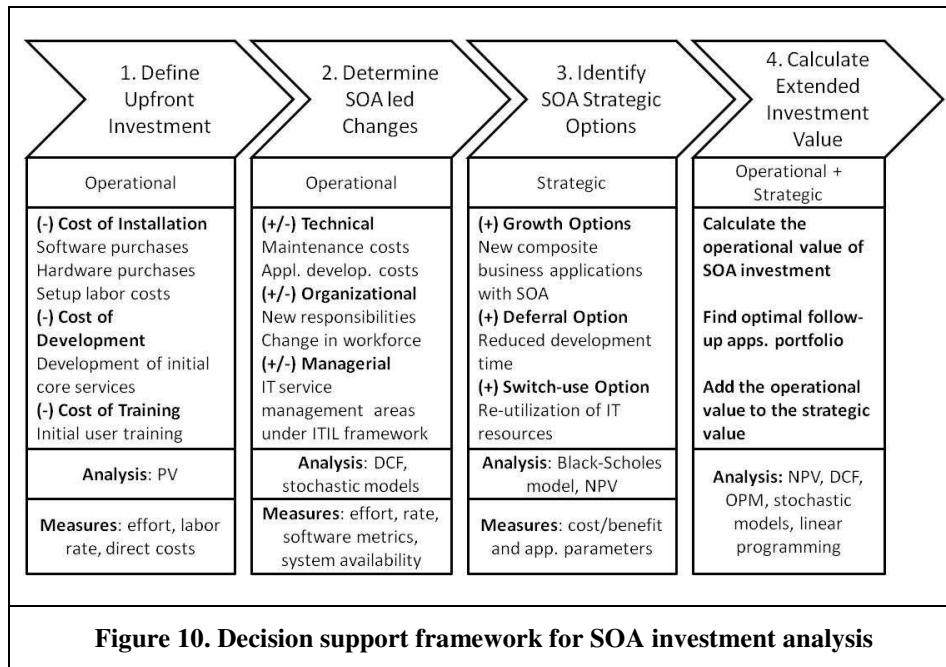
In this section, we discuss on the last step – calculating the extended investment value in more detail. As mentioned before, the extended value (i.e. total value) of an SOA investment is composed of: (1) the operational value of SOA, and (2) the value of strategic options in SOA. Operational value can be calculated by adding the negative cash flows at time $t = 0$ (i.e. up-front investment) into the SOA led changes in IT operations (i.e. changes in technical, organizational and managerial dimensions).

On the other hand, to find the value of strategic options, the optimal follow-up composite business application portfolio must be identified, given budgetary constraints. This is an optimization problem that can be expressed as;

Optimal Application Portfolio Problem:

$$max \sum_{k=1}^{K} x_k \times NPV_k^*$$

$$s.t.$$

$$\sum_{k=1}^{K} \left(x_k \times PV(I_k) \right) \le Y \qquad (6)$$

$$x_k \in \{0, 1\}; \quad k = 1, 2, ..., K$$

where,

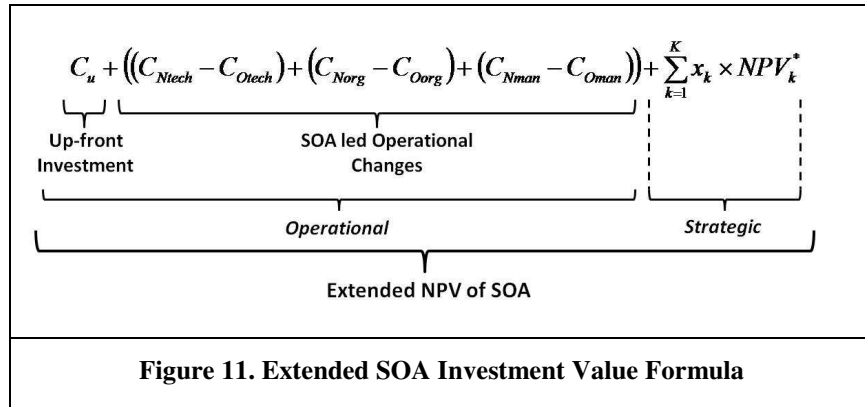$k = 1, 2, …, K$ is the set of all possible future composite applications that can be implemented with SOA

NPV_k^*: Corrected total option value (growth, deferral and switch-use options) of composite business application k.

x_k: the decision variable of whether to include k in the portfolio or not.

I: the total cost of ownership of k (non-corrected).

Y: the budget constraint of the organization regarding ownership costs for future applications.

Solution to this problem would give the value of strategic options in SOA. Strategic options value then can be added to the operational value to obtain the extended SOA investment value, as shown in Figure 11, where C_u is the total up-front expenditure and $C_{N(.)}$ and $C_{O(.)}$ correspond to the operational cash flows in technical, organizational and managerial dimensions after SOA implementation and before SOA implementation, respectively.

$$C_u + \left(\left(C_{Ntech} - C_{Otech} \right) + \left(C_{Norg} - C_{Oorg} \right) + \left(C_{Nman} - C_{Oman} \right) \right) + \sum_{k=1}^{K} x_k \times NPV_k^*$$

Up-front Investment · SOA led Operational Changes · Operational · Strategic · Extended NPV of SOA

Figure 11. Extended SOA Investment Value Formula

A Case Study Implementation of the Framework

To illustrate the application of the framework, we provide analysis of an SOA investment decision in a real-life organization. The organization in discussion is a Fortune 100 firm specializing in defense systems manufacturing. The decision problem involved whether to or not to employ SOA in one of its sub-divisions that develops complex software applications used in defense systems products. While the management of the organization was aware of the potential benefits of SOA, calculating a monetary value for the investment had been a concern. We applied the decision support framework proposed in the paper to estimate the extended NPV of the SOA implementation.

Interviews with the division executives revealed that there are four major application proposals (i.e. software development and upgrade projects) that are in pending process but unlikely to be initiated because of their negative return on investments under the existing development approach. Additionally, the base case SOA implementation was also found to be an infeasible investment based on the operational value, as shown in table 1. In this table, the first row corresponds to the up-front investment required to purchase and install the SOA platform, whereas the remaining rows summarize the SOA led changes in IT operations after the implementation. Technical changes involve SOA-centric (i.e. service based) development and maintenance costs for new applications; and are covered under total costs of ownership (*I*) in Equation 3. Organizational and managerial changes are management estimates that include the cost of SOA based system roles and the impact of system availability change (no change is expected by management in this case) in monetary terms, respectively.

Table 1. Up-front investment and SOA led changes		
Operational Measure	*How to calculate*	*Present value*
Up-front investment (C_u)	Equation 1	- $750,000
Technical changes ($C_{Ntech} - C_{Otech}$)	Included under total costs of ownership of new applications developed with SOA	Factor of I
Organizational changes ($C_{Norg} - C_{Oorg}$)	Management estimates	-$160,000
Managerial changes($C_{Nman} - C_{Oman}$)	Management estimates	$0
Current Operational Value		- $910,000

The next step in the framework involved identifying the strategic options. Four application proposals with negative return on investments under the existing development approach were identified to be the growth option opportunities of the SOA investment. For each of these opportunities, parameter estimations were required to calculate the growth option value using Equation 3. Determining V_0, σ and T were rather effortless. The return on investment (ROI) analysis that was previously conducted by the division included the current values (V_0) and volatilities (σ) of expected future benefits from each application as well as the development schedule estimations (T). 7% was chosen to be the annual risk-free interest rate r. Determining the total cost of ownership (I) was more complicated. Through iterative discussions, estimates were made by studying the unique characteristic of each application and its applicability to the SOA platform. The findings for growth option parameter values and NPV computation using Equation 3 for each application were given in Table 2.

Table 2. SOA Growth Option Parameters and NPVs						
	V_0	I	T *(yrs)*	r	σ	*NPV from growth option*
Application 1	$275,000	$325,000	0.75	7%	25%	$11,900
Application 2	$297,000	$350,000	1.25	7%	30%	$30,350
Application 3	$792,000	$1,500,000	2.83	7%	65%	$231,000
Application 4	$43,000	$120,000	0.5	7%	20%	$0

Deferral and switch-use options are the other two components of SOA strategic options in the decision framework. For deferral option, reduced development time characteristic under SOA based development was considered to correct the development schedule estimations (T) previously identified in ROI analysis. A new parameter t^* is defined for this purpose, where $t^* = T + $ *development time reduced with SOA*. For switch-use option, the salvage value for each service based application was estimated using the Equation 5 and the total cost of ownership was corrected as $I_k^* = I_k - S_k$. Values regarding these adjustments as well as the final corrected NPV for each application were given in Table 3.

Table 3. Adjustments for deferral and switch use options and final corrected NPVs						
	NPV from growth option	t^*	*NPV corrected for deferral option*	S_k	I^*_k	*Final corrected NPV including deferral + switch use options*
Application 1	$11,900	1.08	$18,400	$58,000	$267,000	$42,900
Application 2	$30,350	1.75	$41,650	$50,000	$300,000	$61,770
Application 3	$231,000	3.25	$261,200	$300,000	$1,200,000	$309,000
Application 4	$0	0.6	$0	$85,000	$35,000	$9,600

Given the budget constraints of $2,000,000 for application ownership costs (including application development, user training, additional hardware, etc.), the optimal application portfolio was found to include applications 2, 3 and 4,

according to equation 6. Consequently, the total strategic options value of SOA was calculated as $61,770 + $309,000 + $9,600 = $380,370.

Finally, strategic options value of $380,370 was added onto the current operational SOA value of −$910,000 to find the extended NPV of SOA investment as −$529,630.

There are two main implications of this result. Regarding the investment decision, we conclude that, although strategic opportunities embedded in the SOA implementation mitigate the costs associated with the investment to some extent, currently it is not feasible to proceed with the investment. Secondly, we observe that up-front investment costs constitute the most to the no-go investment decision. As SOA related software and hardware costs decrease with the acceptance and maturity of this new IT paradigm, the investment analysis should be re-visited to update the feasibility decision.

Conclusion and Future Work

Capital budgeting scenarios such as SOA investments need to be evaluated analytically in order to make reliable investment decisions. In this study, we provided a managerial decision framework to analyze the monetary impact of SOA in an organization. This is one of the initial studies in literature to discuss how to measure operational and strategic values from SOA investments. By using simple operational models as well as option pricing methods, our contribution has been to expand the passive NPV of initial positioning investment with flexible strategic opportunities in the SOA domain.

There are certain limitations with this study. First of all, we assumed that composite business applications are opportunities unique to SOA implementations and their implementation values are added to SOA benefits directly. In a more realistic setting, these applications may also be instances of existing technologies and to value the SOA investment, a comparison between the service-centric development approach and the old development approach may be needed. A similar issue can also be observed for the case study problem, in which we only considered a discrete number of new applications as potential strategic options of SOA. Another limitation with the study has been the lack of quantification in some of the operational models, such as maintenance efforts and system availability.

Our immediate future work involves developing methodologies to consider the existing development approaches during application implementation valuation. In a future and more comprehensive study, we also plan to relax the limitations mentioned above by using more complex operational models that are tailored for SOA, and by defining specific metrics for maintenance efforts and system availability.

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