Developing the Method for Values Assessment of SOA-based IS Projects

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Abstract. Measuring the value of IT is always a challenge for investors. Market share for service oriented Information Systems (IS) is constantly growing and it creates the demand for methods of measuring the value of SOA-based IS projects. This research is aimed at adopting existing IT Project assessment methods to this growing demand. The work proposes the method that considers the fact that SOA-based IS deployment and evolution could be split in separate flows, one per service. It will allow using individual discounts rate values since project risk values should be different for different services. It should make project value assessment more accurate comparing to existing methods which use the single flow for the entire project. This research also proposes Real Options for calculating the flexibility fraction of the value. The developed method was verified using own simulation model. Both developed method and the simulation model were applied to value assessment of a real-world project.

Keywords: Software Engineering, Investment Appraisal, SOA.

1 Introduction

Service-oriented market share is constantly growing and the forecasts predict its growth as well from the current $3.4 billion to $9.1 billion by 2014 (at 17% a year growth) [1]. It means that amount of IT projects involving deployment or evolution of Information Systems (so called IS projects) will be conducted to Service-oriented Architecture (SOA) [2] more and more frequently. It makes adoption of IT project assessment methods to SOA-based projects more valuable. Value measuring methods targeted on IT projects exist but none of them is specifically created for assessments of SOA-based IS projects.

We conduct the research which pursues the goal to develop an effective method for objective value measurement of complex IS projects which intensively use modern features of SOA like Software as Service (SaaS) concept, service outsourcing and others. Demand for such method exists and this method should help investors in decision making while developing an IT projects portfolio. Discounted Cash Flow (DCF) [3] is the major instrument in most of the modern value measurement methods. The most important parameter in this technique is the discount rate which depends on risk. Thus the risk factor becomes very significant variable and the importance of it
cannot be underestimated. Flexibility is also important and measuring its value should be especially stressed in SOA-based projects since there are alternatives in such projects since services could be developed in-house or obtained using SaaS approach.

This paper proposes new value assessment method for such SOA-based projects, and verifies the method using a simulation model based on System Dynamics approach. The new method takes into consideration specifics of SOA in architecture of IS proposing several modifications in base assessment method including separate DCF flows for every service and risk assessment-related (project and flexibility components of risk) modifications. The paper is structured as follows. In Section 2 we present conceptual background information for value assessment of IT projects. Section 3 contains description of the proposed assessment method for SOA projects. Then we describe application of the proposed assessment method in the particular case of SOA-based Network Management System in Section 4. The System Dynamics simulation model, verification process and results comparison are discussed in Section 5.

2 Conceptual background

IT project valuation methods could depend on one or several IT valuation models from this list [4]:
- Net Present Value (NPV) models
- Decision Tree Analysis (DTA) models
- Financial Options models
- Real Options models

The NPV model is based on DCF and it doesn’t leave space for managerial flexibility. It real-world applications this type of flexibility usually exists and this is why NPV model is usually used along with some of models especially targeted for flexibility fraction valuation. Combined NPV-DTA model is a popular choice in existing methods of valuation [5,6,7]. One of the main disadvantages of this approach is the need to adjust the discount rate taking into consideration several risk components for every node of the decision tree. It makes this approach to be complicated for practitioners and it was noted by real options method developers [8]. Financial Options models are criticized for inaccurate results and rich set of limitations [9]. Real Options (RO) models are treated as an alternative of DTA approach that solves DTA disadvantages. Some authors point that DTA and RO could provide the same results [10]. This can be achieved if DTA is coupled with utility function estimation and it adds even more complexity to DTA. It makes NPV with Real Options Analysis (ROA) to look like a valid high-level basis for IT project valuation methods. The existing integrated methods are usually proposing NPV-DTA approach [5] while several authors consider using ROA instead of DTA without fitting it into integrated method [10, 11]. This paper proposes using NPV-ROA combination instead of NPV-DTA inside new integrated method that is based on existing integrated method [5] taking into account SOA specifics of projects being evaluated. It is described in details in Section 3.
NPV calculation fraction is affected by SOA architecture as well. Different types of risks are considered in general purpose IT project assessments methods [5]. Company and project risks impact the discount rate while the event risk has impact on Net Present Value (NPV) during flexibility evaluation [5]. SOA brings its own specifics not in IS only but in the assessment techniques as well. In order to take into account specifics of SOA during risk assessment Thomas and vom Brocke [12] propose to extend well-known EPC modeling technique and introduce three-layer diagrams with three separate DCF flows on every Service being considered in the scope of value measurement. Ontology-based approach (OLPIT) was offered on the hand proposing to represent every IT project by the set of atomic and measurable elements defined in the ontology [13]. Separating the main DCF flow of assessment algorithm looks suitable and appropriate for SOA since service orientation leads to high limit of loose coupling and according to SIMM [14] the services are independent entities starting from the low levels of maturity. This is why the EPC-extension-approach [12] with DFC flow separation sounds promising in the scope of value assessment [5]. While separation in several layers does not change discount rate since risks are the same in the scope of one service but separates outcomes and incomes; the separation of the project in independently assessed services makes believe that discount rate could be different since the risk for every service should be individually calculated.

3 Proposed Assessment method

In our research the value assessment method of Hares and Royle [5] was selected as a framework. This integrated method is one of the methods based on NPV-DTA and it is logically clear and complete. It uses DCF as an instrument of NPV calculation. This framework method takes into account three types of the risk in general: company risk, project risk, event risk. We follow work of Hares and Royle [5] and their approach to relate different types of the risks.

Our research is concentrated on adoption of this framework method to assessment of SOA IS projects. The main idea of modification is to have separate DCF passes for every SOA service involved in the project being assessed instead of one DCF flow for all project contents in framework method. Since discount rate depends on the company/project risk, those parameters have to be calculated for every service. Event risk in the framework method is accessed via Decision Tree Analysis (DTA) approach. Another crucial point of modification is migration to Real Options Analysis (ROA) in this matter.

3.1 Separating DCF flows in respect of service orientation

The risk components being used in discount rate definition are (1) the company risk and (2) the project risk. The event risk is used in the separate pass of NVP calculation according to the framework method and it is out of scope at this stage. The company risk is determined using Capital Asset Pricing Model (CAMP) [15] technique. It means that it depends on measure of company’s stock's volatility in relation to the
This parameter is called “company beta”. The influencing specifics of SOA projects does not change company beta calculation. The common case for such projects is deployment of a service that is indeed owned by another company (provider). Stock’s volatilities of two companies still cannot be taken into account because the value assessment is usually taken from one particular side i.e. company and this and only company stock volatility should be taken into consideration.

The project risk is calculated using the Bowater-Scott model [5]. Its value is that it is based on the CAPM [15] but takes into account the variability of money flows in the project. This variability is measured and the beta value of the company is adjusted to suit the project if the cash flow variability is high relative to the company norm the beta value goes up for the project (the project is more risky than the company), if it is low it goes down (the project is less risky than the company). Basically the dispersion of variable sources of potential benefits brought by the project is the source of the project beta value. Those numbers regarding the variable sources of benefits are supposed to be provided by marketing.

Two main necessary modifications were identified from the literature review:
- Separate DCF flows with individual rates based on individual project risk values should be applied for every service. Summary of NPV values should result in final total NPV for the project.
- The method of project risk calculation mentioned by Hares and Royle [5] itself should be revised and readjusted. The dispersion looks too vague, if it takes into account only three points for every outcome component. Instead, the subjective distribution proceeding with Monte Carlo modeling is suggested for use.

The first modification could be illustrated by two schemes (fig. 1). The first one represents the algorithm workflow described in the original framework method. The second schema shows how it is possible to separate DCF flows form the final NVP.

As we can see the main distinctive feature of our modified method is to have an individual pass of the original framework algorithm [5] for every service (i) resulting in NPV(i). Each service (i) pass will have its own project beta value (i) in scope the project beta calculation. Total NPV could be identified using formulae (1).

$$\text{NPV} = \sum_i \text{NPV}_i$$

The second modification could be resolved as follows. First of all, the components of outcomes are divided into constant and variable parts. The variable part is estimated in order to determine subjectively low and high mean values. These values can be estimated using input from the market research. This is followed by simple deviation calculation and then it leads to calculation of the project beta. Most of researches propose to estimate variability of outcomes more precisely. For example, determination of distributions for outcome components and Monte Carlo simulation have been proposed in [16, 17]. We selected this approach to replace simple deviation technique in the original framework method [5] for calculation of the project beta.
3.2 Using ROA to measure the flexibility value

A separate topic of research is the way to take into account flexibility. The original framework method has a special phase to determine the NPV brought by the event risk. DTA technique is used for this purpose. Therefore the ROA technique is considered to be the extension and evolution of DTA in particular conditions:
The key characteristics factors of the company/market should be limited [18].

The elements of the project should be “tridable”. It means, for example, that getting rid of some of the elements in the project is quite possible (let’s say we may eliminate one of the services).

The first requirement looks closely dependent on a particular company or project. Forthcoming application of our proposed method for risk assessment of the project in telecommunication domain seems to fit this requirement since telecom market has transparent and limited set of key characteristics as well as key characteristics of IS in that domain.

The second requirement exactly matches the SOA approach where the system according to SIMM [14] is going to reach its peak in an absolutely reconfigurable eco-system of independent components each of which could be eliminated or postponed in its evolution without significant damage to the system in general.

Such considerations lead to the third modification in the original framework method [5]; namely, it is replacing of DTA with ROA for determination of the event risk specific for the particular project.

4 Applying the proposed method

We offer to apply and evaluate our proposed assessment method to a specific project case of Network Management System (NMS) in comparison with the original framework method [5]. We use the case where two new modules are going to be added to the three-tier based legacy NMS for this task. The SOA is considered to be the architectural approach for this, and SaaS could be one of the ways the components could be deployed in the company. The evolution of the existing system using SOA and evaluating in-house development versus SaaS look like the most essential and relevant way nowadays to evolve IT infrastructure for many companies. It stresses the importance of this research.

The NMS system is installed in a company of large Middle East Telecom provider. The modules (now services) are:

- Policy Management (Policy)
- Root Cause Analysis (RCA).

The Policy service is targeted on automated processing of routine events coming to the system by means of highly configurable rule-based policies. The RCA service is supposed to find the root cause of network breakdowns in the high-rate stream of incoming alerts. Enterprise Service Bus (ESB) [19] is supposed to be used for existing NMS and services coordination. The role and place of these two components in the NMS could be seen on the Extended EPC diagram [12] (fig.2).

Let’s go through the algorithms depicted in figure 2. First start with the original framework method (left scheme in figure 2). Then the modified method will be used for assessment of the project described above.
ESB component is the infrastructural component that is the prerequisite for RCA and Policy services. There are two options that could be related to flexibility of the project. Once ESB development and deployment is done then SOA components could be deployed using two approaches:

- in-house development;
- service rental from a SaaS provider.

These alternatives define two branches for calculation of flexibility fraction of NPV. The figure 3 illustrates these alternative options. The \( p \) is the probability of particular transition in the tree. It is selected as 0.5 in the original framework method where the
DTA is applied in flexibility value assessment stage and it is calculated in new proposed method. Later in this paper we will describe the procedure of its calculation.

![Diagram](image)

**Fig. 3. Alternative project options**

The passive NPV needs to be calculated for every branch. Outcomes, incomes and the discount rate are required components for passive NPV.

The main outcomes are ESB development cost plus services development cost in the case of in-house development and service rent in the case of SaaS deployment approach. Development costs are estimated using COCOMO [20]. The following assumptions were taken into account during outcomes identifications:

- There are no software development, maintenance and hardware outcomes for services Policy and RCA because those services are rent from the SaaS services provider.
- Outcomes related to ESB development could be identified using Basic COCOMO method.
- The project period for DCF is 3 years.
- The monthly rent costs for services are fixed: Policy service rent cost is $30 000, RCA service rent cost is $70 000.

Incomes depend mostly on the model of IS components in the production mode. Such model depends on particular project specifics and the domain. As far as we consider the real-life project in the Network Management domain, specific production model of new IS components of the NMS was created. This model could be described using the formulae (2).

\[ I = u \left[ (t_o w_o c_o) + (t_m w_m c_m) \right] + \sum (I_o w_i s_i) \]  \hspace{1cm} (2)

In this formulae: \( I \) – the yearly income of IT project, \( u \) – the incoming alert rate, \( t_o \) – the alert handling time spent by an operator, \( w_o \) – the ratio of alerts being handled by a service automatically without operator intervention, \( c_o \) – the operator time cost, \( t_m \) – the alert handling time spent by a maintenance crew, \( w_m \) – the ratio of alerts being
handled by a service automatically without maintenance crew intervention, \( c_m \) – the maintenance crew time cost, \( I_0 \) – the yearly income of IT project before it has been started, \( i \) – index of intangible incomes component, \( w_i \) – the improvement ratio of \( i \) intangible incomes component, \( s_i \) – the ratio of service impact on improvement.

As we can see the first summand represents tangible benefits of the project and the second summand consists of intangible benefits (such as market share improvement, decrease of Service Level Agreement (SLA) violation penalties, increase in price because of quality improvement, etc.).

The discount rate is based on the company/project beta. This dependency is described by formulae (3) [5]:

\[
R = R_f + \beta_c \beta_p (R_m + R_d) \tag{3}
\]

In this formulae: \( R \) – the discount rate, \( R_f \) – the risk free rate, \( R_m \) – the industry rate, \( \beta_c \) – the company beta, \( \beta_p \) – the project beta. The beta parameters need to be calculated. The company beta is calculated using CAPM. The project beta is calculated using project income volatility. The framework method calculation was based on deviation estimation using three points supplied by marketing department and new method uses the model described by formulae (2). The probability distribution and their parameters assumptions were made. The distribution is assumed to be normal for all arguments in formulae (2). The distribution parameters of arguments of the first summand are based in historical data of IS running in the production mode before start of the IT project. The distribution parameters of arguments of the second summand are estimated by a marketing department.

DCF was applied to calculate passive NPV for both options in the original framework method and our newly proposed method. The framework method applies DCF to composite flow of all services involved in the project and uses one discount rate for one option. Our method applies DCF to every service (component) of the project individually with the individually calculated discount rate.

Then flexibility fraction of NPV was estimated in the framework method using the DTA technique and the simple tree (fig. 3) with \( p = 0.5 \). The flexibility fraction of NPV was estimated in our proposed method using the ROA technique. It was assumed that we have a case of switch option [11] where base option is the in-house development and the alternative (switch) option is the case of SaaS. The switch option is an American put option and the binomial lattice technique is suitable for it calculation [11]. Figure 4 depicts the overall ROA procedure [21] and describes how the value of \( p \) and the value of this switch option were calculated. Passive NPV analysis, Monte Carlo simulation and determination of volatility \( \sigma \) were already applied during the project beta calculation. The parameters \( p, u, d \) are related to the binomial lattice method of real option valuation [11], \( rf \) – the risk free rate, \( rc \) – the company rate.

In Table 1 we compare the results of NPV valuation produced following the original framework method [5] and our newly proposed method. The new method has DCF flows for every component and this is why there are separate rows for IT project components (Policy, RCA, ESB) along with New Method Total row. The values in this New Method Total row could be compared to values in Framework Method row.
There columns in Table 1 with NPV without taking into account the value of project flexibility, the value of flexibility and the final NPV column that is the most important value to obtain and to compare.

![Diagram](image.png)

**Fig. 4.** Measuring the value of the switch option using ROA

5. Simulation Modeling for Verification of the Proposed Method

Application of the original Framework method and our newly proposed method provided us with the different results (see table 1). The claims were proposed regarding more accurate results of our method. To prove the claims we need a thorough verification procedure. Because the authors did not have direct access to a comprehensive data set describing any of finished complex IT project based on SOA that could be post-evaluated using either the framework method or the proposed method, the decision was made to perform verification using simulation modeling.
The simulation model was developed. It takes into consideration an external environment (i.e. the market process such as market share redistribution) along with an internal environment (i.e. running IS in the production mode and the software development process). System Dynamics [22] was chosen as a simulation modeling approach. This selection is caused by the following: System Dynamics is good enough when the level of details in the model is not high (this is acceptable since the simulation model being developed should not replace the assessment method but rather verify the method); there is a lot of already developed models in System Dynamics notation for the areas involved in our model domain. iThink [23] software developed by iSee Systems was used as an instrument for modeling process since this is one of the most powerful and feature-enabled products for modeling following System Dynamics notation.

To verify the new assessment method the simulation model was applied to the same real-life IT project (the case of NMS extension via adding two new SOA services).

The main structure of the model is shown on figure 5.

![Diagram](image-url)

**Fig. 5.** General structure of the simulation model

The part of the simulation model that represents the IS running in the production mode (Total Savings Discounted on fig.5) allows to determine cost reduction of network exploitation. This part of the model was fully developed by the authors of this paper because it is tightly coupled with specifics of the particular real-world
project and takes into account specifics of the domain. The main components of this sub-model are operator time reduction (Operator Savings Discounted on fig.6) and maintenance crew incidents reduction (Maintenance Crew Discounted on fig.6). The ongoing results of it are: the customer loyalty shift (it would be needed in the market share movement sub-model) and SLA penalty reduction (Penalty Savings Discounted on fig.5).

![Figure 6](image)

**Fig. 6.** Components of IS running in the production mode

The part of the model that considers the market behavior allows determining the income generated by market share increase (Value of Marker Share Improvement Discounted on fig.5). This part of the model is based on existing System Dynamics model called “Bass Diffusion with Type 1 and Type 2 Rivalry” [24]. The sub-model combines two copies of this existing model. Those copies have different customer
switching matrices. The first copy represents the situation in the market before the start of IT project. The second copy shows how situation has changed after the IT project was deployed. This change happened because deployment improved of quality of service and it increased the customer loyalty (fig.5).

Modeling of costs related to software development process (Total Cost Discounted on fig.5) is handled by the part of the main model that is implemented using an existing System Dynamics model for inspection-based software development process [25,26].

Parameters of the model related to software development process were set as they were in the existing model except the lines-of-code value that was set according to the project. Parameters of the model related to IS running in production (such as the incoming alert rate, the operator time cost, the maintenance crew cost and others) were set according to statistical data of a particular company involved in the project. Parameters of the market share shift model were set mostly based on the existing diffusion model [24] since the number of main players in the telecom market (three) in it matches what it is in the real project.

To determine the flexibility value the assumption was made that there is a company (the SaaS provider) that develops the same services and this company would have started selling them for rent with probability 0.5 by the moment the ESB component is deployed in NMS. The simulation model was run for this case the same way as it was run for in-house services development but the difference was in the outcome-related part (ESB-related costs were counted only, but the service rent was added) and in income parts (IS production phase started earlier and market share shift started earlier because the production phase started earlier using the SaaS approach).

In our case the main result of simulation modeling is calculating the final NPV. The comparison of it with NPV values produced by the framework method and new method could be seen in table 1.

6. Conclusion

The new value assessment method was developed by authors. This method is targeted for IT projects where the IT infrastructure is developed using SOA as an architectural approach. The method takes into consideration the SOA specifics. This new method along with the original framework method [5] was applied to the real-life IT project. The NPV values were achieved. They were different. To justify the value of new method against the existing one the verification had to be performed. The simulation model was developed by the authors in order to perform verification. This simulation model was developed following System Dynamics approach and it was applied to the same IT project to fulfill the verification goal.

The NPV value produced by the simulation model is closer to the NPV value provided by our proposed method in comparison with the value of the framework method. It shows that verification has passed successfully. The robustness of new assessment method as well as developed imitation model needs to be verified and this is what is going to be done in nearest future. The modeling experiment was performed for the real-world IT project what was used for assessment method application. This
way the verification of this method was performed only and not the imitation model itself. Verifying the robustness would allow determining if the developed method and imitation model are suitable enough for wide range of IT project where SOA architecture is involved.

Our new method requires more data than the framework method because modified method needs to prepare separate incomes and outcomes for every service (and ESB as a non-service component) while the original framework method only demands for cumulative incomes and outcomes. Moreover our method needs to perform income sensitivity analysis for every service and it also adds complexity (the framework method does this analysis once). An assumption could be made that having more data involved in analysis could lead to more precise results. This statement requires verification and verification of results is important direction of the research. Important phase in verification has been accomplished via developing imitation model and proving the results of new method with help of this model.

The increased complexity of the new method could be eliminated by development of decision support system (DSS) that is supposed to automate all steps of the algorithm involved in the modified method. This DSS is in a prototype phase now.

Such DSS system could be a useful for companies demanding IT infrastructure development using SOA as an architecture approach and SaaS as the deployment method. Market trends show that evolution of existing IS is done exactly this way. Gartner Group is forecasting the enterprise application software market to surpass $12.1 billion in 2011. (That is up 20.7% compared to 2010) [22]. It means that the assessment method being developed in this research has demand for it and the NMS example could be a good reference case study for many companies. The last but not the least result of the research is developed prototype of DSS that automates the new assessment method. Moving this DSS to the phase when it could be used by investor representatives is another area of effort.

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