Using Multi-criteria Analysis to Evaluate Enterprise Architecture Scenarios

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Abstract: In this paper we propose a framework based on multi-criteria analysis as a way to conduct an enterprise architecture scenario evaluation and selection. The proposed solution supports decision making, by evaluating each of the available scenarios using metrics derived from defined goals, based on a Goal-Question-Metric methodology. In this approach the overall goals or objectives (the problem's criteria) are on the top of the GQM-tree, whereas questions of stakeholders and measurable attributes (also called "metrics") are represented as intermediate and leave nodes. According to the multi-criteria analysis each of the alternatives x is evaluated on each metric i, by means of a value function Vi(x). Then, since every criterion has a weight which represents its relative importance in the analysis, the final overall result of each alternative scenario is therefore computed through a weighted sum model.

1 INTRODUCTION

In this paper, we analyse how multi-criteria analysis, can be used in the context of enterprise architecture scenarios. When organizations face a change situation, multiple scenarios may be available to implement that change, each of them with different impacts, and opportunities.

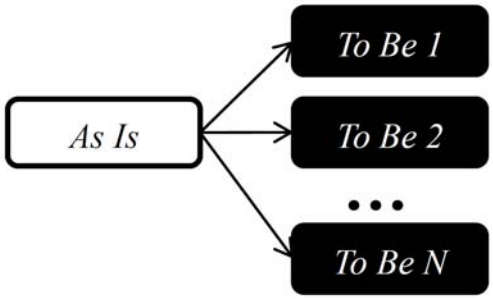

Figure 1: Scenario selection problem.

The decision of which scenario to implement, requires a set of metrics to quantify and compare the existing scenarios between each other, in a formal way. This formal evaluation has its advantages over an informal evaluation, because it will produce results that are better supported and justified, when compared to the results obtained informally.

We will show how the problem of selection enterprise architecture scenarios can be supported by a framework based on multi-criteria analysis.

1.1 Enterprise Architecture

The enterprise architecture, by definition is a representation of a real world organization, either in an "As Is" state, or in a possible "To Be" scenario. This representation can be compared to a city's architecture, although it hides some details about the real city, it gives us a high level view. This holistic view on enterprises can be used to extract some broader indicators about the status of the actual organization, enabling us to place some characteristics in evidence.

The creation of an enterprise architecture, is an essential step in a modern organization. It allows stakeholders to communicate and facilitates decision making within the organization, by creating a common understanding of the organization and its elements (Johnson et al., 2004).

It is not only a communication tool but it also allows to understand how the different components of an organization, actors, processes, applications interact with each other, and assure that they are correctly aligned and together contribute to achieve the organizations goals (Lankhorst, 2009). It is also

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an evaluation tool through the usage of metrics that allow us to check the organization status regarding certain qualities (Vasconcelos et al., 2005).

The framework proposed in this work, is one of such evaluation methods, with the objective of helping in the scenario selection problem, described early.

The structure of the paper is as follows, first we start by defining enterprise architecture in the context of this work, and why its evaluation is important. Then we present how multi-criteria analysis adapts to this particular context and what steps are needed to conduct the proposed analysis. Finally future work and conclusions are presented.

2 MULTI-CRITERIA ANALYSIS PROCESS FOR ENTERPRISE ARCHITECTURE

2.1 Enterprise Architecture Evaluation

Since enterprise architectures represent the real organizations in a holistic view, with its elements connections and rules (Fischer and Winter, 2007), it is possible to evaluate the organization through its architecture, using metrics (Vasconcelos et al., 2007).

In our proposal, this evaluation corresponds to apply a set of metrics, to a set of scenarios. Through the application of these metrics the different scenarios will be scored, and their score will be used to compare them.

These metrics are defined as a way to measure and evaluate different qualities, and their objective is to reduce the uncertainty level related with some reality by quantifying it.

According to (Blackburn and R. Valerdi, 2009) the metrics must be aligned with some objective, in order to quantify it.

Our goal is to realize a multi-criteria analysis, using these metrics as the criteria, and the enterprise architecture scenarios as the possible alternatives.

2.2 Multi-criteria Analysis

Multi-criteria analysis is a method for selecting an option given a set of criteria. In other words, it is a process to discover the most preferred option, given a set of criteria (Dodgson et al., 2009).

It allows us to structure a complex problem with multiple options and restrictions. This is possible by identifying the existing points of view over the problem, and analyse them one at a time, and then through the usage of a weighting method compute the overall result of each alternative.

This method has been widely tested in various contexts with good results, supporting the option selection problem in a structured and formal way.

There are some variants of multi-criteria analysis, depending on the selected method to realize each of its steps. Nevertheless there is a common set of structural elements present in all the multi-criteria analysis methods:

- Criteria: they represent a stakeholder's point of view and concerns in the problem. It's possible to create the problem's set of criteria using two approaches, bottom-up or top-down, they are described in section 2.5;
- Alternatives: are the scenarios which we are evaluating, the possible options to choose from;
- Decision makers: are the stakeholders in the problem's context, they must be able to understand the criteria, in order to give their preferences;
- Uncertainty: since not all factors can be controlled in a given context, when we build the alternatives, different possibilities regarding the uncertainty must be generated;
- Environment: is the whole context where the problem and the analysis are developed. There are a multitude of factors that can affect the analysis, and the best solution can be different depending on the context.

The procedural structure of the analysis presented over the next sections, is shown in Figure 2. For each of the steps we present possible methods to implement the given step, focusing on the enterprise architecture scenario evaluation problem.

Figure 2: Proposed method steps.

2.3 Context Definition

This is the first step of the analysis. The scope and constraints of the problem are defined, in order to have a complete view of the problem. To do so it's necessary to first identify the stakeholders, since

they are the decision makers and will be asked for feedback in future steps of the method. In our problem the context of the analysis, will be the change's scope, this means that the decision makers will be the stakeholders and the teams responsible for the implementation of the change process.

2.4 Identify Alternatives

After having the context of the problem analysed and its scope clarified, we need to identify the possible solutions being evaluated. Depending on the nature of the problem, these scenarios, may be already defined or may be generated in this step. In our problem the alternatives correspond to the possible To Be architecture scenarios.

All the scenarios must be described with the same level of detail and focus. This means using the same framework and architecture viewpoint for all scenarios, otherwise the score of the scenarios could be biased since not all the scenarios would have the same elements or information represented (Johnson et al., 2004).

2.5 Identify Criteria

In order to evaluate the different options, we must also identify the existing criteria. This process depends on the context where the analysis is being done and the selected approach (Blackburn and R. Valerdi, 2009):

- Top-Down: in this approach, criteria are structured in a hierarchical manner. This structure can be seen as a tree, where the main objectives are in the top and are successively detailed into more specific criteria.
- Bottom-Up: in this method, criteria are identified through an elicitation process, and then grouped in broader categories or objectives.

In our proposal, we will be using a Top-Down approach, starting by identifying the main broader scope objectives (Basili et al., 1994). Since our context is an organization's enterprise architecture, more specifically during a change situation, one of the concerns is align the objectives of the change with the organization's objectives. One way to achieve this is to look at the organization strategic map and scorecards in order to extract the high levels objectives of the organization.

2.5.1 Strategic Map and Balanced Scorecard

The Balanced Scorecard is a widely used, organization performance measurement tool, and it allows managers to keep track of the defined objectives, as well as measures used to evaluate those objectives (Kaplan and Norton, 2008). A typical scorecard will contain various objectives regarding different organization domains. These objectives can be from the financial domain, client / market domain or the organization development and learning domain. It's a flexible approach allowing virtually, all types of organizations to represent their goals.

In order to make the link between the high level strategy and the objectives in the balanced scorecard, a strategic map can be used. This type of artifact shows the link between objectives, allowing the stakeholders to see the dependencies between objectives (Kaplan and Norton, 2008).

2.5.2 Metric Selection

Since objectives, are not normally directly measurable, in order to quantify them we must detail objectives into metrics, following the Top-Down approach described early. We will use the Goal Question Metric process (Basili et al., 1994). This methodology allows us to select a group of measurable metrics, that will evaluate the defined set of goals.

The process starts by identifying the goals, and in our case these goals correspond to the ones extracted from the strategic map and scorecard (V. Basili et al., 2007).

Secondly, stakeholders are asked to define questions, that when answered would allow them to be confident about the achievement of each objective. These questions will indicate what entities we need to measure, and what metrics should be used. The next step is to look at the proposed questions, and define metrics that allow us to give a quantitative answer to each of the questions. This process generates a tree, with goals on top that derive into questions and that in turn are linked to metrics. These goals and metrics are the criteria we will be using in our proposed analysis to evaluate the existing scenarios.

2.6 Evaluate Scenarios

Having identified the available alternatives and the evaluation criteria, we must evaluate each scenario versus the identified set of criteria, in order to obtain the scenarios score in all criteria. Depending on the nature of the criteria, the evaluation may be different, going from counting elements in a given scenario's architecture to subjective metrics like preference regarding some service provider. The

usage of subjective metrics although possible must be limited, and whenever possible is better to choose a more objective metric. At the end of this step, the responsible for the analysis, must be in possession of each scenario's scores.

2.7 Weight Criteria

Most of the choice problems analysed in real life do not have a single selection criterion, but multiple criteria as presented in multi-criteria analysis. But since not all criteria are equally important, some sort of compensation, must be applied so that a more important criteria, contributes more to the overall score than less important criteria.

To do this compensation there are several weighting methods available. In the next sections we describe several weighting methods that can be integrated in a multi-criteria analysis (Dodgson et al., 2009).

2.7.1 Trade-off

This method can reveal the indecisions faced by stakeholders, comparing pairs of criteria. The process is the following: for each pair of criteria, two hypothetical alternatives are constructed, one of them has the best score on criterion A and the worst on B, the other alternative is the reverse of the first one. We start by asking the stakeholders which is the preferred scenario, and after they made their choice, we ask how much they were willing to sacrifice the best performing criterion, in order to maximize the worst. The answer to these questions reveals the Trade-Off between the two criteria, or on other words, the weight associated with which criterion (Daniels et al., 2001).

2.7.2 SWING

The SWING method also requires generation of hypothetical alternatives, in this case only two, a Worst alternative (W), where all criteria have the lowest possible score and a Best alternative (B), where all criteria have the best possible score (Mustajoki et al., 2005).

This method starts with the scenario W, and the stakeholders are asked which criterion they want to move first from W to B, and a value of 100 points is attributed to this criterion. Next they are asked which criterion they wish to move next from W to B and how much they value this transition comparing to the 100 points of the first choice. This last step is repeated for every criterion, and at the end we will have all the criteria weighted relatively to the most preferred criterion, in a normalized scale, since all weights are contained in the [0;100] interval.

2.7.3 Change Resistance

In this approach each criterion is given two different performance poles, best and worst, assuming that all criteria are desirable in the final solution. By putting all criteria in the best performance, and asking to the stakeholders to compare all the criteria pairwise, and choose one to be moved from best to worst state, repeatedly, until all criteria have been compared with the rest. The number of times a criterion maintains its best performance, or in other words, resists change, is the weight of that criterion.

2.7.4 Macbeth

The Macbeth method regards not only the weighting step of the analysis, but it integrates weighting criteria as an essential part. It has some swing and trade-off, elements, like generating hypothetical scores (good and neutral), for each criterion. The objective of this method is to build a cardinal scale of value, regarding the stakeholder's preferences, or alternatives attractiveness, like described in (Bana e Costa et al., 1997).

2.7.5 Holistic

The holistic approach, as the name suggests, takes in account the complete set of criteria and the stakeholders are asked to rank the alternatives regarding the overall score. In order to extract the individual criterion weights, is necessary to apply regression statistical methods. This process although simple for the stakeholders, since they don't have to worry about the individual weights, causes other problems like judgement inconsistencies, because stakeholders are unaware of certain factors when thinking over the full criteria set instead of each criterion at a time. The need for statistical regression operations, also adds complexity to the work of the analyst realizing the analysis (Dodgson et al., 2009).

2.7.6 Selected Weighting Method

In our analysis we need each criterion individual weight, relatively to the rest of the set, in order to compute a global score combining the determined weights with the scenarios score obtained in the previous step, section 2.7.2. Any of the suggested weighting methods could be used but in our proposal we will use SWING, due to its simplicity, the capacity to deal with large criteria number without

adding to much complexity to the analysis and because it provides all its weights in a normalized scale that will facilitate computing the overall score.

2.8 Decision and Sensitivity Analysis

Finally with the overall scores of the selected scenarios, it's still necessary to test if the variation of certain weights causes a change in the preference rank of the scenarios. This is called a sensitivity analysis, and can help stakeholders to see the impact of their preferences and revise those same preferences. As so, it's possible to return to a previous step in order to test different weights and their impact on the alternatives scores (Dodgson et al., 2009).

In the end of this analysis a consensus about the chosen scenario must be achieved, and that choice correctly validated according to the scores and preferences of the existing stakeholders.

3 CRITICAL ANALYSIS

The multi-criteria analysis is a solid proved method, for structuring and conducting an evaluation over multiple alternatives, when there are also multiple criteria. Our objective is to apply it to the domain of enterprise architecture evaluation, due to its capability to adapt to diverse domains and formalize the evaluation process.

The process allows stakeholders to understand the impacts of their choices, but also justify those same choices facilitating the decision making process and communication among them.

Selection of metrics from goals using Goal Question Metric, as we propose on this paper, is a different approach from the one proposed in (Vasconcelos et al., 2005), where metrics are associated with quality attributes. The later approach is derived from software evaluation methods.

Since there is still not so much work done in defining a set of general enterprise architecture quality attributes, we use the goal based metric selection. This approach is more flexible, and applicable to a broader set of metrics not limited to quality attributes scope.

The weighting of criteria, is an essential step in the proposed evaluation, since it can drastically change the results. Other weighting method could be used, without consequences to the analysis, but given the simplicity, versatility and stakeholder involvement in SWING method, we suggest the usage of this method over other more complex approaches.

4 CONCLUSIONS

In this work we proposed an enterprise architecture evaluation framework that applies to a common organization situation that is the selection of a future To-Be scenario, in order to implement some new function or respond to another change situation. This framework is still in development, although we have already applied it to test cases and we are currently testing its applicability in real world cases.

Our main goal is that this framework when finished, will contribute to formalize and facilitate the problem of scenario selection.

5 FUTURE WORK

The framework proposed in this work is currently in progress, so there are some points where it can be improved and extended. First regarding the metric selection, here we propose using Goal Question Metric, since its ability to select metrics in various domains, like software and non-software domains has been proved. It also helps at keeping the metrics aligned with the objectives.

But other metrics selection methods or even a pre-defined metrics set could be used. A related future work would be the creation of a metrics library, where metrics were associated with some objective or objective type, and given a particular objective, one could simple search the library for the related metrics and apply them.

An alternative to this could be the definition of quality attributes in enterprise architecture, similar to the ones found in the software domain, and given a quality attribute we would have a set of metrics that measure that attribute.

Other area that could be improved is the alternative identification step. Since our domain is enterprise architecture, developing a tool for scenario generation based on As Is scenario and a set of parameters would be an important improvement.

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