Three Integration Approaches for Map and B-SCP Requirements Engineering Techniques

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ABSTRACT
Integration of requirements engineering techniques has been common and proven beneficial. Map is a strategy-driven modelling technique that elicits requirements in terms of intentions and strategies. B-SCP is an approach to address alignment between requirements and business strategy. To address the problem of strategic requirements evolution in B-SCP, we have previously proposed the possibility of integrating Map with B-SCP. In this paper, we present three integration approaches for Map and B-SCP and evaluate their usefulness for two case studies: Seven Eleven Japan (SEJ) and CommSec Australia. SEJ presents an enterprise problem domain, while CommSec Australia presents a simple application domain. We find that each integration approach has advantages and disadvantages. We also conclude that the usefulness of each integration approach varies depending on the complexity of application domain and the nature of modelled requirements.

Categories and Subject Descriptors
D.2.1 Requirements/Specification

General Terms
Management, Documentation, Verification.

Keywords
Requirements Engineering, Integration, Business Value

1. INTRODUCTION
Integration of modelling techniques has been a frequent approach in requirements engineering (RE) research [1]. Generally, the reasons of the integrations are to complement strengths and weaknesses of the techniques and produce a framework with enhanced functionality [2]. This is also a motivation of our research.
Requirements evolution is a fundamental activity in requirements engineering area. Successful software systems always evolve as the environment in which these systems operate changes [3]. Therefore, we intend to develop a mechanism, which address the evolution of strategic requirements. B-SCP (Business Strategy, Context, and Process) is an approach that identifies a hierarchical structure of requirements in which a higher-level strategic model, through the refinement process, is explicitly aligned with the corresponding operational level requirements model [4]. B-SCP does not address evolution of requirements. On the other hand, Map is a strategy-driven process modelling technique that explicitly supports evolution of requirements through the concepts of As-Is and To-Be models and facilitates gap analysis to address changes in the system [5]. To address the problem of requirements evolution in B-SCP, we have evaluated the possibility of integrating Map with B-SCP [6]. In [6, 7], it is identified that the integration between Map and B-SCP requirements engineering approaches is possible. The main reasons have been the semantic similarities and compatibilities of the approaches. The integrated framework has been tested for one case in [6] by using Seven Eleven Japan (SEJ) case. However, in this paper, we present three integration approaches whose usefulness is evaluated comparatively for two case studies – SEJ and CommSec Australia.

Our main research question (RQ) for the work presented in this paper is:

How can we best integrate Map with B-SCP?

To provide the best possible solution for the integration, we rigorously developed and analysed three integration approaches. Integration approach (I) uses explicit connections between Map and B-SCP concepts, integration approach (II) uses bars to present connections more succinctly, and integration approach (III) shows simple connections but offers an explicit requirements validation mechanism.

To evaluate the three developed integration approaches, we used case studies of Seven Eleven Japan (SEJ) [8], which describes an enterprise problem domain, and CommSec Australia, which describes a relatively simple problem domain [9]. The results of SEJ case study are used for illustration in this paper, while the CommSec Australia case study is elaborated in [7] and we present only the summary of the results in this paper. We find that all three approaches are useful in their context and their use has comparative advantages and disadvantages depending upon a specific situation.

We conclude that results of using of three integration approaches may vary based on characteristics of the application domain. We also find that for our integration, connections between strategic goals of Map and B-SCP models are complex than the connections between technical goals. However, to address the requirements evolution phenomenon in B-SCP and to observe the achievement of B-SCP goals into Map processes we present three integration approaches. The rest of the paper is organized as
follows. Section 2 presents background on the two approaches, Map and B-SCP. Sections 3 and 4 discuss similarities and differences of Map and B-SCP and the used integration theory, respectively. Section 5 introduces the Seven Eleven Japan (SEJ) case study. Section 6 elaborates the three integration approaches and illustrates them on the SEJ case study. Section 7 discusses three integration approaches and their relevance for particular situations. Section 8 summarizes our conclusions and outlines future work.

2. BACKGROUND
This section presents a very brief overview of Map and B-SCP. We refer the reader to the given references for more detail on Map and B-SCP.

Map can be defined as a strategy-driven process model expressed from a goal-driven perspective [5]. In the context of requirements engineering, Map can elicit organisational intentions and strategies as high-level goals and processes. Map uses non-deterministic order to elicit associations between intentions [10]. Map is considered to have advantages over traditional AND/OR goal modelling techniques because Map captures variability through requirements analysis. Here, variability means the ability to change, customise or configure software systems according to the user's requirements [10]. A Map is generally consisted of several facets such as <source intention, strategy, target intention>. Map has a unique refinement approach in which each facet of a Map model can be refined to achieve next level complete Map model. Evolution of a system creates movement from one state to another [11]. MAP elicits the current state as As-Is model and the future state as To-Be model. Map also offers a Gap modelling technique to address the difference between As-Is and To-Be models [12].

To address alignment of requirements with competitive business strategy, Bleistein et al. [4] present B-SCP, a requirements analysis approach for verification and validation of requirements. B-SCP is based upon the three themes of: business strategy, context, and process. For each of these themes a requirements analysis technique is used: i*) goal modelling [13] for strategy, Jackson context diagrams [14] for context, and role-activity diagrams (RADs) [15] for process. A cross-referencing technique is used to connect each theme with the other two to form an integrated model [14, 15].

3. SIMILARITIES AND DIFFERENCES BETWEEN MAP AND B-SCP
The two elements of Map technique, strategy and intention, are essentially equivalent (respectively) to the Business Motivation Model (BMM) concepts of means and ends [17], which have been used in B-SCP [4]. Means represent mission, strategy and tactics and Ends represents vision, goal and objective. Therefore, the B-SCP goal model elements of mission, strategy, and tactic can be treated as Map strategies. Similarly, B-SCP elements of vision, goal, and objective can be treated as Map intentions. Both Map and B-SCP are capable of defining higher-level strategic objective models and aligning them with lower-level models through refinement. An example of such alignment is presented in [6].

We identify two main differences between Map and B-SCP:

(i) Map offers a non-deterministic approach for requirements modelling by means of strategies and intentions, while B-SCP offers a deterministic approach via hierarchical structure in a goal model.

(ii) B-SCP identifies context for a goal model, but Map does not identify context.

Integration of Map and B-SCP allows us to introduce context in Maps and non-determinism to the B-SCP framework. Non-determinism can help to identify problems with hierarchical B-SCP structure. Thus, the integration brings overall improvement to both requirements modelling approaches.

4. MAP AND B-SCP – AN INTEGRATION CONCEPT
Figure 1 presents a conceptual model of relating Map with B-SCP. B-SCP, consisting of requirements set and domain context, develops a hierarchy of requirements models at different levels through refinement. Map also develops models at different levels through a refinement mechanism. So, at each level, as shown in Figure 1, both Map and B-SCP models capture requirements from the same problem domain and show compatibility of the requirements models. Therefore, we present a theoretical concept for integrating Map and B-SCP models at each level. We identify three steps in connecting them:

(1) Identify all the facets of a Map: <source intention, strategy, target intention>.

To perform a reliable integration, we relate basic Map and B-SCP modelling concepts. Therefore, we need to detail each Map into facets, each of which represents a requirement and presents a meaningful process. These processes describe B-SCP requirements effectively. Therefore, we relate facets with each B-SCP requirement, which is represented as a snapshot in time. Note, each facet can be broken down into an intention and a strategy to related them with B-SCP requirements. Given that Map presents a close relationship between intention and strategy, breaking down each facet will lose their meanings and make the integration more difficult to perform.

(2) Relate all the Map facets with B-SCP via context diagram.

Each facet of a Map refers to at least one domain of interest in the B-SCP domain context and its relevant requirements. For example, in Figure 1, Map M-1, the facet <Gi, Sij, Gj> is related to one domain of interest of DA. This connection also inherently refers to the requirements from RA related to the domain of interest DA. This is an example of our integration. However, it is possible that each Map facet may refer to more than one domain of interest in the context diagram and vice versa.

(3) Refine the Map model by selecting one facet only and connecting the Map with the B-SCP model by following steps 1 and 2 above.

Figure 1 also presents an example of the refinement process. The initiating facet in M-1 is labelled <Gi, Sij, Gj>. This facet is refined into a Map M-2, which is an equivalent to the B-SCP level RB-DB. Now, by following the steps 1 and 2, we have to connect each facet of Map M-2 to all the relevant domains of interest of DB. These three steps can be used to achieve further refined level Maps models and integration can be achieved with the adjacent levels of B-SCP goal model. For this paper, we use step 1 and 2 to present and evaluate three integration approaches. The refinement process has been presented in [6] and will not be discussed further in this paper, because it applies equally to all three examined integration approaches.
5. SEVEN ELEVEN JAPAN (SEJ) CASE
SEJ manages a national franchise of independently owned convenience stores using advanced software [8]. SEJ’s suppliers are producers of the products, combined delivery centres, and companies with warehouses and fleets of trucks that are used for deliveries to the franchise stores. SEJ is able to deliver fresh products with a just-in-time delivery philosophy to meet the actual consumer demands [8].

We developed a Map MA model that elicits high-level strategic requirements of SEJ, shown in Figure 2. a, b, c. Map MA identifies three main goals that are achieved by applying several strategies in a non-deterministic manner. Special intentions Start and Stop represent beginning and end of the processes respectively. For further details on Map MA, we refer the reader to [7].

6. THREE INTEGRATION APPROACHES

6.1 Integration Approach I (Explicit)
Integration approach (I) explicitly connects two Map and B-SCP goal models (see Figure 2.a).

We first identify all facets of a Map. Second, we list all domains of interest of domain context and their related goals from the corresponding B-SCP requirements model. Third, we create connections from each Map facet to all relevant B-SCP domains of interest. We denote these connections with arrowhead lines. Through these connections (particularly, domains of interest), Map requirements can be related to B-SCP requirements and, to a limited extent, verified against each other.

We identify that Map MA has nine facets. Each domain of interest of the B-SCP domain context DA is related to requirements set RA of B-SCP goal model via constraints and references (e.g., aa, bb) (see Figure 2.a). Constraint and references are explained in [4]. We use the context identification approach presented in [16] to relate Map and B-SCP requirements that relate each Map requirement represented as <source intention, strategy, target intention> to all its relevant domain entities explicitly in Figure 2.a. This results in twenty-five connections between Map and B-SCP requirements. We do not presented details of these twenty-five associations as they have been presented explicitly in [7].

This integration approach is based on showing associations between entities of two requirements methodologies explicitly. It is similar to past approaches presented in requirements engineering methodologies literature, e.g., [1, 2].

However, this approach has advantages and disadvantages. The main advantage is that it presents the associations between requirements entities explicitly. Conversely, the disadvantage is that it can be difficult to follow these explicit associations, particularly when the numbers of associations are high, which results in congested (overcrowded) diagrams. This is the case with the diagram in Figure 2.a. Another disadvantage is that we cannot explicitly verify Map and B-SCP requirements against each other, because this approach does not connect Map requirements to B-SCP goal model explicitly, but only through domains of interest.

6.2 Integration Approach II (Using Bars)
Integration approach (II) implicitly connects Map and B-SCP goal models. We use Map and B-SCP requirements models of Figure 2.a in Figure 2.b to present the integration approach (II). Therefore we omit requirements set RA oval from Figure 2.b to save some space and avoid information repetition. We adopt the same approach for the Figure 2.c.

We first identify all facets of a Map. Second, we list all domains of interests of domain context and their related requirements from the corresponding B-SCP goal model. Third, we establish bars between Map and B-SCP models to represent groups of domains of interest referring to all Map facets. The criteria for establishing bars are the following. As we start with identifying domains of interest for the first facet of a Map, we develop one bar for that group of domains of interest and establish links from the facet to the bar and from the bar to the domains of interest. For the next facet, if domains of interest are the same as for the already developed bar, then we connect this facet to the bar. Otherwise, we create a new bar and determine its links (as described above). This procedure is repeated for all facets. We associate nine Map requirements with the requirements set RA via domain context by using domain identification approach [16]. We use three bars X, Y and Z to make the integration implicit between Map and B-SCP approaches. Details of these associations are presented in [7].

This integration approach also has advantages and disadvantages. The presentational advantage is the reduced congestion of associations between Map and B-SCP, without losing any association meanings. The connections are easy to follow and without an ambiguity of represented information. On the other hand, a disadvantage of this integration approach is that it requires development of bars, which might be non-trivial for complex cases. Namely, complex cases might require intermediate development of a separate log of associations before development of bars in the model. Analogously to the integration approach I, another disadvantage of the integration approach (II) is that it does not support explicit verification of Map and B-SCP requirements against each other.

6.3 Integration Approach III (Using Tables)
Integration approach (III) achieves verification of requirements in an integrated model by using Map and B-SCP techniques, while keeping this integrated model simple. Similar to Figure 2.b, we omit requirements set RA from Figure 2.c but present related table Figure 2.d.
In integration approach (III), we first connect the whole Map from special intentions Start and Stop with the corresponding domain context of B-SCP. Second, identify all facets of Map and tabulate them on one side. Third, by using context identification approach for Map in [16], we identify domains of interest for each facet and tabulate them against relevant facets. Fourth, we identify requirements from the B-SCP goal model and tabulate them against relevant processes of Map.

The crucial aspect in this integration approach is the use of a table Figure 2.d to capture relationships between requirements in Map and B-SCP, along with their context. This table has five columns. The first two columns (from the left side) contain Id and text for each B-SCP requirement, respectively. The third column lists B-SCP domains of interest (i.e., context) for these requirements. The fourth and fifth column store reference and full name of the corresponding Map facet, respectively. Thus, for each Map facet the table identifies relevant domains of interest and (possibly more than one) B-SCP requirements that have been achieved for this Map facet. On the other hand, it is possible that more than one Map facets are involved to achieve a B-SCP requirement. Explicit identification of these relationships between B-SCP requirements and Map facets allows us to verify each Map facet against B-SCP requirements and their domains of interest. In particular, we are now able to determine how many (and which) B-SCP goals can be achieved when the process of a Map facet is executed, as well as how many (and which) domains of interest are involved in this Map process. Another benefit of this integration approach is that it keeps an already complicated diagram as simple as possible, without losing any of its meaning. We have presented an example of Map and B-SCP requirements relationships by using approach (III) in Figure 2.c. Some examples of requirements verification are presented in table

<table>
<thead>
<tr>
<th>ID</th>
<th>B-SCP Requirements Text</th>
<th>Domains</th>
<th>References</th>
<th>Map Facets</th>
</tr>
</thead>
<tbody>
<tr>
<td>G5</td>
<td>Enable franchise stores to maintain constant</td>
<td>SEJ / Consumer/</td>
<td>&lt;I2, S8, I3&gt;</td>
<td>&lt;Manage Convenience Store, Fresh delivery strategy,</td>
</tr>
<tr>
<td></td>
<td>freshness of perishables</td>
<td>Franchise Store</td>
<td></td>
<td>Provide Consumer Service&gt;</td>
</tr>
<tr>
<td>G6</td>
<td>Enable franchise stores to stock products that</td>
<td>SEJ / Consumer/</td>
<td>&lt;I2, S3, I3&gt;</td>
<td>&lt;Manage Convenience Store, Timely delivery strategy,</td>
</tr>
<tr>
<td></td>
<td>consumers want when they want them according</td>
<td>Franchise Store</td>
<td></td>
<td>Provide Consumer Service&gt;</td>
</tr>
<tr>
<td></td>
<td>to changing needs</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 2. Three integration approaches of Map with B-SCP
Table 1. Comparison of the three integration approaches

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Characteristic</th>
<th>Integration (I)</th>
<th>Integration (II)</th>
<th>Integration (III)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complexity of the application domain</td>
<td>Enterprise Domain</td>
<td>-Difficult to understand connections</td>
<td>+Easier to understand connections with bars</td>
<td>-Too simple connections</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+Explicit connections</td>
<td>-Bars have to be identified</td>
<td>-Separate table is needed</td>
</tr>
<tr>
<td></td>
<td>Simple Application Domain</td>
<td>+Easy to understand connections</td>
<td>-Bars become irrelevant, but they still have to be identified</td>
<td>+Explicit verification by using a table</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+Explicit connections</td>
<td>-Integration I == Integration II</td>
<td></td>
</tr>
<tr>
<td>Requirement nature</td>
<td>Strategic requirement</td>
<td>+Complex connections</td>
<td>+Moderately complex connections</td>
<td>+Simple connections</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Integration I == Integration II</td>
<td>+Explicit verification by using a table</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Technical requirement</td>
<td>+Easy connections</td>
<td>-Integration I == Integration II</td>
<td>+A simple model</td>
</tr>
</tbody>
</table>

Figure 2.d however more detailed examples are provided in [6, 7]. We connect the whole MA with the domain context DA, which uses Map and B-SCP approaches respectively. This connection means that the requirements of Map MA starting from special intentions Start and Stop are related to all domains of interest in DA and, hence, related to all requirements of the B-SCP goal model RA. Complementary to Figure 2.c is Figure 2.d that describes some of the nine facets of Map MA and their relationships to the B-SCP requirements. By using the context identification approach for Map [16], we identify domains of interest from DA and describe them in the third column of Figure 2.d, against their relevant Map facets. Then, we identify B-SCP requirements from RA that have been addressed by the nine Map processes. We describe them in the first two columns of Figure 2.d. Table rows show which requirements in the B-SCP requirements set RA are relevant against which facet of Map MA.

7. DISCUSSION

In the previous section, we have illustrated the three integration approaches on the Seven Eleven Japan (SEJ) case and briefly discussed the advantages and disadvantages that we noticed for this case. Figure 2.a presents results of the explicit integration approach (I). However, there is a congestion of connections which makes the information ambiguous. Figure 2.b presents results of the integration approach (II) that uses bars. Compared to Figure 2.a, the resulting model is less cluttered. Figure 2.c and Figure 2.d show results of the integration approach (III) that relies on the table of relationships between Map and B-SCP requirements. This table Figure 2.d allows verifying Map and B-SCP requirements explicitly against each other. In addition, the resulting diagram Figure 2.d is simple and uncluttered.

While these are useful conclusions, they are results of only one case study, with specific characteristics. It is also important to evaluate these three integration approaches across cases studies with different characteristics. Therefore, we used the CommSec Australia case study described in [7] and [9] to provide information for additional evaluation. While SEJ is an enterprise problem domain, CommSec Australia presents a relatively simple application domain. In the CommSec Australia case study, a Map model was developed of a part of the case and an integration of this Map with the corresponding B-SCP goal model was presented. We are not able to fully describe this case in this paper, but we summarize our conclusions. The most important conclusion is that usefulness of the three integration approaches was different from CommSec case study. The explicit integration approach (I) produced a model that was not complex to understand and the information was clearly presented. The integration approach (II) produced a model in which bars become unnecessary, because there was no complex connectivity problem between Map and B-SCP models. This made both models almost equal in usefulness (while the development procedure in the integration approach (II) is more complex, due to the need to identify bars). For the table-based integration approach (III), the resulting model presented similar pattern of results as in the SEJ case (except that the table was simpler).

A requirements analyst using an integration of B-SCP and Map will attempt to understand if B-SCP requirements have been met in Map processes. An important conclusion of our work is that the first two integration approaches (I and II) provide a limited opportunity to verify Map and B-SCP requirements against each other. On the other hand, the integration approach (III) explicitly tabulates both B-SCP and Map requirements and their relationships and, thus, allows a requirements analyst to verify each B-SCP requirement against Map facets with certainty. Anomalies (such as the facet <Start, Marketing support, Manage Convenience Store> in Figure 2.d that does not correspond to any B-SCP goal) can be noticed easily and then addressed appropriately.

We have also noticed that the usefulness of the three integration approaches differs based on the nature of requirements presented in Map and B-SCP models. For the integration approach (I), strategic nature of a requirement develops a complex association between requirements entities. For the integration approach (II), it establishes a moderately complex association between requirements entities and the bars become useful. For the integration approach (III), a strategic requirement presents a simple association between Map and B-SCP requirements. However, it requires a table to support explicit verification between Map and B-SCP requirements. Conclusions are different for requirements of a technical nature. For them, integration approach (I) provides relatively easier associations between Map and B-SCP requirements. Further, the integration approach (II) becomes not useful because a technical requirement does not present a complex association. The integration approach (III) applied to a technical requirement presents a simple integration model. If the modelled IT system has a mixture of strategic and technical goals, then the requirements analyst should be aware of
the advantages and disadvantages of the each integration approach. Table 1 summarises our conclusions, based on the case studies presented. It lists advantages (denoted in the table with '+') and disadvantages (denoted with '-') of the three studied integration approaches. The comparison is done along two dimensions: complexity of the application domain and requirement nature. For both dimensions, we identified two characteristics that produce different usefulness of the integration approaches. These are enterprise domain (with mostly strategic level goals) vs. simple application domain (usually with dominance of technical level goals) along the complexity of the application domain dimension and strategic requirement vs. technical requirement along the requirement nature dimension.

8. CONCLUSIONS AND FUTURE WORK

We have presented three integration approaches to integrate two requirements engineering techniques, Map [5] and B-SCP [4]. Scope of the integration approaches is strategic requirements and its evolution, which have not been researched deeply. B-SCP does not address the requirements evolution problem of strategic IT, however the Map does. Therefore, we integrate Map with B-SCP to provide evolution mechanisms in the B-SCP framework. Semantic similarities between Map and B-SCP motivated us for their integration. Therefore, we set one main research question ("How can we best integrate Map with B-SCP?") based on the integration concept presented in section 4. The integration concept provoked the idea that the integration can be performed in more than one way. Thus, we set three subsequent research questions (RQ1, RQ2 and RQ3), and developed three integration approaches that address these research questions.

We comparatively evaluated advantages and disadvantages of the three integration approaches on two case studies: Seven Eleven Japan (SEJ) and CommSec Australia. The comparative analysis of both case studies shows that the usefulness of each integration approach depends (at least) on complexity of the application domain and nature of the modelled requirements. For example, the integration approach (II) was not useful for CommSec Australia case study, while it could be considered useful for the SEJ case study. The important advantage of the integration approach (III) over the other two integration approaches is that it provides support for explicit verification of requirements.

In our future work, we intend to perform further industrial case studies to additionally validate our evaluation conclusions. These case studies might provide insights for additional dimensions of comparison of the three integration approaches. We will also introduce detailed solutions for what to do when anomalies (such as that a requirement in one model is not verified in another model) occur.

9. REFERENCES