ABSTRACT
Requirements engineering describes how an IT implementation will support business functions. Most IT systems are operational in nature and typical requirements engineering techniques and methods are usually adequate in capturing and documenting the requirements for such systems. Jackson’s problem frames is a technique that is suitable for straightforward IT systems descriptions. However, when an organization deploys an IT system that must deliver upon its competitive business strategy, then an appropriate technique or method needs to be used to capture that business strategy in order to connect it to business-critical IT requirements. Here we provide an overview of the use and adaptation of problem frames to connect requirements to business strategy. We found that a simplification of the problem frames notation was necessary and that to be really effective, we had to integrate problem frames with goal modelling and Map, a method that helps describe the evolution of IT over time.

Categories and Subject Descriptors
D.2.1 Requirements/Specifications

General Terms
Design, Economics

Keywords
Business-IT alignment, strategy modeling, problem frames

1. INTRODUCTION
Organizations often use IT when developing and changing their business strategy. Strategy changes are necessary in order to compete more effectively in an existing market place, or to open a new market, or attract a new customer. For example, banks regularly offer new financial products over the internet in order to keep up with their competitors or put themselves one step ahead. 7&I Holdings in Japan, owners of the Seven Eleven chain of convenience stores use a highly sophisticated value chain management system in order to get ahead of their competitors. Seven Eleven Japan has used its IT strategically to remain a market leader in Japan. Typical recent requirements engineering approaches, such as i* [1] and UML [2], are inadequate in capturing and modelling competitive business strategy, and in providing explicit traceability to IT requirements to successfully achieve that strategy. i* is an operational goal modelling technique while UML is bottom down object-oriented design approach. Even modern Enterprise Architecture frameworks such as that of Zachman [3], and products such as Telelogic’s System Architect [4] are inadequate in this area because:

1) Very little attention is paid to the higher strategic levels in Zachman – almost all effort and focus is on data modelling and business rules [5]; this is already too technical.

2) Industry and academia has become obsessed with process modelling. BPMN is little more than an overly complex workflow modelling approach, focused on operations and not on business strategy. Other goal modelling approaches such as Tropos [6] and KAOS [7] are similar mould to i* in that they are at best operational techniques. We present only a brief overview of such approaches due to space constraints.

In this paper, again due to space restrictions, we will not present an overview of Jackson’s Problem frames but refer the reader instead to [8] for full details of the technique. The problem frames notation typically presents three simple concepts: machine, problem world and requirements. These three concepts are analogous to our three aspects of business strategy (see Figure 1), allowing us to model the three aspects as three simple problem frames concepts.

The problem frames approach has an advantage over other requirements modelling approaches as: (1) problem frames support decomposition of user requirements in parallel, and (2) user requirements are about modelling relationships in context, not about the functions that must be performed. These two problem frames features are important if we wish to identify alignment between business strategy and IT requirements. We point out here that we consider there is no difference between an IT requirement, a business requirement and context. They are needs that in the context of strategic IT systems, must be achieved, or helped to be achieved, by the strategic IT system. Further, problem frames notations are simple and have been simplified, adapted, extended and generalised to our strategic business modelling approaches. For example, the problem frames requirements notation is adaptable to different types of modelling such as process modelling. While problem frames can be divided into three parts – requirements, problem world and machine, they present strong relationships between them. During the decomposition process, these three parts are decomposed in parallel to address sub-problems. In this paper, we present a method that uses problem frames for eliciting business strategy and alignment with IT requirements. Our research question is:

How can we use problem frames for modelling business strategy?

We find that the three parts (requirements, problem world and machine) of the problem frames approach are useful in representing the three concepts of business strategy model – strategic business requirements, IT systems and context. We
propose a simplification to constraint and reference notations for the strategic business model. We discuss \textit{adaptability, extendibility and generalisability} aspects of problem frames with respect to the three concepts of business strategy model. We discuss two research streams – B-SCP [9] and Map extension [10] in which problem frames have been used to identify business strategy-IT requirements alignment. While B-SCP presents three themes: business strategy, context and process, Map is a strategy-driven business process modelling technique that elicits requirements as intentions and strategies. We adapt the requirements notation of problem frames to elicit B-SCP and Map requirements. To extend the B-SCP approach, we propose an extension to the problem frames approach. The machine notation is generalized to represent IT systems for strategic business models.

Major contribution of this paper is that it identifies through examples that problem frames are adaptable, extendable and generalisable to business strategy modelling. It is considered as input to discuss business strategy modelling with problem frames. The rest of the paper is organized as follows. Section 2 identifies three important aspects of business strategy modelling and presents a brief introduction to B-SCP and Map extension approaches. Section 3 describes a simplification, adaptation, extension and generalisation approach to problem frames. Section 4 concludes and presents future research.

2. BUSINESS STRATEGY MODELLING

Our business strategy model consists of three important aspects, strategic business requirements, IT systems and context (see Figure 1). Strategic requirements are business and organisational goals, here IT systems represent a machine (computer system), or a collection of machines, e.g. an enterprise level distributed computer system. Context represents collection of domain entities (e.g. suppliers, partners, users) related to strategic requirements and IT systems. Our model considers IT systems and context, as part of strategic business requirements. We model these three aspects separately but within a comprehensive framework which shows that these aspects are strongly inter-related. These three aspects have to go through a decomposition process to identify detailed level problems.

The problem frames approach allows us to model these three aspects of business a strategy effectively. Problem frames essentially allow us to model three types of entities: requirements, problem world and the machine. In terms of representing three aspects of a business strategy model, we use the requirements section of problem frames to elicit strategic business requirements, the problem world section to represent context, and the machine to represent IT systems that support strategic business requirements. During the decomposition process, problem frames support representation of the three aspects-related information at further sub-problem levels.

![Figure 1: Three aspects of a business strategy model](image)

We now present a brief overview of two examples where strategic business models are developed using the Jackson’s problem frames approach.

B-SCP uses the problem frames approach to represent three themes, business, strategy, context and process [9]. B-SCP uses selected i* notations to represent goals and tasks in problem frames, Jackson’s context diagrams (part of the problem frames) for context and Role Activity Diagram (RAD) for processes [9]. B-SCP uses an AND/OR refinement approach to present a hierarchy of requirements and alignment between business strategy and IT requirements. By using the problem frames decomposition approach, B-SCP is able to present problems at different levels in detail and to show explicit linkages between these levels.

Map is a strategy-driven business process modelling technique that uses intentions and strategies to develop requirements models [11]. Intentions refer to goals, and strategies refer to processes which are employed to achieve goals. Map is a strategic requirements modelling technique that presents close relationships between an intention and a strategy. However, Map does not identify domain context explicitly for a model.

We use the problem frames approach to extend Map; some extensions are mentioned below:

1. to identify context for Map processes [10].
2. to present alignment between higher level contextualized Map models and lower level models [12].
3. to present possibilities for extending problem frames with Map approach [13].

3. SUITABILITY OF PROBLEM FRAMES FOR STRATEGIC MODELLING

From the perspective of B-SCP and Map extensions, we discuss simplicity, adaptability, extendibility and generalisability of problem frames.

3.1 Simplifying Problem Frames

According to Jackson, requirements either reference or constrain domain entities in a context diagram. A requirement constraint indicates “the machine must ensure that the state or behaviour of that domain satisfies the requirement” (page 370) [8]. A requirement reference indicates the domain provides a description of phenomena in the domain context. Requirements constraints and references are indicated by dotted lines from the requirements to domain entities in the domain context diagram. An arrowhead indicates that the domain is constrained by the requirement; a requirement reference, with no arrowhead indicates that the requirement refers to some phenomena in that domain.

It is our opinion that this level of detail is an unnecessary complication to problem frames when applied at the strategic level. Whether a requirement references or constrains a domain entity is entirely dependent upon the requirement itself. Even when there is only one requirement per domain entity, the one requirement will inform the engineer of exactly how that domain is to behave or respond to the requirement. In strategic IT, typically there are several requirements that reference and constrain several domain entities, particularly at higher levels in a progression of problems. As such, we remove the arrowhead and replace it with a simple connecting line.

Another step in simplifying problem frames for our purpose, is the removal of a number of different kinds of domain. Here, Jackson [8] classifies 3 types: lexical, causal and biddable, plus Jackson
has three specialisations: real world domain, design domain and machine. A lexical domain is a representation of data; a causal domain is a domain whose behaviour can be controlled or observed in some way, and a biddable domain represents a human, who is supposed to carry out the requirements in the real world, but might not, given the nature of humans to choose their actions. A simple domain can be anything other than the system being designed and implemented – this is the machine – and a design domain, which is a recognition of a software application that needs to be built or already exists, such as a customer database or a user screen, which forms part of the machine domain. Hall and Rapanotti [14] propose a further domain type, a ‘knowledge’ domain, which is something akin to a set of rules that governs how an employee works, such as the scripts used by call centre operatives, that ‘force’ the operative to work in a certain way by responding to such scripts irrespective of the needs of the customer. Our view of these types is that they are also unnecessarily complex in a strategic IT situation. Except for differentiating between domain entities and machines, our experience is that the other distinguishing factors do not matter. Stakeholders who validate strategic models, such as executives and senior management, want to see a simple easy to read model. They are not interested in categories of domains but rather that the domain is the right one, i.e. the domain entity actually fits with the other domain entities. The reason for this is again the same – the business requirements for the enterprise will tell us very clearly how we want the domain entities to behave. Perhaps at the level of abstraction Jackson describes in [8], these distinctions are necessary. It is our contention that for the level of abstraction described in this paper they are not necessary, and as such, we do not use them.

3.2 Adaptability of Problem Frames

Problem frames components are adaptable to be used in different types of requirements modelling approaches. We discuss here, how the requirements notation of problem frames was adapted for B-SCP and a Map extension. The problem frames requirements notation is generally represented by an oval of dotted line. Commonly it is used to elicit text based operational level requirements for the software systems identified in the problem-world part of the problem frames. B-SCP adapts the problem frames requirements notation to present a goal model of strategic business requirements (see Figure 2). The goal model uses 1st notations to represent soft and hard goals, objectives and tactics. The B-SCP approach also presents explicit traceability linkages between requirements entities of a goal model so that the goal model presents a hierarchical structure of requirements entities. The problem frames decomposition approach is also adapted to identify refined levels of a B-SCP goal model. Thus, the problem frames approach can be used to align business strategy with IT requirements through different decomposition levels. For more details, we refer the reader to [9].

Map is a business process modelling technique that uses intentions and strategies to represent business processes. The Map technique allows us to create many models aligned with higher level models. So, each model represents a complete system. We also have adapted the requirements notation of problem frames to represent Map models. The main purpose of this representation is to identify the domain context for a Map model and to test the feasibility of using problem frames with the Map modelling approach [10]. The Map requirements part of Figure 2 shows how we have adapted the requirements notation of problem frames for Map models. Problem frames can be adapted effectively to one complete strategic Map model in its requirements section. The decomposition approach of problem frames is also adapted effectively with the Map refinement approach. Each complete refined Map model can be represented as sub-problem in the problem frames notation so that it presents a hierarchy of Map models aligning business strategy with IT requirements. For more details on this approach, we refer the reader to [10][12].

In summary, we have evaluated the adaptation possibilities of requirements notation of problem frames for two types of requirements modelling approaches – B-SCP represents requirements as a snap shot in time, and Map represents business processes. The problem frames decomposition approach has also been adapted to the refinement approaches of B-SCP and Map effectively and helps to present alignment between business strategy and IT requirements.

3.3 Extendibility of Problem Frames

B-SCP uses problem frames to present alignment between higher level strategic business and detailed level models. To address the evolution in B-SCP, we have presented an extension approach to problem frames in [13]. In that, we have brought Map modelling technique to the B-SCP framework to address the challenges of strategic requirements evolution (Figure 3). Now, problem frames have two types of requirements and one central problem world. As discussed in section 2, we do not consider constraints and references for a strategic business model. We refer each Map process to its relevant domain entity in the domain context by using simple arrow headlines.

3.4 Generalisability of Problem Frames

Problem frames identify a machine entity to represent software. Generally, problem frames identify machines for operational level problems. However, our goal is to use problem frames to identify strategic business models which includes three important aspects, strategic business requirements, context and IT systems (see Figure 1).
We generalize the concept of machine entity in problem frames to represent the IT systems of a business strategy model. IT systems represent more than just a machine. There may be a collection of machines/small IT systems/an enterprise level distributed systems referring to the organisational strategic objectives. Therefore, a machine can either be adapted by changing its notation or generalized it to represent other computer systems such as an IT system. We consider a machine notation should be generalized instead of adapted. The reason for this is that a machine typically represents computers i.e. software and hardware in problem frames. When a machine is generalized to IT systems it will still be representing hardware and software but on larger scale. We achieve machine level requirements, but through the decomposition approach that is applied first to the business strategy model. It achieves sub-problems including lower level IT systems and then further decomposition provides operational level requirements including simple machines.

4. CONCLUSION AND FUTURE WORK

Business organizations are in tremendous competition to gain a competitive edge and they heavily rely on strategic IT. Requirements engineering research lacks frameworks for eliciting organizational business strategy. The problem frames approach provides an opportunity to represent important aspects of a business strategy. We have used three concepts of problem frames — requirements, problem world and machine—to represent three important aspects of a business strategy – strategic business requirements, context and IT systems. In order to leverage problem frames for business strategy modelling in the B-SCP and Map extension approaches, we have simplified, adapted, extended and generalized problem frames notations. In this way, we have answered the research question posed in this paper: How can we use problem frames for modelling business strategy?

We have presented a preliminary approach of using problem frames at strategy level. In this regard we have referenced two past works that have used problem frames explicitly in business modelling context. However, our approach has not analysed problem frames adaptation on the semantic level. Thus a deeper analysis is left for future work. Further, it must be also noted that further research is required as problem frames also have limitations for the modelling of business strategy; there is a wide range of information used for business strategy decisions that is not well captured by problem frames. One example is modelling of competition. Suppose we want to build an on-line book store and there is already a number of competing on-line book stores. To succeed from the business viewpoint, we have to somehow differentiate our offering, e.g., on book price, selection of books, usability, attractiveness of the user interface, etc. The information about what our competitors do and how our offering is better (using some criteria) is one of the basic elements of business strategy. However, it is not well captured in any of the current extensions or adaptations of problem frames. Some high-level aspects can be captured through requirements (or maybe problem domains), but we believe that it would also be beneficial to model details that would enable more precise analysis of business strategy models based on (or using) problem frames. Deciding how to best integrate such information into modelling based on problem frames could be an interesting topic for future research.

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6. REFERENCES