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The Journal of Systems and Software 79 (2006) 362–378
The Journal of Systems and Software
www.elsevier.com/locate/jss

Validating strategic alignment of organizational IT requirements using goal modeling and problem diagrams

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Received 21 December 2004; received in revised form 18 April 2005; accepted 22 April 2005
Available online 27 June 2005

Abstract

Ensuring that organizational IT is in alignment with and provides support for an organization's business strategy is critical to business success. We present an integrated approach to requirements engineering for organizational IT. To help validate IT-business strategy alignment, we propose a single model according to Jackson's problem diagram framework to encompass both business strategy and system requirements. We use an organizational strategy analysis technique to deconstruct business strategy. Strategy is then modeled using a goal-oriented requirements engineering notation; a framework for modeling an organization's business strategy proposed by the Business Rules Group is used to construct the goal model. We use Jackson's context diagrams to represent both business and IT domain context. Our approach is illustrated via application to an exemplar, constructed from a variety of sources in the literature describing Seven–Eleven Japan.

Keywords: Requirements engineering; Strategic alignemt; Goal-modeling; Problem frames

1. Introduction

Strategic alignment of IT exists when a business organization's goals and activities are in harmony with the information systems that support them (McKeen and Smith, 2003). Effective strategic alignment positively influences IT effectiveness (Ciborra, 1997; Galliers, 1991; Porter, 1987) and leads to superior business performance (Chan et al., 1997; Croteau and Bergeron, 2001; Tallon and Kraemer, 2002). It is thus not surprising that CIOs and IT executives consistently rank alignment of IT with business strategy a top priority (Luftman and MacLean, 2004; Reich and Nelson, 2003; Tallon et al., 2000; Watson et al., 1997; Brancheau et al., 1996). Despite this, issues of business strategy and strategic alignment are almost entirely ignored in requirements engineering research literature. While the literature describes a number of requirements engineering frameworks and approaches that highlight various aspects of requirements analysis for organizational IT (Yu and Liu, 2001; Gordijn and Akkermans, 2003; Loucopoulos, 2001; Loucopoulos and Kavakli, 1995; Bubenko et al., 1994; Nurcan and Rolland, 2003; Rolland et al., 1998; Rolland et al., 2004; Kolp et al., 2003), none incorporates an explicit analysis of business strategy, making it difficult to use such approaches to validate systems requirements against the objectives of an organization's business strategy.

We propose a requirements analysis framework that enables verification and validation of requirements in terms of alignment with and support for business strategy. We developed our framework by using

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doi:10.1016/j.jss.2005.04.033

problem diagrams (Jackson, 2001), to model business context. We also apply goal modeling to recognized business strategy analysis and modeling approaches. This paper refines and extends previous research (Bleistein et al., 2004a,b,c,d, 2005).

It is common practice in requirements engineering research to apply a new technique to a requirements engineering exemplar for initial validation. However, we found the requirements engineering research literature to be devoid of well-documented examples of organizational IT that encompass business strategy. We therefore developed a requirements engineering example suited to the objective of demonstrating a capability of verifying and validating requirements in terms of alignment with business strategy. We based the example on research on Seven–Eleven Japan's IT appearing in both management and information systems literature (Bensaou, 1997; Whang et al., 1997; Rapp, 2002; Weill and Vitale, 2001; Makino and Suzuki, 1997; Kunitomo, 1997; The Economist Newspaper Limited, 2001). This example allows us to verify that our framework can model both system requirements and business strategy, and to demonstrate alignment between these.

The rest of this paper is organized as follows: Section 2 reviews relevant research in strategic alignment and requirements engineering. Section 3 discusses the theory behind the framework, and shows how problem diagrams and goal modeling can be applied to include business strategy in requirements analysis. Section 4 presents a proof-of-concept example based on the case of Seven–Eleven Japan. Section 5 discusses and evaluates the framework. Section 6 offers conclusions.

2. Background

In this section, we review relevant requirements engineering and strategic alignment research. Overall, requirements engineering approaches for organizational IT do not encompass business strategy. At the same time, frameworks for analyzing and evaluating strategic alignment tend to treat organizational IT at a relatively abstract level that do not detail system requirements.

An organization's business strategy can be defined as "the understanding of an industry structure and dynamics, determining the organization's relative position in that industry and taking action either to change the industry's structure or the organization's position to improve organizational results" (Oliver, 2001). Business strategy includes both the rationale for and the means by which a business organization competes with industry rivals (Porter, 1996).

Requirements engineering research describes a number of approaches that address a various of aspects of organizational IT (Yu and Liu, 2001; Gordijn and Akkermans, 2003; Loucopoulos, 2001; Loucopoulos and Kavakli, 1995; Bubenko et al., 1994; Nurcan and Rolland, 2003; Rolland et al., 1998; Rolland et al., 2004; Kolp et al., 2003). However, these do not include recognized frameworks for strategy analysis or a means for explicit expression of business strategy. Rather, the aspects of organizational IT that these approaches address, tend to be functional and operational, and concern mostly operational business objectives. Use of these approaches thus makes it difficult for requirements engineers to validate system requirements against the intentions of executive management stakeholders, who make the business strategy that they expect the eventual IT system to support.

In strategic alignment research, there are a number of frameworks and approaches proposed for evaluating and validating alignment between IT and business strategy (Luftman et al., 1999; Reich and Benbasat, 1996; Henderson and Venkatraman, 1991). In contrast to the requirements engineering research discussed above, strategic alignment research tends to highlight management issues, but ignores connections to system requirements. Some research identifies critical enabling and inhibiting factors of successful strategic alignment (Luftman et al., 1999), but focuses uniquely on activities and behaviors of managers. Other research proposes conceptual frameworks that might be used to measure strategic alignment in terms of internal consistency and external validity (Reich and Benbasat, 1996). Henderson and Venkatraman propose the *strategic alignment model* (SAM) that draws connections and linkages between strategy and IT (Henderson and Venkatraman, 1991), but this model is not taken beyond the conceptual level. Avison et al. (2004) operationalize SAM via a general, extended enterprise architecture knowledge management framework, but fail to demonstrate feasibility for validating lower-level system requirements.

Some research has attempted to address issues of business-IT alignment in terms of IT portfolio management (Jeffery and Leliveld, 2004; Prahalad and Krishnan, 2002; Benko and McFarlan, 2003; Weill and Broadbent, 1998). Portfolio management describes business processes by which an organization determines a mix of active IT projects, staffing, and budget to be allocated to projects. However, portfolio management approaches ignore means of ensuring system requirements alignment in the requirements analysis phase of IT projects.

3. Framework for strategic alignment validation

The gap between requirements engineering and analysis approaches and frameworks for validating strategic alignment of organizational IT has lead us to seek out existing requirements engineering techniques that might be applied to modeling and analyzing business strategy.

We have selected problem diagrams (Jackson, 2001), and requirements engineering goal modeling (Dardenne et al., 1993; Anton, 1996; Chung et al., 1999; Yu, 1993; Liu and Yu, 2001), which we use in an integrated framework. In this section, we discuss these techniques, explain the rationale for choosing them, and show how we integrate and apply them to validate alignment of IT requirements with business strategy. Section 3.1 discusses representation and analysis of business strategy within an integrated framework of problem diagrams and a goal model. In Section 3.1, we provide a general overview of Jackson problem diagrams, describe how a problem diagram framework can be used to represent business strategy, and discuss how a goal model can be integrated into a problem diagram framework. Section 3.2 focuses on the goal model, and discusses the analysis, deconstruction, and transformation of abstract and informal expressions of strategic intent into a coherent goal model. We introduce *VMOST analysis* (Sondhi, 1999), a technique for deconstructing business strategy into core components. We then describe how these components can be used to construct a goal model of business strategy with guidance from a business motivation model proposed by the Business Rules Group (Kolber et al., 2000).

3.1. Problem diagram framework for requirements analysis

Problem frames (Jackson, 2001) is a requirements analysis framework that we argue can be used to represent an organization's business strategy and to analyze requirements in terms of support for and alignment with that strategy. Section 3.1.1 provides an overview of problem frames. Section 3.1.2 shows how it is possible to represent business strategy as a problem diagram. Section 3.1.3 illustrates how problem diagrams can be decomposed from high-level, abstract, business model context down to low-level system context, and discusses integrating goal modeling with problem diagrams.

3.1.1. Overview of problem diagrams

Problem frames capture, structure and classify recurring software development problems (Jackson, 1995, 2001) according to a problem diagram framework. Problem diagrams provide an analytical framework for requirements based on real-world physical entities and their observable interactions and behaviors. We make extensive use of problem diagrams in our requirements analysis approach for strategic alignment because of their focus on describing software problems in real-world terms. A problem diagram describes properties of a software problem according to two "moods" (Jackson, 1995, 2001) to represent the way the world is now and the way we would like the world to be. *Indicative* mood represents everything in the problem that is given and will remain unaffected by the software system, including physical domain entities such as people, organizations, departments and devices, and their shared phenomena, such as activities, processes, events, states, commands, and information. *Optative* mood represents the way we would like everything to be, given the construction of the software system, and thus represents the requirements (Jackson, 2001). Requirements include business goals, objectives, processes, and all other business and systems requirements whose purpose is to alter the 'As Is' view of the world in some way. A problem diagram thus consists of two major components: a requirements part and a domain context diagram, as a requirement can only be understood in the context in which it occurs (Jackson, 2001). Context diagrams contain real-world *physical* domain entities called *domains of interest*, and the phenomena two or more domains of interest share. *Shared phenomena* consist of observable behavioral phenomena that occur between entities in a context diagram. Context diagrams always contain one special domain of interest, the *machine*, which is a general-purpose computer that we program. The requirements part of a problem diagram describes the effects in the real world that the *machine* should guarantee.

Fig. 1 illustrates some essential elements of a problem diagram. The requirements are enclosed in a dotted-line oval. The context diagram contains several domains of interest and the *machine*. For most software problems there will be multiple requirements ovals, domain context diagrams, and numerous domains of interest.

In the context diagram, the *machine* and three domains of interest, D1, D2, and D3, are interconnected with solid line *interfaces*, labeled a, b, c, and d, representing shared phenomena. Shared phenomena between domains are described through the following syntax:

b: Domain of Interest D2! {Shared Phenomenon p}

meaning "at b, Domain of Interest D2 is responsible '!' for phenomenon p."

Requirements either *reference* or *constrain* domains of interest in the context diagram. A *requirement constraint* indicates that "the *machine* must ensure that the state or behavior of that domain satisfies the requirement" (p. 370) (Jackson, 2001). A *requirement reference* indicates the domain provides a description of phenomena in the domain context. Requirements *constraints*

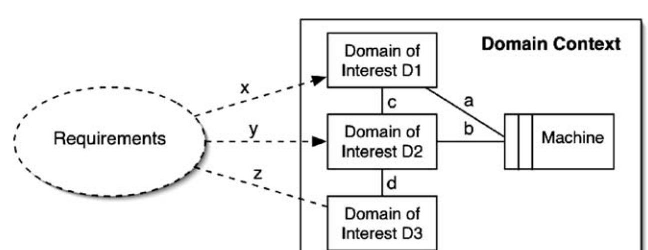

Fig. 1. Anatomy of a problem diagram.

and *references* are indicated by dotted lines from the Requirements to domains of interest in the context diagram. An arrowhead indicates that the domain is constrained by the requirement, such as constraints x and y on domains of interest D1 and D2, respectively. A requirement reference, with no arrowhead such as reference z on D3, indicates that the requirement *refers* to some phenomena in that domain. Constraints and references are described using syntax similar to that of shared phenomena:

y: Domain of Interest D2! {Requirement r}

meaning "at y, Requirement r, for which Domain of Interest D2 is responsible, constrains Domain of Interest D2."

Domains of interest may appear a number of times in the problem diagrams and problem frames through the principle of *projection*. *Projection* refers to the ability to describe domain context according to various viewpoints, levels of abstraction, and degree of detail (Jackson, 2001). A requirement might concern only certain phenomena or certain behavior of a domain, given the particular sub-problem addressed. In a different projection, the other domain phenomena might be of interest to the requirement for that particular problem. As projection is also a means of decomposing domain context into increasingly finer degrees of detail, it is particularly useful when managing requirements at multiple levels of abstraction.

3.1.2. A problem diagram framework for strategic alignment

While there are many requirements elicitation and analysis tools and techniques such as use cases and scenarios (Alexander and Maiden, 2004; Cockburn, 2001), Jackson problem diagrams furnish a framework that is particularly accommodating in problem analysis of business strategy, and it is for this reason that we use problem diagrams in our approach. Oliver's concept of strategy (2001) discussed in Section 2 fits nicely into a problem diagram framework. "Understanding of an industry structure and dynamics", and "determining the organization's relative position in that industry" refer to a business model (Magretta, 2002). The business model is the problem context in which physical domains of interest represent business model participants whose interactions are described as shared phenomena. "Taking action either to change the industry's structure or the organization's position to improve organizational results", refers to activities and processes by which the organization achieves its business objectives. These are the *requirement.* The IT-enabled organization supporting that strategy is represented as the *machine*. The way in which the *machine* supports requirements of business strategy, effectively describes successful strategic alignment.

A problem diagram at the level of abstraction of business strategy, however, is very distant from the *machine*. Requirements described at this level are likely to be too abstract to begin designing and implementing a *machine* solution consisting only of hardware, software, data, network resources, and individual people. To refine requirements from high-level problem diagrams down to the machine, the concept of a *progression of problems* (Jackson, 2001), that leverages the idea of *projection*, discussed previously in Section 3.1.1, is particularly useful.

Fig. 2 illustrates a progression of problem diagrams. Requirement ovals RA, RB, RC, RD, and RM each refer to domain context diagrams DA, DB, DC, DD, and M respectively. The domain context DA represents the *indicative* properties of the problem context at the level of the business model. Requirement RA represents the *optative* properties of business strategy. Through analysis of DA, it is possible to decompose the domain context into a more refined context diagram DB. Then through an analysis of DA and RA, it is possible to find a requirement RB that refers only to DB while satisfying RA. Similarly, through analysis of DB, it is possible to decompose the domain context into context diagram DC. Then through an analysis of DB and RB, it is possible to find a requirement RC that refers only to DC while satisfying RC, and so on. Through this process of domain context decomposition, analysis, problem projection, and refinement, ultimately the requirement refers just to the *machine*, yielding the system specification (Jackson, 2001).

3.1.3. Integrating goal modeling with problem diagrams

Although *progression of problems* serves as a powerful framework for transforming business strategy into system requirements via a process of domain context analysis and decomposition, the requirements analyst using this technique is forced to rely uniquely on domain context decomposition to refine requirements to increasingly lower levels of abstraction. A progression

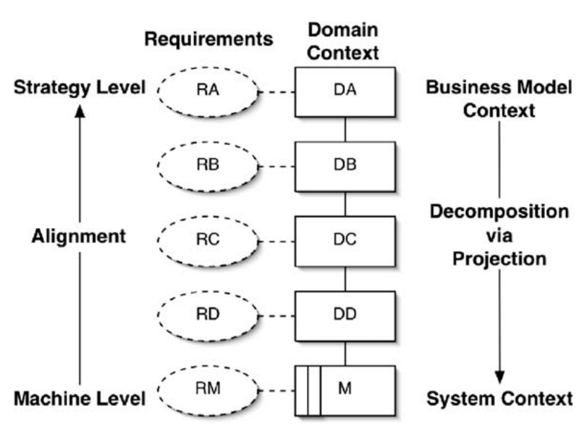

Fig. 2. Progression of problems adapted from (Jackson, 2001) p. 103.

of problem diagrams as described in (Jackson, 2001) provides no explicit, direct linkages between requirements in problem diagrams at different levels of the progression to describe how requirements at different levels of abstraction are related. However, when validating strategic alignment, explicit traceability of the optative properties from system requirements to strategic business objectives is critical. In order to explicitly and directly link requirements between problem diagrams in progression, we have chosen to integrate problem diagrams with goal modeling.

Goals are essentially optative as they refer to intended properties a system is to ensure (Zave and Jackson, 1997), which makes goal modeling appropriate for use in the requirement part of a problem diagram. Goals may be formulated at different levels of abstraction, from high-level strategic concerns to low-level technical ones (van Lamsweerde, 2001), and are thus useful in validating system requirements against business objectives. Goal modeling thus furnishes a mechanism for linking requirements in a progression of problem diagrams. In our approach, we therefore use a goal model to represent the requirement part of the Jackson problem diagram.

The integration of a goal model with a progression of problems is illustrated in Fig. 3. The requirements at each level of abstraction are described as a portion of a larger goal model, enclosed with a dotted line oval in accordance with problem diagram notation (Jackson, 2001) discussed in Section 3.1.1. The goal model portions, labeled RA, RB, RC, and RM, represent requirements at a level of abstraction equivalent to that of the *domain context*, labeled DA, DB, DC, and M, to which they refer within the progression of problems. The sub-goals are projections of their super goals, and satisfaction of the sub-goals ensures satisfaction of the super goals. Lower-level requirements can be validated against higher-level goals, thus enabling validation of strategic alignment of requirements, as the objectives of business strategy are found in the highest levels of the goal model.

3.2. Modeling business strategy with goals

While there exist a number of goal-modeling approaches to organizational IT in requirements engineering research (Yu and Liu, 2001; Bubenko et al., 1994; Nurcan and Rolland, 2003; Rolland et al., 1998, 2004; Kolp et al., 2003), as mentioned previously, none encompasses an organization's business strategy. We present a sequence of activities for analyzing, deconstructing, and transforming informal expressions of strategic intent, such as business plans and executive interviews, into a requirements engineering goal model, as described in Fig. 4.

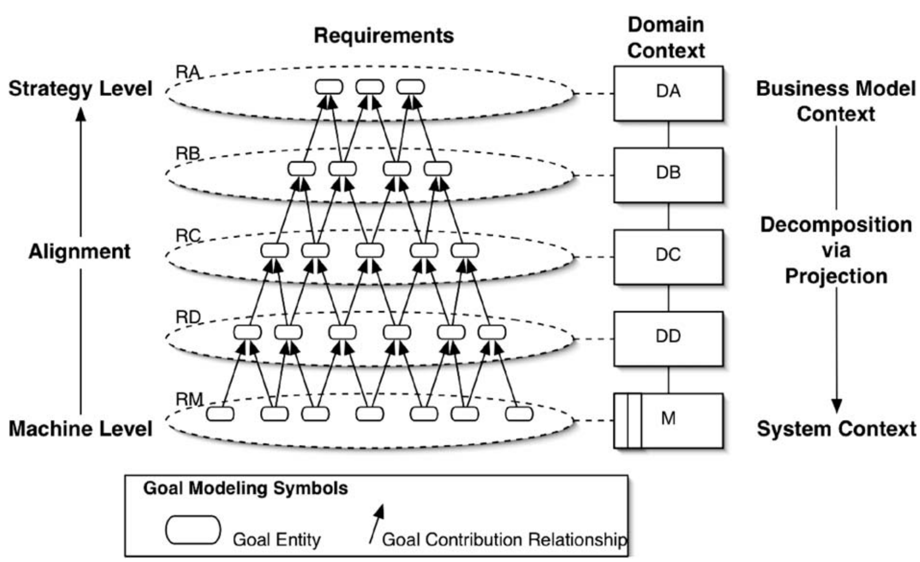

Fig. 3. Integrating goal model with progression of problems.

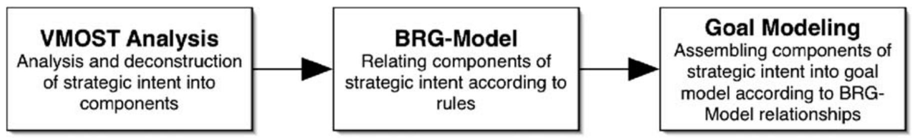

Fig. 4. Process for goal modeling strategic intent.

VMOST analysis (Sondhi, 1999) is used for analyzing and deconstructing business strategy into component parts. Then, the Business Rules Group's *Standard Model for Business Rules Motivation* (BRG-Model) provides rules for relating the components of business strategy to each other when constructing a model of business strategy. We apply the BRG-Model rules in assembling the components of business strategy into a goal model. Section 3.2.1 presents VMOST analysis. Section 3.2.2 describes the BRG-Model. Section 3.2.3 discusses modeling the VMOST and BRG-Model components as goals.

Table 1
VMOST concepts

Vision
An end-state toward which the organization strives
Mission
The primary activity of the the organization that achieves the vision
Goal
An abstract statement of intent whose achievement supports the vision
Strategy
An long-term activity designed to achieve a goal
Objective
A specific and measurable statement of intent whose achievement supports a goal
Tactic
A short-term action designed to achieve an objective

3.2.1. VMOST analysis

VMOST analysis (Sondhi, 1999) provides a means for deconstructing business strategy into core components of vision, mission, goals, strategies, objectives, and tactics, defined in Table 1. VMOST analysis aids in understanding how these components relate to, align with, and provide support for each other by an analyst's response to a number of *key questions*. We have adapted Sondhi's key questions and present them in Table 2.

3.2.2. BRG-Model rules

The BRG-Model helps in modeling an organization's systems such that they align with and provide support for the organization's business motivation (Kolber et al., 2000). Based on the same strategic planning components as VMOST, the BRG-Model describes a framework in which organizational "means" achieve organizational "ends". *Means* consist of processes, tasks, and activities and include *mission*, *strategy*, and *tactic*. *Ends* are states (goals) toward which the means are meant to strive. These include *vision*, *goal*, and *objective*. Fig. 5 illustrates a conceptual framework of the BRG-Model, and describes the rules by which each component relates to other components.

While the BRG-Model describes rules by which the components of business motivation relate to each, the

Table 2
VMOST analysis key questions, adapted from Sondhi (1999)

Key question	Rationale
Vision and mission	
(1) What is the overall, ideal, end-state toward which the organization strives (vision)?	Identification of the vision
(2) What is the primary activity that the organization performs to achieve the end-state (mission)?	Identification of the mission
(3) How are the responses to Questions 1 and 2 (vision and mission, respectively) appropriate and relevant to the environment?	Confirmation of understanding of vision and mission by understanding their rationale in terms of industry and market
(4) Are the responses to Questions 1 and 2 (vision and mission, respectively) explicit or implied? How?	Explanation of how the mission and vision are understood, whether taken from explicit statements of stakeholders, or interpreted via analysis of observed patterns of activities and behavior
Goals and strategies	
(5) What are the basic activities and their rationale by which the organization competes with industry rivals?	Confirmation of understanding of what drives strategic goals and activities by which the goals are achieved
(6) What goals does the organization set to determine if it is competing successfully?	Identification of strategic goals
(7) What activities does the organization perform to achieve the goals in Question 6?	Identification of means by which strategic goals are achieved
(8) How do the goals in question 6 support the response to question 1 (vision)?	Confirmation of understanding the strategic goals by understanding their rationale in terms of supporting the vision
Objectives and tactics	
(9) What are the measurable objectives that indicate achievement of goals identified in Question 6, and what activities does the organization perform to achieve those objectives?	Identification of objectives, the means by which those objectives are achieved, and confirmation of measurability
(10) How do the objectives identified in Question 9 support the goals identified in Question 6?	Confirmation of understanding of tactics and their objectives in terms of the rationale for supporting strategic goals

Fig. 5. BRG-Model, adapted from (Kolber et al., 2000).

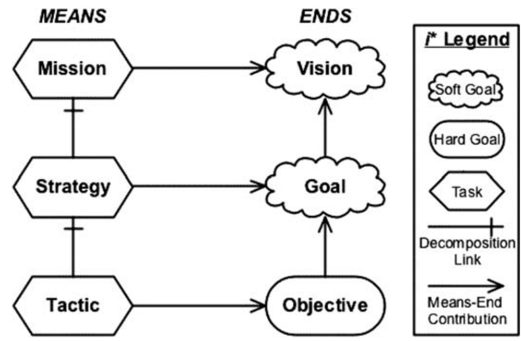

Fig. 6. BRG-Model operationalized.

Business Rules Group provides no modeling notation to operationalize the BRG-Model.

3.2.3. Goal-modeling

The components of both VMOST analysis and the BRG-Model are similar and at times equivalent to goal modeling entities. We do not advocate the use of a specific requirements engineering goal-modeling notation in our approach. We operationalize the BRG-Model by borrowing notational entities from *i** (Yu, 1993), an existing notation recognized in the requirements engineering research community. The entities we borrow from *i** are *hard goal*, *soft goal*, and *task*. These are defined in Table 3. *Vision* and *goal* entities are types of abstract goals and are equivalent to *soft goals*. An *objective* is a concrete goal, and equivalent to a *hard goal*. *Mission*, *strategy*, and *tactic* each represent activities or encapsulate processes, and are equivalent to a *task*. To illustrate the operationalization of the BRG-Model using goal modeling notation, we recast the BRG-Model in Fig. 5 into goal modeling notation in Fig. 6.

Arrows indicate a means-end contribution link. Crossed lines represent *task* decomposition links. Fig. 6 thus illustrates a usable modeling notation for the BRG-Model framework. This framework enables an end-to-end process for understanding, analyzing, and modeling an organization's business strategy through VMOST Analysis, the BRG-Model, and goal-modeling.

Table 3
Goal modeling entity definitions

Soft goal	An abstract goal whose achievement is not quantitatively measurable
Hard goal	A goal whose achievement is quantitatively measurable
Task	A specific activity or process
Decomposition link	Link indicating task decomposition into sub-tasks
Contribution link	Link indicating contribution to a goal from sub-goals

We consider the linking of VMOST analysis to goal modeling via the BRG-Model to be a major a contribution to the application of goal modeling in requirements engineering research.

4. Example: Seven–Eleven Japan

We use the case of Seven–Eleven Japan (SEJ) and its IT system to illustrate our approach. The SEJ literature (Bensaou, 1997; Whang et al., 1997; Rapp, 2002; Weill and Vitale, 2001; Makino and Suzuki, 1997; Kunitomo, 1997; The Economist Newspaper Limited, 2001) provides a rich picture of both SEJ's business strategy and the IT system SEJ uses to implement its strategy to compete with business rivals.

SEJ manages a national franchise of independently owned convenience stores. SEJ uses its IT to actively collect and analyze individual customer purchase pattern data at the point-of-sale in each franchise store, which are correlated with local social and environmental factors to develop a remarkably reliable, real-time predictive model. SEJ's IT system enables franchisees to predict customer purchasing behavior, store-by-store, item-by-item, hour-by-hour, effectively enabling management of a supply chain of business partners to stock stores just-in-time according to changing customer demand.

Our objectives in using the SEJ example are to demonstrate (1) developing a requirements engineering goal model that encompasses business strategy using VMOST analysis and the BRG-Model; (2) integrating a goal model and a progression of problem diagrams; and (3) illustrating validation of system requirements against strategic business objectives via traceable links.

We present a partial view, or a projection of the requirements problem (Jackson, 2001), sufficient to illustrate the feasibility of our approach. Section 4.1 presents a VMOST analysis of SEJ's strategy. Section 4.2 maps the VMOST analysis results to the BRG-Model. Section 4.3 describes a walkthrough of a goal model integrated into a progression of problem diagrams. Section 4.4

illustrates how system requirements can be validated against the business strategy of SEJ via explicit, traceable links.

4.1. SEJ VMOST analysis

We present the results of VMOST analysis of SEJ's strategy using the key questions, appearing in Table 2.

Question 1: What is the overall, ideal, end-state toward which the organization strives (vision)? SEJ's Chief Executive Officer (CEO) described his vision to create a chain of convenience stores "where you can find a solution for any of your daily life problems" at hours when needed (Bensaou, 1997).

Question 2: What is the primary activity that the organization performs to achieve the end-state (mission)? The CEO's plan was to use IT to help realize the vision in Question 1, enabling SEJ to leverage information to coordinate a supply chain of business partners to ensure that stores were stocked with precisely the products that consumers want when they want them (Bensaou, 1997; Makino and Suzuki, 1997).

Question 3: How are the responses to Questions 1 and 2 (vision and mission, respectively) appropriate and relevant to the environment? Stores in Tokyo, where land is a premium commodity, tend to be very small, and thus have little space to stock inventory. Shelf space must be filled only with products that move quickly, and stock must be replenished frequently. SEJ's business strategy focuses heavily on a value proposition to storeowners that addresses these requirements.

Question 4: Are the responses to Questions 1 and 2 (vision and mission, respectively) explicit or implied? How? The CEO describes SEJ's vision and mission explicitly in numerous interviews (Bensaou, 1997; Makino and Suzuki, 1997).

Question 5: What are the basic activities and their rationale by which the organization competes with industry rivals? It is critical to the success of storeowners that they maximize use of limited floor space. Franchise storeowners continuously endeavor to shorten inventory turnover time. To this end, SEJ needs to predict with precision what products customers will demand, when they will demand them, and then deliver inventory just-in-time to meet that demand. This is particularly challenging for perishable goods, such as box lunches and other processed fresh foods as customers' tastes change daily depending on the weather, holidays, and neighborhood events. Tastes also vary from store-to-store depending on neighborhood demographics. Competing with the need to limit inventory is the need for customers to find what they want in the store. Should a customer fail to find the product he is seeking, not only does SEJ lose the opportunity to make a sale, but SEJ has also learned through experience that the customer may never return (Bensaou, 1997).

Question 6: What goals does the organization set to determine if it is competing successfully? SEJ promises storeowners that it will enable them to maximize the use of their limited floor space, shorten inventory turnover time, reduce lost sales opportunities and lost customers, reduce scrap rates, and minimize unsold perishable goods while guaranteeing their freshness (Weill and Vitale, 2001). These constitute SEJ's goals.

Question 7: What activities does the organization perform to achieve the goals in Question 6? SEJ must enable stores to stock products that customers want when they want them according to continuously changing customer needs. SEJ achieves this by supporting effective stock order decision-making for the store clerks via a precisely tuned predictive model of consumer purchasing patterns store-by-store, product-by-product, hour-by-hour. SEJ develops and runs the model continuously to manage its franchise network supply chain.

Question 8: How do the goals in Question 6 support the response to Question 1 (vision)? SEJ's goals represent the value proposition to franchise stores, as they are SEJ's proposal to solve many of the critical difficulties facing Japanese retail shop owners. Enabling a system that allows franchise stores to stock exactly what products customers want when they want them supports CEO's vision.

Question 9: What are the measurable objectives that indicate achievement of goals identified in Question 6, and what activities does the organization perform to achieve those objectives? SEJ provides shop clerks with a means to visualize and analyze sales performance data in real time. To develop a detailed predictive model of consumer behavior, SEJ must collect data continuously at the point-of-sale for each store. The data includes a brief customer profile consisting of the customer's approximate age and gender, the products purchased, and the location, time and date of purchase. The SEJ system relies on store clerks to enter customer profile data, as only they have the direct interaction with customers necessary to perform this data collection.

Question 10: How do the objectives identified in Question 9 support the goals identified in Question 6? Clerks may consult a visual display of several types of reports that track sales performance data including sales trends, stock levels, scrap rates, and stockout rankings by item on a graphic order terminal (GOT). These reports enable clerks to analyze real time sales data, which aids them in identifying sales to support stock order decision-making. SEJ relies on its point-of-sale (POS) cash registers to enable collection of customer profile data. When a customer makes a purchase, before completing the transaction, the clerk looks at the customer and enters his gender, and his approximate age by selecting from a number of age range options. This customer profile information is bundled with the purchase information. Ultimately, this data is remitted to SEJ for analysis, and aids in the monitoring of changing customer tastes, and in the continuous development of SEJ's predictive model of consumer purchasing behavior.

4.2. From VMOST analysis to BRG-model

Based on responses to the key questions in the VMOST analysis presented in the section above, we now use the BRG-Model as a basic structure to identify and label individual *means* and *ends* entities. We present the resulting BRG-Model in Table 4. Each component is given a unique ID according to its type. We include an additional component, *assumption*, labeled A. An assumption is used to explain rationale behind other entities. We consider all optative properties of a system to be requirements, including business goals, objectives, activities, business processes, policies, and any other business or system requirements. We thus treat the entities in Table 4 as *requirements*, as these represent behavioral properties the system is intended to ensure.

For each component in Table 4, we identify other components to which it "links", including both goal

Table 4
VMOST analysis for Seven–Eleven Japan mapped to BRG-Model

Ends				Means			
ID	BRG-Model entity type	Links to	Involved domains	ID	BRG-Model entity type	Links to	Involved domains
	Vision (soft goal)				*MISSION (Task)*		
VI	Enable franchise stores to capture and keep customers by providing customers with their everyday needs when needed		Customer, Franchise Store, SEJ System	M1	Provide franchise stores with the ability to stock their stores with exactly what their customers want, when they want it	VI	Customer, Franchise Store, SEJ System
	Goals (soft goals)				*Strategies (Tasks)*		
G1	Enable franchise stores to reduce lost opportunity/customers	VI	Customer, Franchise Store, SEJ System				
G2	Enable franchise stores to minimize unsold perishables	VI	Franchise Store, SEJ System				
G3	Enable franchise stores to maximize use of limited floor space	VI	Franchise Store, SEJ System				
G4	Enable franchise stores to shorten inventory turns	VI	Franchise Store, SEJ System				
G5	Enable franchise stores to maintain constant freshness of perishables	VI	Franchise Store, SEJ System				
G6	Enable franchise stores to reduce scrap rates	VI	Franchise Store, SEJ System				
G7	Enable franchise stores to stock products that their customers want when they want them according to changing needs	G1–6	Franchise Store, SEJ System	S1	Supply stores with the right products at the right time	G7, M1	SEJ System, Supplier, Logistics Provider, Fracnhise
G8	Support effective stock order decision-making for each franchise store	G7	Franchise Store, SEJ System	S2	Continuously forecast store sales, item-by-item, lour-by-hour	S1	Franchise Store, SEJ System
G9	Aid in identifying sales trends per product by store down to an hourly basis for each store	G8	Franchise Store, SEJ System	S3	Support just-in-time (JIT) delivery for franchise stores	S1	SEJ System, Supplier, Logistics Provider, Fracnhise Store
G10	Develop a detailed, fine-grained, predictive model of consumer behavior store-by-store, product-by-product, hour-by-hour	G8	Franchise Store, SEJ System	S4	Use predictive model to forecast customer demand with great precision	S2	Franchise Store, SEJ System

Table 4 (*continued*)

Ends				Means			
ID	BRG-Model entity type	Links to	Involved domains	ID	BRG-Model entity type	Links to	Involved domains
G11	Enable shop clerks to display and analyze real-time sales data	G9	Clerk, GOT, GOT display, Stock	S5	Coordinate supply chain participants via data network linking them	S3	SEJ System, Supplier, Logistics Provider
	Objectives (hard goals)				*Tactics (tasks)*		
O1	Provide a visual display of sales performance data	G11	GOT, GOT display, stock	T1	Clerk tracks sales by item	O1	Clerk, GOT, GOT
				T2	Clerk tracks stock levels by item	O1	Display, Stock Clerk, GOT, GOT
				T3	Clerk tracks scrap trends	O1	Display, Stock Clerk, GOT, GOT
				T4	Clerk tracks stockout rankings	O1	Display, Stock Clerk, GOT, GOT Display, Stock
O2	Collect data constantly on customer age and gender and their purchase patterns for each store continuously	G9 correlation, G10	Franchise Store computer, SEJ Computer	T5	POS records customer and related sales data, and remits to store computer	O2	POS, SEJ Computer
O3	Require clerks to profile customers at POS to complete transaction	O2	Clerk, Customer, *POS*	T6	Clerk checks out customer	T5	Clerk, Customer,
				T7	Clerk profiles customer	T6	POS Clerk, Customer, POS
				T8	Clerk assesses customer age and gender by sight at POS	T7	Clerk, Customer
				T9	Clerk records customer age at POS	T7	Clerk, POS
				T10	Clerk records customer gender at POS	T7	Clerk, POS
				T11	Clerk registers product sales at POS	T6	Clerk, Product,
				T12	POS opens register drawer only after clerk enters customer profile	T6, O3	POS, Clerk
	Assumption (i Belief)*	*REFERS TO*					
A1	All products must be identified by UPC	T11					

contribution, and task composition relationships. Describing these relationships helps determine the position of the component in the goal model. We follow the rules governing contribution relationships according to the BRG-Model. We also identify involved domains of interest; i.e., the real-world physical entities that constitute the context in which the requirement occurs. Identifying involved domains is the first step not only in constructing context diagrams but also in detailing shared phenomena, requirements references and constraints. This information is necessary when integrating the goal model with a progression of problem diagrams.

4.3. Progression of problem diagrams

Once the relationships among the components in Table 4 are detailed, it is simple to use them to construct a goal model as the information in the table effectively provides instructions for doing so. We construct a goal model from Table 4 in the left-hand side of Fig. 7. We also use the identified domains involved in Table 4 to help construct context diagrams that appear on the right-hand side of Fig. 7. The integration of the goal model and the context diagram at each level in the progression presents a problem diagram for that particular level of abstraction. In Table 5, we describe the shared phenomena between domains of interest. In the subsequent sections, we take the reader on a walkthrough of the progression of problem diagrams. Reference to both Fig. 7 and Table 5 is necessary to understand this walkthrough.

4.3.1. Requirements set RA and domain DA

The business model and strategy is the top-level requirements engineering problem for SEJ, described by RA and DA in Fig. 7. It is here that we bound the requirements problem, because it is here that SEJ bounds their problem. DA contains three domains of interest: the *SEJ System*, which we treat as the machine domain, the *Franchise Store*, and the *Customer*, meaning the individual consumers who patron the SEJ stores. These three domains of interest are critical to describing SEJ's vision and mission, as SEJ's value proposition to its franchisees describes how the *SEJ System* enables a *Franchise Store* to best serve its *Customer* base to compete.

We now examine the shared phenomena in DA, described in Table 5. At interface a, the SEJ System is responsible for "stock ordering advice" and "supplier and logistics management" phenomena, shared with the Franchise Store. At interface b, the Franchise Store is responsible for a "retail of everyday consumer products" phenomenon, shared with its Customer base.

Let us continue with an examination of the requirements in RA. SEJ's vision is to (V1) *Enable franchise stores to capture and keep customers by providing customers with their everyday needs when needed*. The mission to (M1) *Provide franchise stores with the ability to stock their stores with exactly what their customers want, when they want it* makes the vision V1 operative. The core goals consisting of components of the plan for SEJ's vision V1 are to *Enable franchise stores to* (G1) *reduce lost opportunity/customer*, (G2) *minimize unsold perishables*, (G3) *maximize use of limited floor space*, (G4) *shorten inventory turns*, (G5) *maintain constant freshness of perishable goods*, and (G6) *reduce scrap rates.*

Requirements V1, M1, and G1–6 all *constrain* the *Franchise Store*, constraint *t*, indicated by a dashed line with an arrowhead. In contrast, customers have free will,

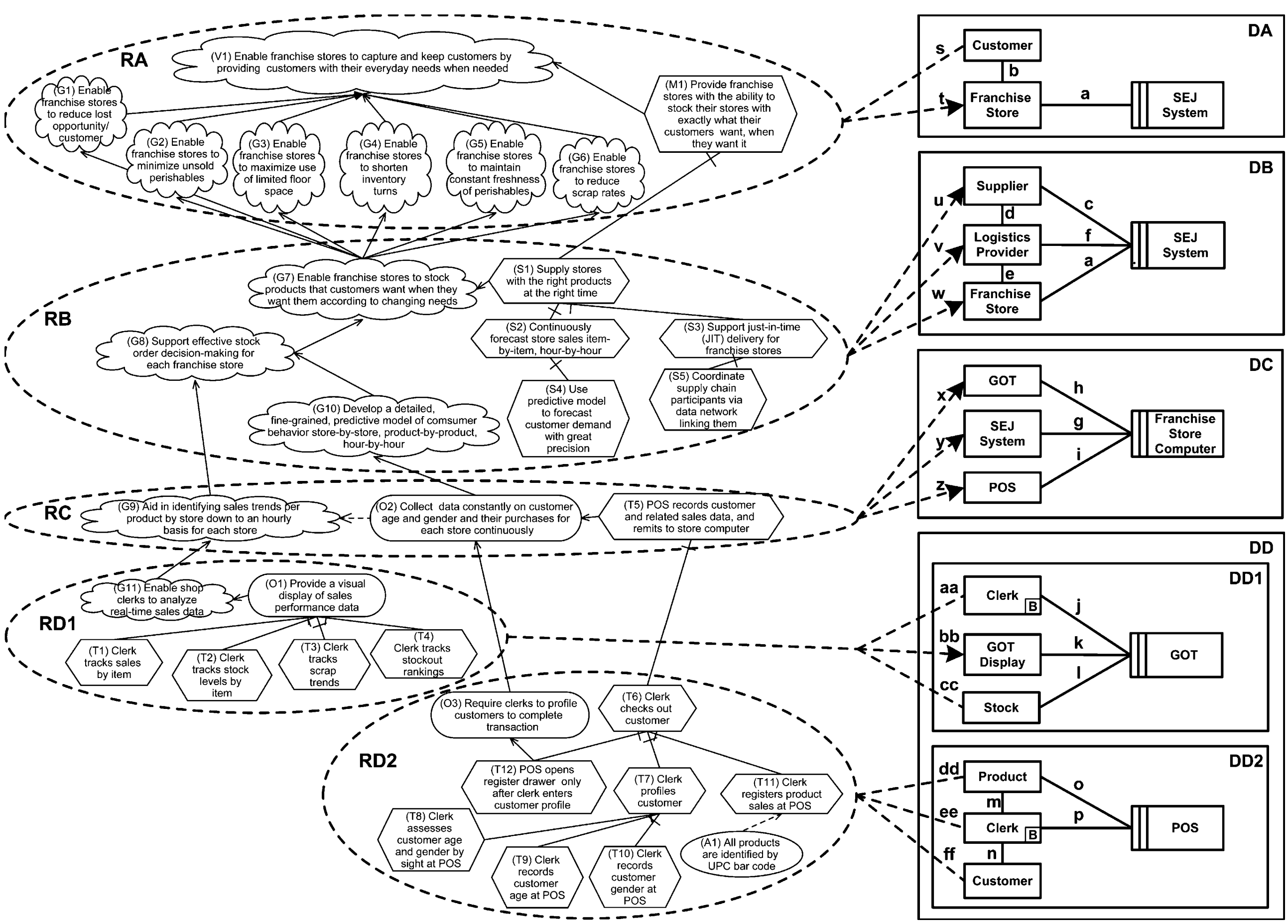

Fig. 7. SEJ integrated goal model and context diagrams in progression of problems.

Table 5
Phenomena of SEJ problem description

Indicative			Optative		
Interfaces			Requirements		
Domain context	Responsible Domain entity	Shared Phenomena	Req't set	Responsible domain entity	Requirements
DA	a: SEJ System!	{Stock ordering advice, supplier and logistics management}	RA	s: SEJ System!	VI
	b: Franchise Store!	{Retail of everyday consumer products}		t: SEJ System!	VI, M1, G1–6
DB	a: SEJ System!	{Stock ordering advice, supplier and logistics management}	RB	u: Supplier!	S1, S3, S5
	c: SEJ System!	{Stock Order Placement}		v: Logistics Provider!	S1, S3, 55
	d: Supplier!	{Ex-factory delivery}		w: Franchise Store!	G7,8,10, S2, 54
	e: Logistics Provider!	{Delivery to Franchise Store}			
	f: SEJ System!	{Logistics services coordination}			
DC	g: Franchise Store	{Transmission of Computer! purchase pattern data}	RC	x: GOT!	G9
	h: Franchise Store	{Display of graphical Computer! reports of sales performance data}		y: SEJ Computer!	O2
	l: POS!	{Transmission of customer profile and purchase data}		z: POS!	T5
DD			RD		
DD1	j: Clerk!	{Report options}	RD1	aa: Clerk!	G11, T1–4
	k: GOT!	{Reports display}		bb: GOT Display!	O1, T1–4
	l: GOT!	{Stock movement information}		cc: GOT!	O1.T1–4
DD2	m: Clerk!	{Product handling}	RD2	dd: Product!	A1
	n: Clerk!	{Customer contact}		ee: Clerk!	T6–11
	o: POS!	{Barcode scanning}		POS!	O3, T12
	Product!	{Barcode information}		ff: Clerk!	T8
	p: Clerk!	{Scanning, data entry}			
	POS!	{Opening register}			

and cannot be constrained. The *Customer* domain of interest is only *referenced* by requirement V1, indicated by a dashed line without an arrowhead, reference *s*, as V1 references customers' everyday needs, vital to the success of both SEJ's IT and its business. Note that despite having no direct interaction with any machine device in the system, understanding the *Customer* domain is absolutely critical to getting SEJ's IT requirements right.

4.3.2. Requirements set RB and domain DB

Context diagram DB shows four domains in Fig. 7, the *SEJ System,* again treated as the machine domain, the *Franchise Store*, the *Supplier*, and the *Logistics Provider*. At interface a, the *SEJ System* is responsible for "stock ordering advice" and "supplier and logistics management" phenomena, shared with the *Franchise Store*, as previously noted. At interface c, the *SEJ System* is responsible for a "stock order placement" phenomenon, shared with the *Supplier*. At interface d, the *Supplier* is responsible for an "ex-factory delivery" phenomenon, shared with the *Logistics Provider*. At interface e, the *Logistics Provider* is responsible for a "delivery" phenomenon, shared with the *Franchise Store*. At interface f, the *SEJ System* is responsible for a "logistics services coordination" phenomenon, shared with the *Logistics Provider*.

RB describes a number of SEJ's goals and strategies. Strategy (S1) *Supply stores with the right product at the right time*, supports M1 in RA. S1 helps achieve goal (G7) *Enable franchise stores to stock products that customers want when they want them according to changing needs*, which contributes to G1–6 in RA. S1 is further refined into strategies (S2) *Continuously forecast store sales item-by-item, hour-by-hour*, and (S3) *Support just-in-time delivery for franchise stores*. S2 is further supported by (S4) *Use predictive model to forecast customer demand with great precision*. Strategy (S5) *Coordinate supply chain participants via data network linking them* supports S3. Goal (G8) *Support effective stock order decision-making for each franchise store* contributes to G7, and is supported by (G10) *Develop a detailed, fine-grained, predictive model of consumer behavior store-by-store, product-by-product, hour-by-hour.*

The requirements in RB constrain each of the *Supplier*, *Logistics Provider*, and *Franchise Store* domains of interest in DB: *u* constrains the *Supplier* with requirements S1, S3, and S5, for which the *Supplier* is responsible; *v* constrains the *Logistics Provider* with requirement

S1, S3, and S5, for which the *Logistics Provider* is responsible; and *w* constrains the *Franchise Store*, with requirements G7, G8, G10, S2, and S4, for which the *Franchise Store* is responsible.

4.3.3. Requirements set RC and domain DC

DC in Fig. 7 shows four domains of interest: the *Franchise Store Computer*, which is the *machine* domain, the *SEJ System*, and two devices used inside the *Franchise Store*, the *Graphic-Order-Terminal* (GOT) and the *Point-of-Sales Register* (POS). The GOT is a device used to produce visual reports of sales performance data. The POS is the checkout register that the clerk not only uses to ring up sales but also to enter data on customer profiles. At interface g, the *Franchise Store Computer* is responsible for a "transmission of purchase pattern data" phenomenon, shared with the *SEJ System*. At interface h, the *Franchise Store Computer* is responsible for a "display of graphical information" phenomenon, shared with the GOT. At interface i, the POS for is responsible for a "transmission of customer profile and purchase data" phenomenon, shared with the *Franchise Store Computer*.

In RC Fig. 7, goal (G9) *Aid in identifying sales trends per product by store down to an hourly basis for each store* supports G8 in RB. Objective (O2) *Collect data constantly on customer age and gender and their associated purchases for each store continuously* supports G10 in RB. Note that O2 also supports G9 via a *correlation relationship* indicated in Table 4, and by a dashed line in Fig. 7. A *correlation* refers to a contribution that is not expressly intended (Yu, 1993). Tactic (T5) *POS records customer and related sales data, and remits to store computer* is formulated to achieve O2.

The *GOT*, *SEJ System*, and *POS* in DC are each constrained by the requirements in RC: G9 constrains the GOT, constraint *x*; O2 constrains the *SEJ System*, constraint *y*; and T5 constrains the POS, constraint *z*.

4.3.4. Requirements set RD and domain DD

We have broken Domain DD into two sub-projections, DD1 and DD2, as Domain DD describes the context of two separate devices in an SEJ franchise store, the *GOT* and the *POS*. Due to space limitations we only present RD2 and DD2 here.

Domain DD2 contains four domains of interest: the *POS,* treated as the *machine* here, the *Customer*, the *Product* purchased by the customer, and the *Clerk*. At interface m, the *Clerk* is responsible for a "product handling" phenomenon, shared with the *Product*. At interface n, the *Clerk* is responsible for a "contact" phenomenon, shared with the *Customer*. At interface o, the *POS* and the *Product* share both "barcode scanning" and "barcode information" phenomena, for which the *POS* and the *Product* are respectively responsible. At interface p, the *Clerk* and the *POS* share both "scanning and data entry" and "opening register" phenomena, for which the *Clerk* and the *POS* are respectively responsible.

RD2 describes a number of tactics, objectives, and one assumption. Tactic (T6) *Clerk checks out customer* supports T5 in RC. Tactics (T7) *Clerk profiles customer* and (T11) *Clerk registers product sales at POS* are each formulated to achieve tactic T6. For the tactic (T7), *Clerk profiles customer* the clerk is expected to look at the customer and make an assessment whether the customer is male or female, and determine a rough approximation of age. T7 is refined into three sub-tactics, T8–10: (T8) *Clerk assesses customer age and gender by sight at POS*, (T9) *Clerk records customer age at POS*, and (T10) *Clerk records customer gender at POS.* For T9 and T10, the POS prompts the *Clerk* to select the appropriate range for the *Customer's* age, followed by a gender selection, prior to concluding the transaction. SEJ attempts to enforce that the clerk enter the customer data via tactic (T12) *POS opens register drawer only after clerk enters customer profile*, which is formulated to achieve objective (O3) *Require clerks to profile customers to complete transaction*. After entering the customer profile into the POS, (T11) [the] *Clerk registers product sales at POS*. Note that assumption (A1) *All products must be identified by UPC* refers to T11. It is assumed that clerks scan product UPC barcodes at checkout.

The requirements in RD2 all reference domains of interest in DD2. At dd, the *Product* domain is referenced by A1 in order to retrieve product information. At ff, T8 refers to the *Customer*, as the clerk must look at the customer to assess age and gender. At ee, tactics T6–12 and O3 all refer to the *Clerk*. T6–11 are all about the checkout process, for which the clerk responsible, whereas O3 and T12 concern requiring the clerk to enter customer profile data, for which the POS is responsible. Note that the *Clerk* domain of interest has a letter "B" in the lower-right corner. The "B" indicates that the *Clerk* domain is "biddable" (Jackson, 2001), meaning that we can only *bid* the clerk to behave according to the requirements, but not necessarily force him, or *constrain* him, to do so. Note that T6–12 and O3 do not constrain the *Clerk*. Even O3 and T12, which concern requiring the clerk to profile the customer and enter the data, cannot *constrain* the *Clerk.* The software cannot force the clerk to comply with the requirements of his job. Software can only ask the clerk to enter the data, and one can only hope that he does. Yet even if the clerk does enter the data, the clerk may still get lazy or sloppy and enter bogus age and/or gender data either intentionally or inadvertently. The software can do nothing to prevent this.

4.4. Validating strategic alignment of the SEJ system

In Section 4.3, we have refined requirements down to a relatively low level of detail, equivalent to the starting point of many requirements engineering problem examples appearing in (Jackson, 2001). We do not continue with further refinement, because to do so would simply be to describe a standard software requirements specification exercise. Our aim is to illustrate an explicit link between system requirements and the objectives of business strategy. In this section, we demonstrate how it is possible to validate strategic alignment of low-level systems requirements against business strategy via the traceable links in Fig. 7. We then explain in the context of the SEJ example how validation of strategic alignment of requirements can be critical to the success of the business.

In the case of the POS register, we understand the requirement (T7) *Clerk profiles customer* in RD2 not only in terms of the functionality of the POS described by requirements T8–10 within the context of DD2. By tracing the contribution relationships up through RC, RB, and RA and examining the domain contexts DC, DB, and DA to which these requirements respectively refer, we also understand these requirements in terms of their importance to the achievement of SEJ's business objectives within their appropriate domain context, culminating with their contribution to SEJ's business strategy. Meeting requirement T7 in RD2, contributes to meeting (O2) *Collect data constantly on customer age and gender and their purchases for each store continuously* in RC, which subsequently contributes to meeting (G10), (G8), and (G7) *Enable franchise stores to stock products that their customers want when they want them according to changing needs* all in RB, ultimately contributing to meeting SEJ's goals and vision described in RA. In this manner, we are able to trace how the lowest-level system requirements align with and provide support for the highest-level business objectives.

Strategic alignment of low-level requirements in some cases can be critical to the success of the business. Assuming a failure to meet T7, we might also find a failure to meet requirements up through RC, RB, and RA. Failing to meet requirements in RA, could spell disaster for SEJ, as this could mean failure to achieve SEJ's core goals in serving its customers, the franchise storeowners, and even SEJ's vision. It is for this reason that understanding how low-level IT systems requirements ultimately support the business strategy is so critical when validating requirements.

5. Discussion and evaluation

The integration of goal modeling with problem diagrams has a number of advantages over using either technique in isolation. Each goal entity refers to specific shared phenomena between domains of interest within the referred domain context. This explicit referencing of *shared phenomena* enables verification of requirements in context within which they occur at an appropriate level of contextual abstraction. The goal model provides a mechanism for verifying alignment as it enables explicit connections to requirements at adjacent levels in terms of super goals and sub-goals. Thus, context diagrams help ensure that requirements are consistent with business and system context, while the goal model helps ensure that systems requirements achieve business objectives. At the same time, integrating goal modeling with problem diagrams helps improve manageability of requirements analysis of complex systems. The progression of problem diagrams from the strategy level toward the system level enables a partitioning of requirements according to level of abstraction with reference to appropriate domain context. Each partition of requirements as part of a larger goal model represents a smaller and more manageable portion of that goal model, situated clearly within its domain context.

In applying our approach to the SEJ case study, we did not find the process of modeling business strategy with goals to be straightforward. It was necessary to repeat the steps in the process several times to refine and enhance our model to a degree where we felt the model convincingly represented SEJ's strategy and system requirements. In addition, we recognize some potential limitations to the analytical approach we describe. First, we treat strategic alignment as a state of being. Requirements are determined to be in or out of alignment according to a snapshot in time of an organization's strategic intent, as does most research in strategic alignment (Avison et al., 2004). We do not address changing requirements according to changing strategy over time. Second, VMOST analysis and the BRG-Model are not necessarily appropriate in all cases. Many organizations learn their strategies as they go, and develop them through experience and trial and error over time (Mintzberg et al., 1998). This implies that an organization may not know what its strategy is, or may not be able to articulate it. In this case, both VMOST analysis and the BRG-Model may not be so useful, and other means for eliciting and analyzing organizational motivation may be required. One possible requirements elicitation approach is scenario authoring (Rolland et al., 1998), a goal-oriented methodology for organizational IT that provides a linguistically based algorithm for developing variations and permutations on questions. Through this technique, it is possible to ultimately map out an organization's IT needs. While not specifically intended for strategy analysis and evaluation, scenario authoring could be an effective tool when strategy is unclear.

5.1. Comparison with other approaches

While we make use of goal modeling, we depart from existing techniques in the separation of requirements from domain context according to the problem diagram framework (Jackson, 2001). This separation of concerns enables us to easily use VMOST analysis and the BRG-Model, which similarly treat an organization's intent and motivation separately from the context in which these occur. For this reason, we use only entities representing goals and tasks in the goal model. In contrast, techniques such as *i** (Yu, 1993), KAOS (Dardenne et al., 1993), and GBRAM (Anton, 1996) incorporate entities of actors, agents, and IT resources directly into a goal model. In our approach, we represent such entities in context diagrams.

Using VMOST analysis and the BRG-Model in conjunction with goal modeling has advantages. VMOST analysis provides a means for deconstructing and analyzing business strategy. The BRG-Model subsequently provides a set of rules that are appropriate for modeling goals within a context of business strategy. In this way, using VMOST analysis and the BRG-Model in a goal modeling process helps reduce analytical complexity and ambiguity for the goal modeler. In contrast, goal modeling alone provides no means for analyzing business strategy, and uses rules based uniquely on context-free reasoning frameworks (Anton, 1996; Chung et al., 1999; Dardenne et al., 1993; Liu and Yu, 2001; Yu, 1993).

One of the reasons that goal modeling techniques, particularly *i**, mix contextual and goal entities is to highlight requirements dependencies between agents (Yu, 1993). In our approach, these dependencies are understood as shared phenomena, possibly making them less apparent in comparison to *i**. At the same time, this can be an advantage when modeling complex systems with multiple dependencies between agents. In our experience using *i**, modeling multiple dependencies of even moderately complex systems tends to hopelessly muddle a goal model (Bleistein et al., 2004d). In this case, separation of concerns and using projection help make the model more comprehensible and easier to use.

We make extensive use of problem diagrams, a relatively new analytical framework compared to structured analysis (DeMarco, 1979; Yourdon, 1989) and UML (Booch et al., 1999). Inadequate requirements are often cited as the commonest cause of software project failure (Jackson, 2001), a view supported by evidence (Verner and Evanco, 2005). One form of requirements inadequacy is "shallowness," or "failure to go deep enough into the problem context" (Jackson, 2001). A dataflow context diagram shows flows between terminals and the system (DeMarco, 1979; Yourdon, 1989). In UML, the initial focus is on use cases (Booch et al., 1999). These approaches start with an attempt at understanding problem context, but fail to go deep enough into problem context. The focus of these approaches is at the interface where the real world and the system meet (Jackson, 2001; Kovitz, 1999). Requirements are not always at this interface, but are often far removed from it. Problem diagrams allow an analyst to go much deeper into problem context, away from the computer system, to explore, examine, and analyze properties, behaviors, and activities of entities and actors that are not present at the interface. These properties, behaviors, and activities can also be highly relevant and important in requirements analysis (Jackson, 2001, 1995; Kovitz, 1999). A requirements specification must focus on external behaviors and contain enough detail to satisfy customers (Davis, 2003). For systems that are intended to support a business strategy, these behaviors include those expected in the business environment. A complete and coherent description of this is simply not possible in either structured analysis or use cases. Jackson's context diagrams provide a more accurate understanding of the problem environment, particularly the business environment, than might be found in traditional systems analysis. At the same time, our approach does not address dataflow diagramming or object modeling which ought to be handled using techniques designed specifically for these. Our approach could be used as a precursor to these.

5.2. Understanding requirements through process

We consider the analysis of organizational motivation, business strategy, and within the context of these, IT systems requirements, to be inherently qualitative and subjective. While we attempt to bolster our modeling techniques with structural supports such as VMOST analysis and the BRG-Model, there is no guarantee that the resulting model is absolute, correct, or that a different, independent analyst would not produce a different yet equally valid model. Some might consider this inherent "softness" to be a problem, but we do not. Thomas and Hunt (2004) write of a "fundamental" fallacy among software developers "...that underlying every project there's some absolute, discoverable set of requirements. If only we could find them, and then build accurately against them, we'd produce a perfect solution..." They lament, "This is a wonderful dream, but it's unlikely to be true..." and go on to state soberly "...that requirements (as some absolute, static thing) just don't exist. The benefit of requirements gathering is not [only] the requirements themselves...Instead, the benefit is the process we go through while gathering them: the relationships we form with our stakeholders and the understanding we start to develop about the domain." Indeed, we believe that much of the strength of our approach is not just in knowing the set of low-level system requirements captured. Rather, it is also the understanding of the organization's real, fundamental, critical business needs, and how the requirements of the intended system must support these, made explicit by the process of analysis and modeling that we propose.

6. Conclusion

Despite the recognized importance of alignment of IT with business strategy, requirements engineering research has not focused on this issue. We have presented a requirements engineering framework that encompasses analysis of business strategy to help enable validation of requirements against that strategy. We illustrate a process using VMOST analysis (Sondhi, 1999) to deconstruct business strategy, and then construct a goal model according to rules described in the Business Rules Group's Standard Model for Business Motivation (BRG-Model) (Kolber et al., 2000). Goal modeling is integrated into a problem diagram framework from Jackson's Problem Frames (Jackson, 2001). We use multiple sources from the literature on Seven–Eleven Japan (SEJ) to construct an example case whose scope encompasses both business strategy and IT needs. SEJ is used as an exemplar to test our approach. We found that it is possible both to refine objectives of business strategy down to system requirements and to validate system requirements against business strategy via explicit and traceable links.

This paper makes the following contributions to requirements engineering research: (1) it presents a goal modeling approach that encompasses explicit analysis of business strategy; (2) it provides an integration and linking of business strategy analysis techniques (VMOST and BRG-Model) to requirements analysis frameworks (problem diagrams and goal-modeling); and (3) demonstrates means of validating system requirements against business strategy via explicit and traceable links.

In the next stage of our research, we intend to apply our approach to requirements analysis in a live, industry project. Our intention is to use the project to further develop and refine our approach based on experience gained.

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