Strategic Models for Business Intelligence

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Abstract. Business Intelligence (BI) promises a range of technologies for using information to ensure compliance to strategic and tactical objectives, as well as government laws and regulations. These technologies can be used in conjunction with conceptual models of business objectives, processes and situations (aka business schemas) to drive strategic decision-making about opportunities and threats etc. This paper focuses on three key concepts for strategic business models -- *situation*, *influence* and *indicator* -- and how they are used for strategic analysis. The semantics of these concepts are defined using a state-of-the-art upper ontology (DOLCE+). We also propose a method for building a business schema, and demonstrate alternative ways of formal analysis of the schema based on existing tools for goal and probabilistic reasoning.

Keywords: Business Intelligence, Situation, SWOT, Key Performance Indicators, Influence Diagram, Goal Model, Goal Reasoning.

1 Introduction

Business Intelligence (BI) promises a range of technologies for using information within organizations to ensure compliance to strategic and tactical objectives, as well as government laws and regulations. As a research field, BI encompasses data and knowledge management, modeling of processes and policies, data quality, data privacy and security, data integration, data exchange, data cleaning, inconsistency management, information retrieval, data mining, analytics, and decision support.

The past decade has seen unprecedented interest in BI technologies and services, and a corresponding growth of the BI market. By now, most competitive organizations have a significant investment in BI, much of it technology-related, based on software tools and artifacts. But business people -- be they executives, consultants, or analysts -- are in general agreement that what helps them the most is not new gadgets producing a dizzying array of statistics. Instead, they are interested in having their business data analyzed in their terms, which are strategic objectives, business models and strategies, business processes, markets, trends and risks. This gap between the worlds of business and data remains today the greatest barrier to the adoption of BI technologies, as well as the greatest cost factor in their application to specific projects.

We propose to bridge this gap by extending the notion of conceptual schema to include concepts beyond entities and relationships. In particular, we are working on the design of a business modeling language (the *Business Intelligence Model*, or just *BIM*) [26] as a business-level counterpart to the Entity-Relationship Model, so that strategic objectives, business processes, risks and trends can all be represented in a business schema, for purposes of analysis and monitoring. Users can query a business schema, much like conventional database schemas, but in terms of business terms. Such queries are to be translated through schema mappings into queries defined over databases and data warehouses, and the answers are to be translated back into business-level concepts [27].

This paper focuses on three key concepts in BIM, those of *situation*, *influence* and *indicator*, and how these are used, in the context of goal modeling, to develop and analyze business schemas of an organization. Keys contributions of the paper include (i) defining the semantics of these terms using a state-of-the-art upper ontology (DOLCE+) [1], (ii) outlining a design process for building a business schema that captures strategic business goals, situations that influence these goals, and indicators that are used to measure their fulfillment, and (iii) demonstrating alternative ways of analyzing a business schema using existing tools based on goal and probabilistic reasoning techniques.

The rest of the paper is organized as follows. Section 2 introduces key BIM concepts and aligns them with the ontological categories in the DOLCE+ ontology. Section 3 offers our view on how business schemas are instantiated. Using a complete example, Sections 4 and 5 discuss how a business schema is constructed in a three-phase process and analyzed using existing tools. We discuss related work in Section 6, and conclude and point out to future work in Section 7.

2 Key Concepts for Strategic Business Models

This section introduces the three key concepts for building business schemas in context of goal modeling. Given its wide popularity, we only give a brief introduction to the notion of goal here, and refer the interested readers to [16-18, 20] for a complete discussion on goal modeling, and to [21] for a formalization of this concept and other related concepts.

A *goal* represents an objective of a business, defined during strategic planning, and pursued during subsequent business operation. The basic characteristics of a goal include: (i) it may be (AND/OR) refined into subgoals so that its satisfaction depends on that of its subgoals; (ii) a goal may be satisfied in more than one way if it or its subgoals are OR-refined, in which case a choice needs to be made among alternatives; and (iii) a goal's satisfaction may be affected by that of goals other than its subgoals. Goal analysis produces a goal model consisting of an AND/OR refinement tree with additional positive/negative contributions. The satisfaction of a goal can be inferred from that of others in the same goal model using a label propagation algorithm [7-8].

In addition to goals, we also model *domain assumptions* that assume properties of the domain in pursuing satisfaction of a goal. For example, the goal "to schedule meeting" may be AND-refined into subgoals "to collect timetables" and "to choose timeslots" assuming "there are meeting rooms available". A domain assumption may, in fact, be false (broken), in which case goal fulfillment is not possible.

For each concept to be introduced in this section, we first present it in an intuitive way with examples; then we formalize it by aligning it to an ontological category in an upper ontology named DOLCE+ [1]. DOLCE (Descriptive Ontology for Linguistic and Cognitive Engineering) is a foundational ontology that contains a specification of domain-independent concepts and relations based on formal principles derived from

Linguistics, Philosophy, and Mathematics. DOLCE+ is an extended version of DOLCE that includes concepts related to descriptions and situations.

2.1 Situation

During strategic planning, SWOT (Strengths (internal, favorable), Weaknesses (internal, unfavorable), Opportunities (external, favorable), and Threats (external, unfavorable)) analysis [2] is often used to identify the internal and external factors that are favorable and unfavorable for fulfilling certain goals. We propose to model these concepts in terms of the notion of situation. Intuitively, a *situation* defines a partial state of the world in terms of things, their properties, and interrelations among them [23]. For example, the partnership between a company and a research network would be an external, unfavorable situation for the company's competitor with respect to maintaining its technological superiority.

In DOLCE+, situation is considered a fundamental ontological category. A DOLCE+ situation is a social object (i.e., a shared concept in a social setting), which is classified under non-physical endurant (i.e., it persists/endures over time). Accordingly, its existence depends on a community of agents (social), and it may have direct temporal qualities, but only indirect spatial qualities that come from the entities associated with it.

Since we are interested in strategic business models, we focus on organizational situations, which are DOLCE+ situations defined relative to an organization. When this is the case, the organization in question is the *viewpoint* of the situation. Note that the same situation may be favorable from one viewpoint, but unfavorable from the other. Aligning a new concept with DOLCE+ allows us to reuse the formalization [13] of the properties (including those described informally in the previous paragraph) of a DOLCE+ situation, so that we can focus on identifying and defining new properties. On top of the axioms in [13], Table 1 shows a few additional axioms for organizational situations. Whenever possible, we reuse some the predicates from DOLCE+; these predicates are prefixed with "*D*". In particular, we say an organizational situation is *internal* to its viewpoint if all its components are related to the viewpoint through parthood relations. Likewise, it is said to be *external* if none of its components are related to the viewpoint through parthood relation. As we will see later, together with the axioms for favorable/unfavorable situations, our formalization handles all four types of situations in the SWOT analysis.

Organizational Situation: "*an organizational situation (OS) is a DOLCE+ situation (D:S) associated with an organization (D:ORG) through the viewpoint relation (VP).*"

$OS(x,y) \rightarrow D{:}S(x) \wedge D{:}ORG(y) \wedge VP(x,y)$

Internal Situation: "*all components (D:C) of an internal situation (IS) are related to the viewpoint of the situation through parthood relation (D:P).*"

$IS(x,y) \rightarrow OS(x,y) \wedge \forall z(D{:}C(z,x) \wedge D{:}P(z,y))$

External Situation: "*no component (D:C) of an external situation (ES) is related to the viewpoint of the situation through parthood relation (D:P).*"

$ES(x,y) \rightarrow OS(x,y) \wedge \neg\exists z(D{:}component(z,x) \wedge D{:}P(z,y))$

Table 1. Axioms for organizational situations.

2.2 Influence

To reason about goal fulfillment under the influence of situations, we extend the contribution relation from goals to situations. Traditionally in goal modeling, one goal is said to contribute to the other if its satisfaction/denial implies (partial) satisfaction/denial of the other. Such relations also hold between situations and goals. We call this type of influence logical influence.

To support probabilistic reasoning, we also support probabilistic influences among situations, goals and domain assumptions. In this case, situations and domain assumptions are represented by random variables whose values are their possible states; each state is assigned a probability of that situation or domain assumption being true. In Section 5.3, we show how this type of influence is used to support decision-theoretic analysis.

Table 2 shows new axioms for influences. More specifically, following [20], a logical influence is characterized along the following dimensions: (i) *direction*: a positive (resp. negative) influence exists from a situation to a goal, if it (when being true) increases (resp. decreases) the chance of the goal being satisfied; and (ii) *degree*: an influence is full, if it is a casual relation (i.e., 100% chance); otherwise, it is partial. We say an organizational situation is *favorable* for an organization for achieving a goal if has a positive logical influence on that goal; It is *unfavorable* if it has a negative one.

Influence: *"there are two types of influence relations (INF): goal- (G-INF) and Bayesian- (B-INF). type" (in order to talk about its properties, we reify the influence relation)"*

$\mathrm{INF}(i,x,y) \rightarrow \mathrm{G\text{-}INF}(i,x,y) \vee \mathrm{B\text{-}INF}(i,x,y)$.

Goal-type Influence: *"Goal-type influence (G-INF) occurs from situations (OS) to goals (G), domain assumptions (DOM), or among goals"*

$\mathrm{G\text{-}INF}(i,x,y) \rightarrow (\mathrm{OS}(x) \wedge \mathrm{G}(y)) \vee (\mathrm{OS}(x) \wedge \mathrm{D}(y)) \vee (\mathrm{G}(x) \wedge \mathrm{G}(y))$

Bayesian-type Influence: *"Bayesian-type influence (B-INF) occurs among situations (OS) and domain assumptions (DOM)"*

$\mathrm{B\text{-}INF}(i,x,y) \rightarrow (\mathrm{OS}(x) \wedge \mathrm{OS}(y)) \vee (\mathrm{OS}(x) \wedge \mathrm{D}(y)) \vee (\mathrm{D}(x) \wedge \mathrm{D}(y))$

Positive Influence: *"a positive influence (P-INF) is a goal-type influence (G-INF), which has great-than-zero strength (ST)."*

$\mathrm{P\text{-}INF}(i,x,y) \rightarrow \mathrm{G\text{-}INF}(i,x,y) \wedge \exists n(\mathrm{ST}(i,n) \wedge n>0)$

Negative Influence: *"a negative influence (N-INF) is a Bayesian-type influence (B-INF), which has less-than-zero strength (ST)."*

$\mathrm{N\text{-}INF}(i,x,y) \rightarrow \mathrm{G\text{-}INF}(i,x,y) \wedge \exists n(\mathrm{ST}(i,n) \wedge n<0)$

Favorable Situation: *"a favorable situation (FS) has a positive influence (P-INF) on a goal (G) or domain assumption (DOM) of its viewpoint."*

$\mathrm{FS}(x,y) \rightarrow \mathrm{OS}(x,y) \wedge \exists iz(\mathrm{P\text{-}INF}(i,x,z) \wedge (\mathrm{G}(z) \vee \mathrm{DOM}(z)) \wedge \mathrm{D{:}P}(z,y))$

Unfavorable Situation: "*a unfavorable situation (US) has a negative influence (N-INF) on a goal (G) or domain assumption (DOM) of its viewpoint*."

$\mathrm{US}(x,y) \rightarrow \mathrm{OS}(x,y) \wedge \exists iz(\mathrm{N\text{-}INF}(i,x,z) \wedge (\mathrm{G}(z) \vee \mathrm{DOM}(z)) \wedge \mathrm{D{:}P}(z,y))$

Table 2. Axioms for Influence.

2.3 Indicator

A successful business depends both on its initial strategic planning and subsequent business operations. Performance measures play an important role in helping businesses align their daily activities with the strategic objectives. Generally speaking, performance measures quantify various aspects of business activities, including their input, execution and output, for monitoring, control and improvement purposes [22]. We model performance measures in terms of indicators.

A natural place for indicators in DOLCE+ is under the quality category. A DOLCE+ quality is a basic entity that can be perceived or measured. An indicator inherits the basic properties of DOLCE+ qualities, including: (i) it always inheres to, and therefore constantly depends on another individual (including another quality), (ii) it takes its value from a quality space (a type of an abstract entity), and (iii) it can inhere directly to an entity, or indirectly through related entities. An example is that “a patient’s hospital stay” (a DOLCE+ entity) has direct temporal qualities (e.g., the length of the stay), but has only indirect spatial quality, inherited through its participants (e.g., the patient).

Performance measures employed in a business environment often form an aggregation hierarchy -- a higher-level measure is defined in terms of lower-level ones. Top level measures (e.g., satisfaction of service, quality of care) usually give a clear picture whether a business is moving towards fulfilling its strategic objectives, while leaf level measures (e.g., patient length of stay, emergency room wait time) are usually tied to specific actions and responsibilities. However, no parthood relation is defined for qualities in the DOLCE+. To represent non-leaf measures, we have introduced additional axioms for indicators, some of which are shown in Table 3.

In particular, we say an indicator is *composite* if it refers to other indicators in its definition; otherwise, it is an *atomic* indicator. An atomic indicator inheres directly to a single individual. For example, “admission wait time” is a temporal indicator inheres to the “admission service” whose participants include a particular person and a hospital. A composite indicator may inhere indirectly to (possibly more than) one individual through its parts. For example, “wait time” is a composite indicator that are defined in terms of “admission wait time”, “test wait time”, “procedure wait time”, etc., which inhere to different hospital services. Currently, we are working on processes, algorithms, and tools support for defining composite indicators. Part of the result is presented in a companion paper [24], which focuses on the concept of composite indicator, i.e., indicators defined by aggregating other indicators, and how to reason with them both in quantitative and qualitative terms.

Indicator: *“an indicator (I) can be either an atomic indicator (AI) or composite indicator (CI)”*
$I(x) \equiv AI(x) \vee CI(x)$
Atomic Indicator: *“An atomic indicator (AI) cannot have parts (D:P)”*
$AI(x) \rightarrow \neg\exists y(I(y) \wedge D{:}P(y,x))$
Atomic Indicator: *“An atomic indicator (AI) inheres directly to (D:DQT) a single particular (endurant (D:ED), perdurant (D:PD), abstract (D:AB), or quality (D:Q))”*
$AI(x) \rightarrow \exists y(D{:}DQT(x,y) \wedge (D{:}ED(y) \vee D{:}PD(y) \vee D{:}AB(y) \vee D{:}Q(y)))$.
Composite Indictor: *“A composite indicator (CI) has other indicators (I) as parts (D:P)”*
$CI(x) \rightarrow \exists y(I(y) \wedge D{:}P(y,x))$
Composite Indictor: *“A composite indicator (CI) inheres indirectly to (D:DQT, D:DT) a particular (endurant (D:ED), perdurant (D:PD), abstract (D:AB), or quality (D:Q)) through its parts”*
$CI(x) \wedge I(y) \wedge D{:}P(y,x) \rightarrow \forall z(\, (D{:}ED(z) \vee D{:}PD(z) \vee D{:}AB(z) \vee D{:}Q(z))$
$\wedge\, D{:}DQT(y,z) \rightarrow D{:}DT(x,z)\,)$.

Table 3. Axioms on Indicators.

3 Instantiation of Business Schemas

As with any other modeling framework, it is necessary to distinguish between an instance of a concept (goal, situation, etc.) in the application domain and the class of such individuals denoted by that concept. For example, “to reduce wait time” is a goal class which describes a set of goal instances to reduce wait time that pursued by specific hospitals at specific times in the application domain. We create models in which elements present concept classes. We call such models *Business Schemas*. A long term goal of our work is to connect a business schema to the databases that store (partial) information about its instances, and use it as an interface to query the underlying data. In this paper, we show the first step towards realizing this goal: how to build (Section 4) and reason with (Section 5) business schemas.

Before we discuss the development of a business schema, it is necessary to outline our view on how such a schema, once constructed, will be instantiated. A business schema is instantiated when the instances of its elements are created. A goal instance is created whenever an organization decides to pursue it (i.e., to make it at least partially satisfied). An organization may pursue a goal many times (e.g., to sell a type of a product). A goal instance is *unsatisfied* upon creation, and maybe *active* or *inactive* (*suspended*) depending whether it is being pursued, and finally be *satisfied* or *abandoned*. For example (

Figure **1**), an instance of the goal “to open a sales channel” is created whenever a company plans to sell its product through a new retailer. Graphically, we denote a goal using an oval, and use a darker fill for instances.

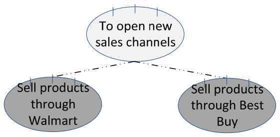

Figure 1. Goal.

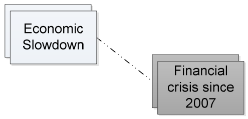

Figure 2. Situation.

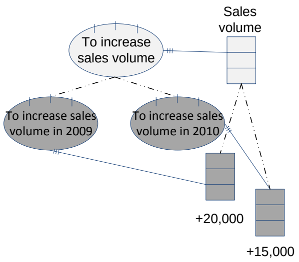

Figure 3. Indicator.

A situation instance is created whenever it has the potential to become true as perceived by an organization. A situation instance upon creation must be connected to a goal, domain assumption, or another situation instance through an influence link. A situation instance may either be *true* or *false*. For example (

Figure 2), the financial crisis originated from the United States in 2007 is an instantiation of the situation “economic slowdown”.

Finally, an indicator instance is created whenever a value is obtained (measured / calculated) for that indicator at a particular time point. In other words, indicator instances represent concrete measurements. An indicator instance has a single state *obtained*. Notice that by definition, an indicator instance (being a DOLCE+ quality) must inhere to some other entity (e.g., a goal instance). The inherence link therefore represents a measurement relation. For example (Figure 3), the indicator “sale volume” may be instantiated annually.

4 Developing Business Schema

A business schema can be constructed in three phases. We illustrate this process using a concrete example built from real-world analysis reports, published by DataMonitor[1], a company that specializes in industry analysis for a number of industry sectors. This example is in the Technology sector.

As we have mentioned earlier all modeling concepts introduced in the paper are used in relation to the concept of goal. Therefore, we start the process with a goal modeling phase. We follow the TROPOS methodology [20] to construct the goal model. More specifically, we start with a list of high-level goals, which are then refined (through AND/OR-decomposition links) and interrelated (through influence links) to produce a goal model. In a business schema, a goal may also be decomposed into domain assumptions, in addition to sub-goals. Leaf goals are operationalized into processes. Thanks to the OR-decomposition and influence links, a goal model usually captures not a single, but several alternative ways to fulfill the root goals. Figure 4 shows part of the resulting goal model. Given the wide popularity of goal modeling and due to the space limit, we omit more detailed explanation of this phase.

In the second phase, we identify the internal and external factors that may influence the fulfillment of goals in the schema constructed in the previous phase. More specifically, we identify situations that may positively or negatively influence (the fulfillment of) the goals and (the truth value of) domain assumptions. We follow the SWOT classification [2] as a guideline to identify different types of situations (i.e., strengths, weaknesses, opportunities and threats). Figure 5 shows part of the resulting business schema.

More specifically, we start with the domain assumptions in the schema, and ask the question: what observable evidences could potentially support or challenge these assumptions. For example, the fact “high R&D expenditure” (strength) positively contributes to the domain assumption “strong R&D capability” being true, while the fact “healthy balance sheet” (strength) means with high degree of certainty there are “sufficient funds” available to make strategic investment. Situations may also influence goals directly. For example, the fact “increased competition” (threat) may hinder the fulfillment of the goal “to open new sales channels”. Influences may also occur among situations. For example, the situation “low cost financing” (opportunity), which is caused by “economic slowdown”, positively contributes to “high R&D expenditure” and “healthy balance sheet”.

Definition and specification of an indicator hierarchy (especially the composite ones in the hierarchy) is a highly domain-specific process, and is dealt with in a separate paper by the same authors [24]. In this example, we assume a set of indicators are already in place (which is true in practice in many organizations), the task of the modeler in this phase is to associate these indicators with the elements in the schema. Figure 6 shows a few indicators associated with the goals under “to increase sales”. Note that these indicators are composite indicators, and may be further decomposed in

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[1] http://www.datamonitor.com/

practice. For example, “sales volume” may be broken by the types of products/services, fiscal periods, or geographical locations. Also notice that although not shown, “total sales” (in dollar amount) can be mathematically determined by “sales volume” and “gross margin”, entailing a hierarchical relation among these indicators.

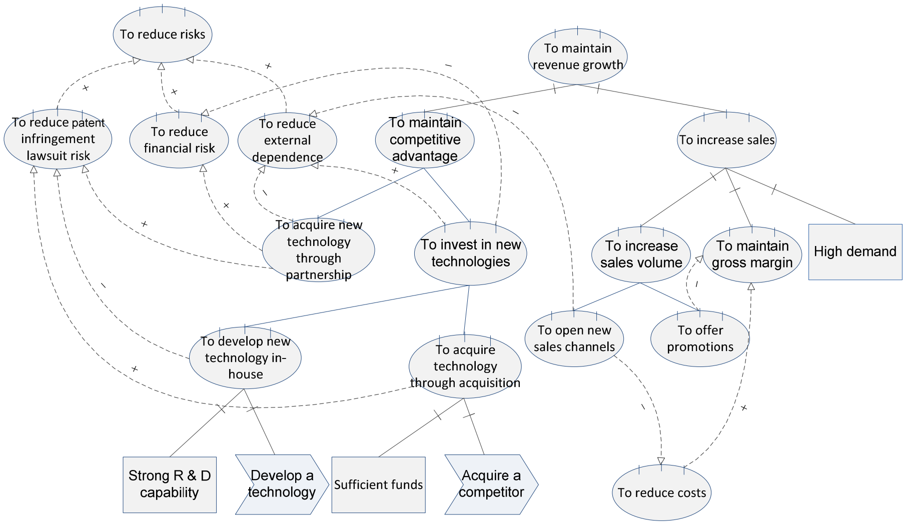

Figure 4. Business Schema Example: Goals.

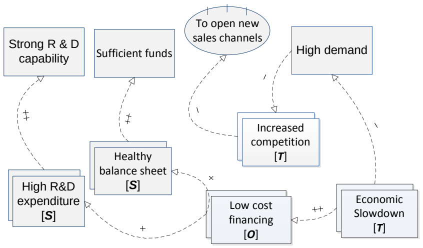

Figure 5. Business Schema Example: Situations.

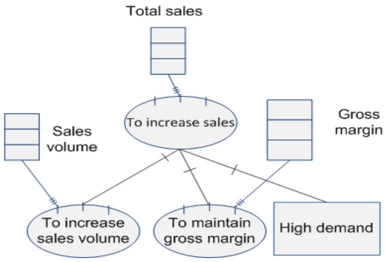

Figure 6. Business Schema Example: Indicators.

5 Reasoning with Business Schemas

A business schema, once constructed, can be analyzed in various ways. Strategic planning [6] usually starts with the definition of an organization's mission, followed by the specification of the goals toward the mission and the strategies to achieve the goals. For a given goal, it is not uncommon that alternative strategies exist. Therefore, analyzing those alternative strategies are important tasks in any strategic planning process. Section 5.1 and 5.2 discuss two types of analyses, namely exploration of possible strategies and evaluating specific strategies, using goal reasoning techniques [5]. In addition, during the strategic planning process, a strategy is normally produced by making decisions at a number of decision points. At each point, one option is chosen from a pool of available options. Section 5.3 discusses how this decision-making process can be supported using the probabilistic decision analysis technique.

In all cases, a pre-process step is carried out to project a business schema into a target model acceptable by the host tool that supports a specific reasoning technique. Such projections are automated using a set of translation rules. Definitions of such translation rules are straightforward in most cases. We omit their details in this paper.

5.1 Exploration of Possible Strategies

Goal-Oriented Requirements Engineering [19] has long studied the problem of systematic exploration of alternative plans for achieving specified goals. Given a goal model and an assignment of desired satisfaction values (either qualitative or quantitative) to its root goals, a *top-down/backward reasoning* algorithm [7] find *all* possible assignments to the leaf nodes in the model that are consistent with the desired assignment to the root goals. An assignment to the leaf nodes is consistent with the desired assignment, if it leads to the desired assignment following a forward propagation algorithm (discussed below).

In our example, two root goals are "*to maintain revenue growth*" and "*to reduce risks*". An exploration of strategies amounts to answer the question: what are the all possible ways to realize these two goals?

To demonstrate the use of a top-down goal reasoning algorithm to explore possible strategies, we use the Goal Reasoning Tool (GR-Tool)[2] from the Tropos project. Let us assume we assign "*total satisfied*" to the first goal and "*partially satisfied*" to the second one. Figure 7 shows a particular assignment produced by the tool. In this strategy, the goal "*to establish strategic partnership*" is preferred to "*to invest in new technologies*", while the goal "*to offer promotion*" is preferred to "*to open new sales channels*". Notice this strategy results in conflicts in fulfilling both root goals (i.e., they both satisfied and denied due to the conflicting contribution links). Although not shown here, one of the conflicts is avoid in another strategy the goal "*to develop new technologies in-house*" is chosen.

5.2 Evaluation of Specific Strategies

Once all alternative strategies are enumerated, a mechanism is needed to evaluate and eventually select a strategy. A bottom-up/forward reasoning algorithm for goal models [8] can be used for this purpose. A *bottom-up/forward reasoning* algorithm starts with an assignment of satisfaction values to the leaf nodes. Such an assignment corresponds to a particular strategy to fulfill the root goals under evaluation. It then forward propagates these input values to the root goals, according to a set of pre-defined propagation rules. This analysis amounts to check if the input assignment to the leaf nodes causes all root goals to be satisfied (at the desired levels).

An evaluation of a specific strategy amounts to answer the question: if we pursue this strategy, will two root goals "*to maintain revenue growth*" and "*to reduce risks*"

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[2] http://www.troposproject.org/tools/grtool/

be satisfied at our desire levels. These apply to the strategies produced by a top-down algorithm, and as well as those that could be produced by modifying the satisfaction values of some leaf nodes.

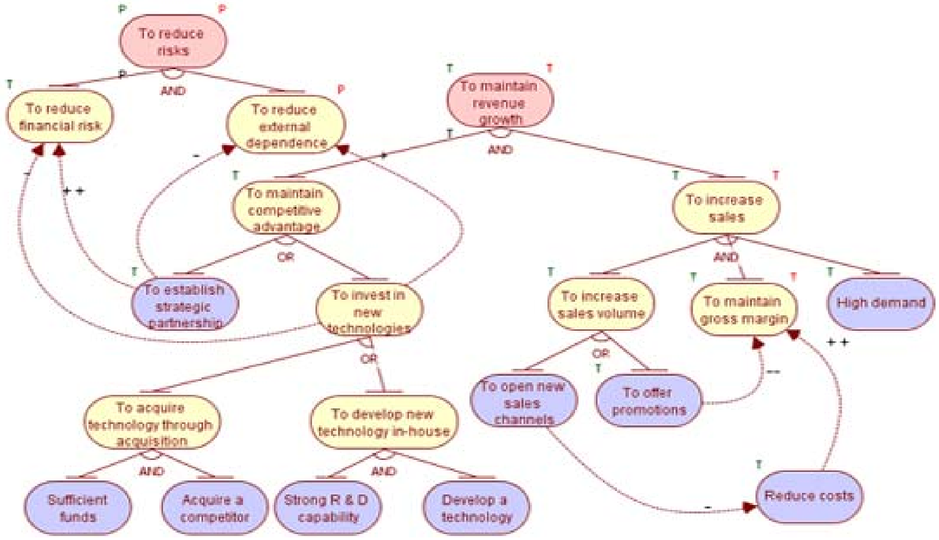

Figure 7: Top-down reasoning using GR Tool.

To demonstrate the use of a bottom-up goal reasoning algorithm to evaluate individual strategies, we use the jUCMNav tool[3], an Eclipse plug-in that supports bottom-up reasoning on goal models. In this example, we choose to achieve competitive advantage by fulfilling the goal the goal "*to acquire new technology through acquisition*". The bottom-up reasoning algorithm tells us, this choice leads to one root goal "*to maintain revenue growth*" being partially satisfied, while the other one "*to reduce risks*" fully satisfied.

Figure 8 presents the evaluation of one of strategy using jUCMNav. Although not shown here, this strategy is obviously preferred to the other one we have evaluated, where one of the root goals is fully denied.

5.3 Evaluation of Specific Strategies

A strategy is produced by making decisions at a number of decision points. At each point, one choice is selected from a pool of available ones. Decision analysis techniques support this finer-grained decision-making task; they rest on an empirically verified assumption that humans are reasonably capable of framing a decision problem, listing possible decision options, and quantifying uncertainty, but are rather weak in combining information into a rational decision.

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[3] http://jucmnav.softwareengineering.ca/jucmnav/

An influence diagram [4] is decision model that include: decision nodes for specifying decision options, chance nodes for quantifying uncertainty, and value nodes for quantifying user preferences using utility functions. An influence diagram supports a decision by computing the expected utility value of each decision option. The option with the highest value is optimal and should be chosen by the decision maker.

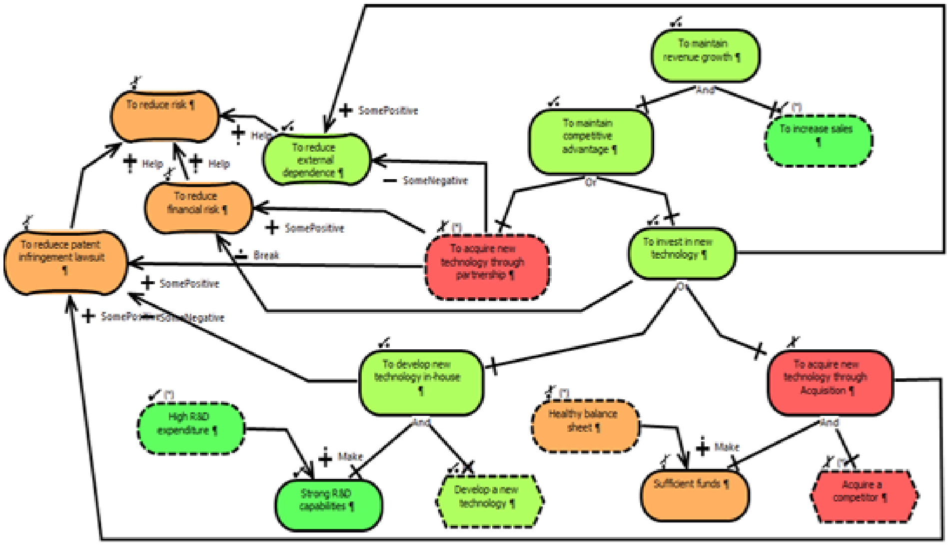

Figure 8: Bottom-up goal reasoning jUCMNav.

In our example, to pursue the goal “*to increase sales volume*”, two decision options are available (according to its OR decomposition): we can increase sales volume either by pursuing the goal “*to open new sales channels*” or “*to offer promotions*”. Notice that the goal “*to maintain gross margin*” is also involved here through influence links. Therefore, decision analysis amounts to answer the question: which of these two sub-goals should we pursue in order to maximize expected gain for the indicators “*sales volume*” and “*gross margin*”.

To demonstrate the use of the decision analysis technique, we use GeNIe[4], a tool for creating and reasoning with decision theoretic models including Influence Diagrams. Figure 9 shows the result of analyzing the decision for the goal “*to increase sales volume*”. In this figure, we also show an example of the conditional probability table (for the change node “*high demand*”), and an example of utility function (for the decision node “*sales volume*”). As we can see, the tool tells us the option “*to open new sales channels*” is preferable over “*to offer promotions*” as far as the utilities “*sales volume*” and “gross margin” are concerned.

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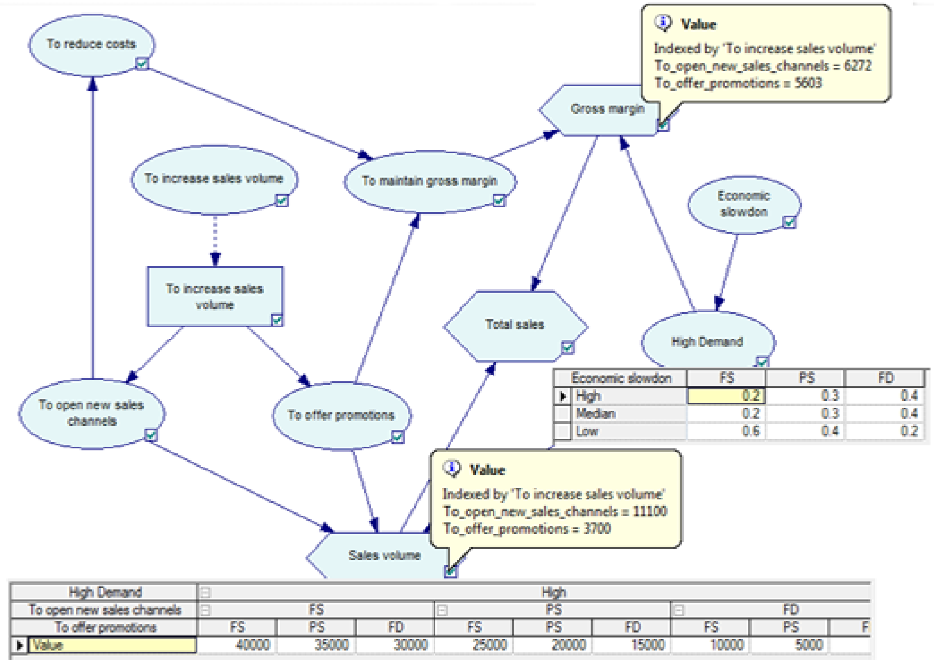
[4] http://genie.sis.pitt.edu/

6 Related Work

The use of business-level concepts, such as business objects, rules and processes, has been researched extensively for more than a decade [9-11]. These efforts have more recently resulted in standards, such as Business Process Modeling Notation (BPMN) [12]. These proposals focus on modeling business objects and processes, with little attention paid to business objectives. One exception is the Business Motivation Model (BMM) [8]. What differentiate our work from BMM is that we give formal semantics to our modeling concepts by aligning them to the upper ontology DOLCE+, while concepts in BMM are only defined informally. For example, BMM includes several intentional concepts, such as vision, goal and objective; it is unclear if these concepts are mutually exclusive or are allowed to overlap.



Value
Indexed by 'To increase sales volume'
To_open_new_sales_channels = 6272
To_offer_promotions = 5603

Economic slowdon	FS	PS	FD
High	0.2	0.3	0.4
Median	0.2	0.3	0.4
Low	0.6	0.4	0.2

Value
Indexed by 'To increase sales volume'
To_open_new_sales_channels = 11100
To_offer_promotions = 3700

High Demand	High								
To open new sales channels	FS			PS			FD		
To offer promotions	FS	PS	FD	FS	PS	FD	FS	PS	F
Value	40000	35000	30000	25000	20000	15000	10000	5000	

Figure 9: Decision analysis using GeNIe.

Modeling of goals has a long tradition within Requirements Engineer community [14, 16-18]. However, these models lack primitive constructs for situation, influence and indicator which are important to Business Intelligence applications. Recent proposals extending URN [18] do include indicators [15], but our concept of indicator is more general than that defined in URN: it covers both atomic and composite indicators, and pays special attention to the definition of composition indicators and the construction of indicator hierarchies.

Modeling of situations, especially unfavorable ones (e.g., weaknesses or threats), has received much attention in the field of security requirements engineering. Within the security community, it is often referred to as "vulnerability". For example, [25] proposed a vulnerability-centric modeling ontology. More specifically, it identified the basic concepts for modeling and analyzing vulnerabilities, and proposed criteria to compare and evaluate security frameworks based on vulnerabilities. Inspired by the widely used SWOT analysis, our proposal supports a more comprehensive classification of situations, covering both favorable and unfavorable situations, which could be either internal or external to an organization.

7 Conclusion

As the first step towards bridging the gap between the worlds of business and data in the adoption of BI technologies, we are working on the design of a business modeling language as a business-level counterpart to the Entity-Relationship Model. In this paper, we have introduced three key concepts for building business schemas, which are intended to capture the internal and external factors that affect the strategic goals of an organization, and as well as the performance measures on their fulfillment. We have presented a formal semantics of these terms using a state-of-the-art upper ontology, and shown how such business schemas could be constructed in systematic way and analyzed using existing algorithms and tools.

As for our future work, on one direction, we are planning to carry out a real-world case study to evaluate the proposed concepts. The plan is to use our concepts during the requirements elicitation and analysis phase in a Business Intelligence project of a local Toronto hospital, in parallel to its actual development effort. The goal is to evaluate our proposal by comparing the requirements models constructed in terms of our modeling concepts with the official models produced by the development team. On the other direction, as we have pointed out in the introduction section, for a business schema to be useful, we also need develop technologies to connect it to underlying databases. Part of this work is being carried out to develop techniques that map business schemas with database schemas, within the context of the strategic network for Business Intelligence[5]. On our side, we are planning to develop a query language for business schemas, which allows end users can construct queries using concepts closer to their own business terms.

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