Enterprise Modeling for Business Intelligence

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Abstract. Business Intelligence (BI) software aims to enable business users to easily access and analyze relevant enterprise information so that they can make timely and fact-based decisions. However, despite user-friendly features such as dashboards and other visualizations, business users still find BI software hard to use and inflexible for their needs. Furthermore, current BI initiatives require significant efforts by IT specialists to understand business operations and requirements, in order to build BI applications and help formulate queries. In this paper, we present a vision for BI that is driven by enterprise modeling. The Business Intelligence Model (BIM) aims to enable business users to conceptualize business operations and strategies and performance indicators in a way that can be connected to enterprise data through highly automated tools. The BIM draws upon well-established business practices such as Balanced Scorecard and Strategy Maps as well as requirements and conceptual modeling techniques such as goal modeling. The connection from BIM to databases is supported by a complementary research effort on conceptual data integration.

Keywords: Business Intelligence, Key Performance Indicators, Strategic Planning, Analytics, Enterprise Modeling, Conceptual Modeling.

1 Introduction

In all kinds of enterprises, from businesses to government to healthcare, data is becoming increasingly abundant. As more and more operations are conducted or supported digitally, massive amounts of data can be collected and analyzed. Organizations are taking advantage of computational capabilities to slice and dice the data, pose ad hoc queries, detect patterns, and to measure performance. The vision of the data-driven enterprise holds promise for greater strategic agility and operational efficiency [1], supported by a range of software tools under the general label of Business Intelligence (BI).

Yet the benefits of BI can be elusive. Despite the availability of voluminous data, meaningful and productive use of that data remains a major hurdle for BI initiatives. Data exists throughout the enterprise to serve numerous different

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purposes, and have diverse semantics and representations. Much of the IT implementations of business operations are not directly suitable or comprehensible for enterprise level decision making. There is a huge conceptual distance between business thinking and decision making on the one hand, and the raw data that is the lifeblood of daily operations on the other. BI initiatives therefore can be very costly, take many months, require serious commitment from business stakeholders and IT personnel, and still produce results that are of uncertain benefits.

We argue that the benefits of BI and the data-driven enterprise can be more easily attained by constructing a smoother path between business thinking and IT implementation. The core of this vision is a conceptual model for representing a business viewpoint of data. Business decision makers do not want to think in terms of tuples in databases, or dimensions in star schemas. They think in terms of customer satisfaction, market share, opportunities and threats, and how to rearrange business processes. These concepts then need to be mapped to IT implementations in a coherent and effective way that minimizes manual effort.

We propose a Business Intelligence Model (BIM) that draws upon well-established concepts and practices in the business community, such as the Balanced Scorecard and Strategy Maps, as well as techniques from conceptual modeling and enterprise modeling, such as metamodeling and goal modeling techniques.

The BIM will be used by business users to build a business schema of their strategies and operations and performance measures. Users can therefore query this business schema using familiar business concepts, to perform analysis on enterprise data, to track decisions and their impacts, or to explore alternate strategies for addressing problems. The business queries are translated through schema mappings into queries defined over databases and data warehouses, and the answers will be translated back into business-level concepts.

The BIM is the foundation for the broader research agenda of the Business Intelligence Network (BIN)[1], which aims to raise the level of abstraction for the next generation of BI tools, so that the benefits of BI will be accessible to all members of the enterprise, with minimal help from specialist intermediaries. The BIN research project is supported by BI industry leaders.

A case study to test the BIM in a real world setting is being conducted at a hospital currently engaged in a BI initiative. In this paper, we outline the key features of the BIM using a hypothetical business setting, loosely based on and extending an example from the BSC Institute[2]. Details of the BIM can be found in [2].

Section 2 of this paper describes the BestTech case study. Section 3 introduces the main features of BIM and its metamodel. Section 4 presents how to use BIM for strategic planning while, in Section 5, its application for operations management. In Section 6, we illustrate analytic queries for the example enterprise setting. Sections 7 and 8 discuss, respectively, related work and conclusions.

[1] http://bin.cs.toronto.edu/home/index.php and http://www.nserc-crsng.gc.ca/Partners-Partenaires/Networks-Reseaux/BIN-RVE_eng.asp

[2] Balanced Scorecard Institute http://www.balancedscorecard.org (2010).

2 An Illustrative Enterprise Setting: BestTech Inc.

BestTech Inc. is a fictitious Canadian specialty retailer and e-tailer of consumer electronics, personal computers and entertainment software and maintains a 24 hour computer support task force. BestTech Inc. offers consumers a unique shopping experience with the latest technology and entertainment products, at the right price, with a no-pressure (non-commissioned) sales environment.

In its *strategic planning process* [3], BestTech identifies as its strategic goals increased *profitability* and *visibility* in the Canadian market expanding also into Europe. To achieve these goals, it intends to improve its brand image investing in marketing campaigns but also improving its distribution infrastructure and the quality of service provided to customers. In particular, BestTech needs to overcome the bad reputation it had developed in the Internet community for damages and delays in the products delivered to customers.

BestTech wants to be aware of threats and opportunities in the market and how such situations can influence its business. Moreover, since BestTech cannot manage and control what it cannot measure, it desires to have a clear representation of its operational layer to monitor the organization's performance with real-time data.

Indeed, the executive board wants to communicate its strategies to middle management and frontline workers, and share and monitor performance indicators at all levels, facilitating greater collaboration and coordination among business units and individual employees.

BestTech seeks advanced methods and tools to help conceptualize its business strategies and operations, and to perform analytics on its enterprise data to detect problems, allocate resources efficiently, and make better decisions.

3 The Business Intelligence Model (BIM)

The Business Intelligence Model allows business users to conceptualize their business operations and strategies using concepts that are familiar to them, including: Actor, Directive, Intention, Event, Situation, Indicator, Influence, Process, Resource, and Domain Assumption. These concepts (and their semantics) are synthesized from business and conceptual modeling sources. For example, strategy concepts draw upon the Balanced Scorecard and Strategy Maps [4,5], combined with intentional and social concepts from goal-oriented requirements engineering, notably [6,7,8]. The notion of influence is adopted from influence diagrams [9], a well-known and accepted decision analysis technique. SWOT analysis concepts [10] (strengths, weaknesses, opportunities, and threats) and others have been adopted from OMG's Business Motivation Model standard [11]. The concepts are formalized through metamodeling in terms of abstract concepts such as Thing, Object, Proposition, Entity, and Relationship, taking inspiration from DOLCE [12]. Abstraction mechanisms, such as generalization, aggregation and classification are also provided. Full details can be found in [2].

While the BIM by itself can facilitate understanding of the enterprise, the more fundamental aim, in the context of BI, is to provide a business-friendly

way to exploit the vast amounts of data collected by the enterprise. The BIM works together with advanced conceptual data integration technology currently under development, jointly within the BIN business intelligence research project.

In particular, indicators in BIM are connected[3] to enterprise databases or data warehouses through the CIM – the Conceptual Integration Model. CIM provides access to multi-dimensional data through a high-level conceptual model. Mappings are defined so that each construct in the conceptual model is associated with a query on the physical model. At design time, a business analyst would specify in the CIM what information is needed and in what form, so that the system could respond to business user queries in terms of BIM concepts at runtime. The CIM is detailed in [13].

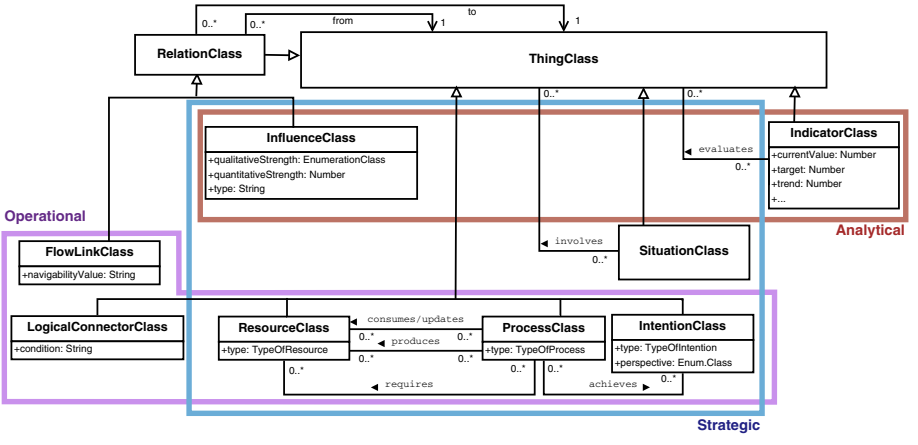

Fig. 1. The BIM fragment which provides Strategic, Operational and Analytic primitives. The "type" attributes are used to represent different business terminology. For example, the type attribute for "ProcessClass" can assume the values: *Initiative, Project, Action, Activity and Task.*

Figure 1 shows the main elements of BIM illustrated in this paper. Three groups of concepts work in concert – strategic, operational, and analytic. Strategic analysis drives analytical BI, while results from analytics direct the focus of operational initiatives, as suggested in [14].

We illustrate how BestTech can use BIM to address strategy, operations, and analytics in the following sections.

4 Modelling and Reasoning about Strategies

To support strategic reasoning, BIM provides constructs for modeling hierarchical goal structures, with alternatives and subgoals and actions for achieving

[3] A semi-automatic approach is under development within BIN to address such an issue.

them. Key performance indicators (KPIs) can be associated with goals at any level. Internal and external environmental factors are modeled as situations, reflecting internal *strengths* and *weaknesses*, and external *threats* and *opportunities*. Resources are allocated to initiatives and processes according to the chosen strategies. We illustrate these aspects using the BestTech example.

4.1 Hierarchy of Goals, Actions and Key Performance Indicators

Figure 2[4] provides a graphical representation of BestTech's strategic plan expressed in BIM. It shows how BestTech translates its vision and strategies into actions, and the one or more KPIs chosen to measure performance towards each of its *strategic goals*[5].

For example, the "Brand image improved" strategic goal is pursued through the "Expand into Europe" initiative, and is monitored by the KPI "Brand awareness score". It has positive influences on the financially-oriented goal of "Revenues increased", and the customer-focused goal of "Market share increased".

Following [4,5], the overall strategic plan is balanced along the four perspectives of *Financial*, *Customer*, *Internal Process* and *Learning & Growth*.

Given this representation of a strategy plan, one is able to perform analysis on possible goals conflicts or to evaluate the satisfaction level of alternative (sub)strategies. BIM provides a mechanism for forward and backward goal reasoning adopted from [15].

4.2 SWOT Situational Analysis

Recognition of strengths, weaknesses, opportunities, and threats is essential to strategic management. Toyota's recall of 9 million vehicles due to sudden unintended acceleration or steering problems was a *weakness* for Toyota that led to its worst ranking in the annual J.D. Power quality survey [16]. This situation led Toyota to adopt a conversion strategy from "Selling more cars" to "Quality of service and customers assistance increased".

BIM models strengths, weaknesses, opportunities, and threats as relations between the primitive constructs *Situation* and *Intention*. Figure 3 shows an example in which a market vacated by a competitor can raise the probability of success for BestTech to increase its market share.

SWOT analysis can help to select among alternative strategies, and to determine their viability. Competitive advantage can be recognized by matching strengths to opportunities. A conversion strategy would convert weaknesses or threats into strengths or opportunities.

[4] The graphical representations provided in this paper are not intended as end-user visualization but for the description and illustration of BIM 's features and functionalities.

[5] The term *Strategic goal* is one of the values which can be assumed by the type attribute for the "IntentionClass" in Figure 1. Depending on the context, such attribute can assume other values such as: *Tactical goal*, *Operational goal*, *Soft goal*, etc. We refer to such terms with the general term Intention.

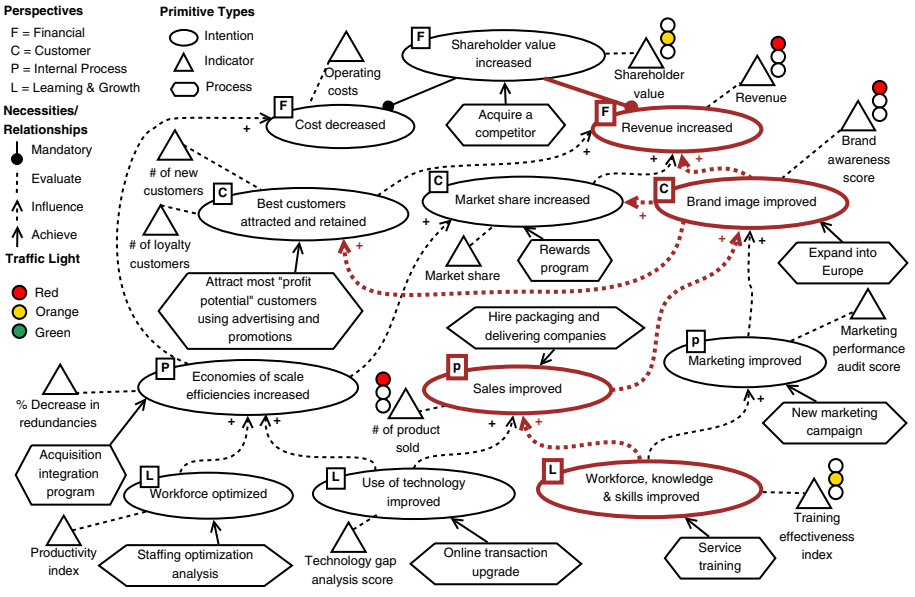

Fig. 2. The BestTech strategy plan, including Financial, Customer, Process, and Learning & Growth perspectives. One of the possible sub-strategies to increase revenue is highlighted in thicker red lines.

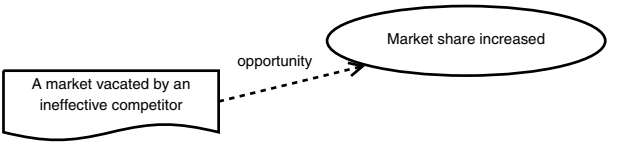

Fig. 3. An opportunity for BestTech to increase its market share

4.3 Allocation and Monitoring of Resources

Resource allocation is a fundamental aspect in a strategic planning process since action plans and initiatives rely on available resources, e.g., *human resources*. Management constantly needs to make decisions about what initiatives to fund or not to fund, and at what levels. Figure 4 shows an example in which a *monetary resource*, namely "Investment on advertising and promotions", is associated with the "Attract high-profit-potential customers with advertising and promotions" initiative.

The "Total investment for advertising" KPI is used to monitor the actual amount of money consumed by the initiative. The KPI target ($6,000) represents the level of funding assigned by the executive board. In this case, BestTech has exceeded the budget already with expenses at $ 7,200, while at the same time, the number of customers attracted (8,000) has surpassed the desired target of 6,000. (Figure 4)

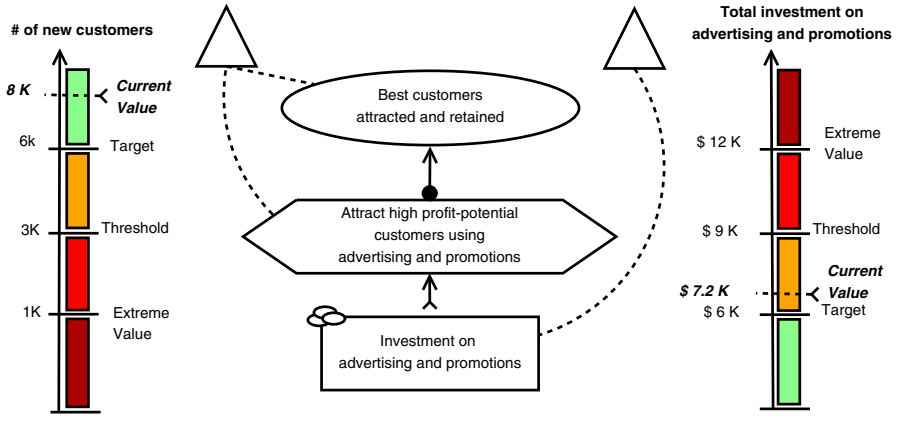

Fig. 4. An example of resource allocation and monitoring

In general, since resources are consumed over time and are (usually) limited, KPIs can be defined on them to monitor their availability and consumption at strategic and operation levels.

4.4 Business Schema

The complete set of goals, objectives, situations, processes, resources, etc., and relationships among them, e.g., strengths, threats, etc., constitutes a *business schema*, which can acquire instance data through the CIM framework introduced in Section 3. An example of such a schema for BestTech is provided in [2].

A business schema is a valuable resource for an organization since, besides providing a big picture of the organization and the business environment in which it operates, allows a number of different kinds of analyses to be performed:

- *forward or backward goal analysis* [15], to reason about conflicts and contributions among goals using the *influence* relationships (positive, negative, qualitative strength, etc.);
- in-depth *situation analysis*, to evaluate those situations which help or hurt the strategies of an organization. In particular, opportunities, threats, weaknesses, strengths are identified to take remedial actions or to set higher target values;
- *consistency check analysis*, to verify that each goal has associated an action (for its achievement) and/or a KPI (for its monitoring);
- *balanced strategy analysis*, to assure whether the overall strategy is well distributed among all the four Balanced Scorecard perspectives or unbalanced toward a specific one;
- *resource analysis*, to evaluate resource consumption and to optimize use of resources, relying on a global overview of their allocation;

These kinds of analyses can be used to support long-term analysis on high-level strategic goals and decisions, as well as shorter term objectives and targets and

day-to-day operations, as presented in the next section. The specific analysis techniques are discussed in more detail and illustrated in [2].

5 Modelling and Reasoning about Operations

Operations management needs to ensure that business operations are *efficient* in resource usage, e.g., cost per unit for delivery, and *effective* in meeting customer requirements, e.g., quality of delivery. As described in Section 2, operational goals need to be related to strategic goals. BestTech desires to increase its profit (G1) by, among others, improving its brand image (G4) in the Internet community (the blue top layer in Figure 5).

To achieve these strategic goals, BestTech intends to adopt two approaches at the operational level (bottom purple layer in Figure 5): i) reduce delays in the delivery[6] of products (G14 but also G16) and ii) decrease the probability of defects or damages in the products delivered (G15 and G17). The latter will also help to reduce the number of products returned (related to G9) by increasing at the same time the effective number of products sold (G5).

Indeed, the satisfaction of operational goals (G12-G17) will be propagated to middle goals (middle layer in dark red, G7-G11), such as "(G8) Online sales process improved" and "(G9) Customer satisfaction maximized" which, in turn, will improve the brand image (G4) by avoiding delays, damages and defects in the products delivered. This view of the BIM shows the alignment of the operational layer towards the achievement of strategic objectives.

To monitor and analyze the efficiency and effectiveness of the *Online sales process*, the BIM allows BestTech to define a global view of its workflow (using concepts[7] from the operational group in Figure 1). Figure 6 shows such a workflow in terms of activities and resources produced or consumed, which can be summarized as follows:

A customer makes an on-line order which is accepted or rejected depending on the availability of the products in the inventory. After the payment is performed (in the figure we skipped this for sake of simplicity) the order is processed by the packaging activity which withdraws from the storage the list of products contained in the order. Finally, the package is delivered to the customer.

To analyze the performance of the described process and its impact on the satisfaction of operational and strategic goals, a set of KPIs are defined on the workflow's activities and resources.

These KPIs and the relationships among them constitute what we call a **Indicators Graph** (IG), which is shown in Figure 7.

[6] In Figure 5, the "Delivery (lead) time" is the time between the creation of the order and the receipt of the order.

[7] BIM provides a "light" modeling for business process which can also be used at strategic level. Moreover, referring to the five perspectives presented in [17], BIM aims to cover the *Business Process Context, Informational, and Organizational Perspectives* while other well-known models, e.g., the Business Process Management Notation [18] focus more on the *Behavioural and Functional perspectives*.

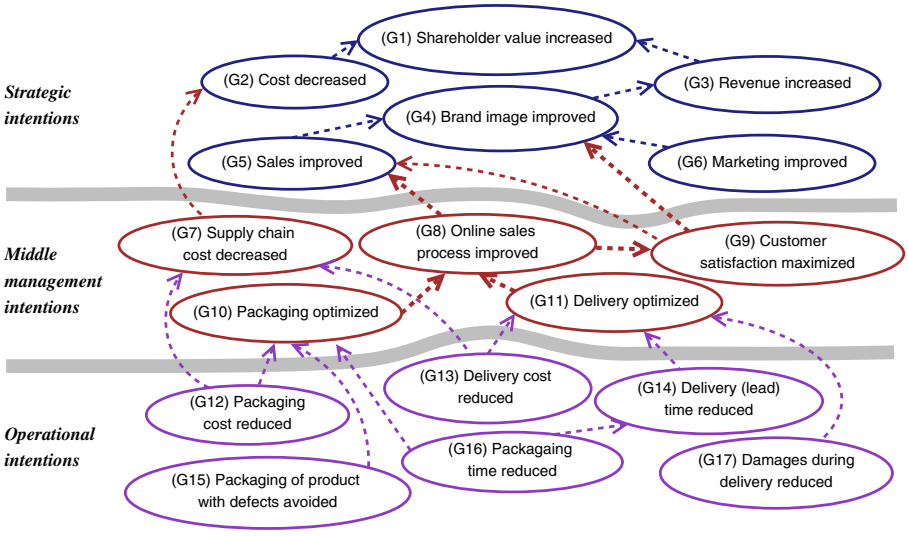

Fig. 5. Strategic, Mid-Level, and Operational intentions leading to increased shareholder value (partial view)

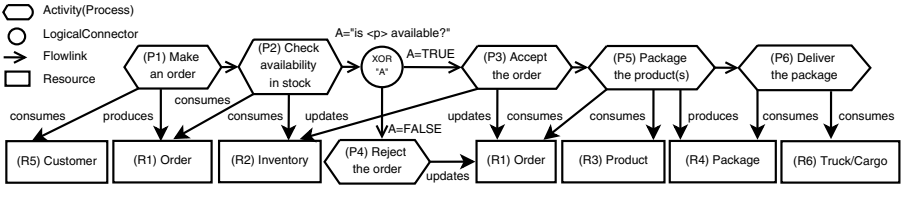

Fig. 6. The Online sales process workflow

In the graph, the cause-effect relationships can have two meanings:

- **deterministic**, the metric used to evaluate the *influencee* is defined as a function of (the metrics of) the *influencers*, e.g., the "Shareholder value" is calculated by the "Revenue" minus the "Operating costs";
- **probabilistic**, the *influencee* depends on the *influencers* through a probabilistic relationship, e.g., "# of stock available at customer first request" is influenced by "Size of safety stock"[8] in a probabilistic manner; which means that, a high value for "Size of safety stock" raises the probability of a high value for "# of stock available at customer first request".

In this paper, we limit the exposition to the **qualitative**[9] representation of such cause-effect relationships (as depicted in Figure 7); however, as described in

[8] Safety stock is a term used to describe a level of stock that is maintained below the cycle stock to buffer against stock-outs.

[9] i.e., the definition of causal dependency arcs among different indicators.

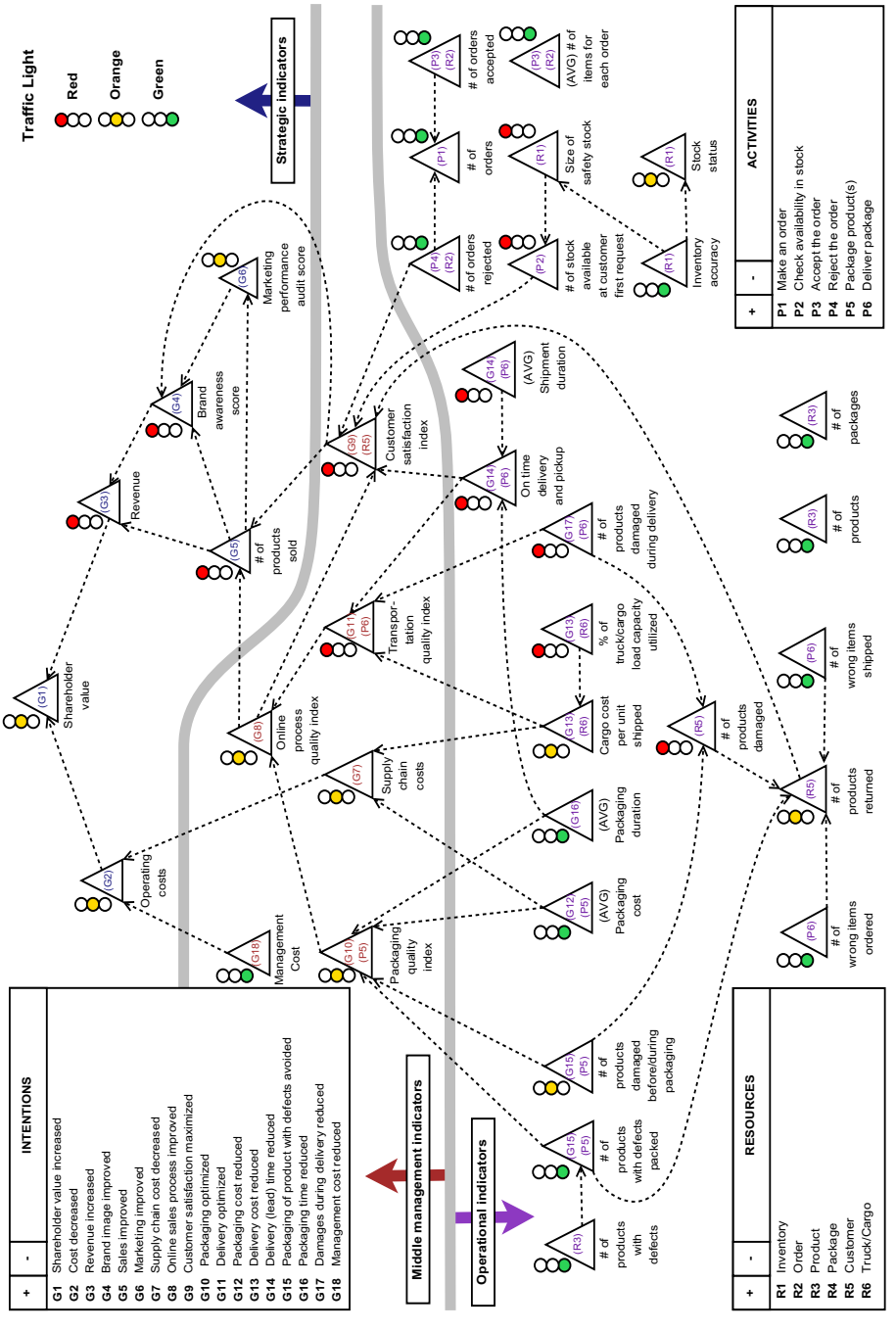

Fig. 7. BestTech's Indicators Graph

Section 8, our final goal is to **quantify**[10] such cause-effect relationships defining also a degree of *soundness* and *completeness* of the Indicators Graph with respect to the specific context.

We recall that, as described in Section 3, we translate the KPIs illustrated in Figure 7 into the CIM 's conceptual model which in turn is mapped to the physical model of enterprise data in data warehouses or databases.

6 Analytics and User Profiles

As described in previous sections, the main goal of strategic planning is to drive the performance of the company as a whole, by enabling senior executives to collaborate on and agree to corporate strategies and by facilitating the sharing of those goals with middle management and frontline workers. This approach sets the foundation for performance management in the form of KPIs which spans the organization from the strategic to the operational.

The Indicators Graph in Figure 7 is an example of such a foundation; it is also a useful input for *Analytic* activities [1] which are used to identify those aspects of the business which need to be further analyzed. Indeed, analytics help to investigate (from many different angles) those factors that have a high impact on business performance by determining the location or cause of major problems.

For example, analytics can help to answer the following questions: *"if profits are declining, is it because of low sales, or increasing expenses? if customer churn rates are on the rise, is it because of poor product quality, or lack of success in customer loyalty initiatives?"*[14].

BIM enables and supports such analytical activities by providing an underlying *performance framework* (see the Analytic box in Figure 1) which is tied to the strategies and operations of the organization. Moreover, since BI is intended to be used by employees at all levels, BIM helps to define ad-hoc *Analytic User Profiles*[11] for different employees.

Examples of profiles and analytics queries for BestTech are the following:

CEO Analytic User Profile:

Q1. *Where are the cost pressures and what the most probable causes?* A CEO can read the "Operating costs" indicator that can be refined into "Management costs" and "Supply chain costs", among others. Figure 7 indicates to the CEO that the latter is the actual problem. At this point the CEO could take a strategic decision adopting cost-cutting measures, but this may exacerbate the already "low" quality of service. Another possibility is to request the manager who is responsible for the "(G7) Supply chain cost decreased" goal to discuss about a possible solution at the operational level (see Q4 below).

[10] A careful reader can observe that there is a main issue in evaluating together deterministic and probabilistic information; this is part of our future research.

[11] A profile is defined by the set of indicators associated with the *Intentions* (e.g., strategic goals, operational goals, etc.) that an actor is responsible for.

Q2. *What is the status of the brand image? Why is it suffering?* The "Brand awareness score" provides such information revealing a difficult situation for BestTech. By refining such information, the CEO discovers that the "Marketing performance audit score" has an orange color, influenced by a red in "# of products sold". Before undertaking any remedial action, the CEO decides to request the middle management to explain why BestTech is not achieving its target in selling products (see Q3 below).

Sales Manager Analytic User Profile:

Q3. *Are we reaching the target in selling products? If not, why not?* The "# of products sold" provides a negative answer. The cause is due to the "Online process quality index" as well as the "Customer satisfaction index". The Sales manager further investigates through the analytic queries Q4 and G5.

Q4. *What are the major issues in the Online sales process?* This question addresses the CEO's investigation for both aspects of efficiency (costs analyzed in Q1) and effectiveness (benefits in Q2 and Q3). In term of effectiveness, Figure 7 shows that "Shipment duration" is too high, causing a red value for "On time delivery and pickup". Moreover, a red value for "# of products damaged during the delivery" represents another issue of effectiveness. In terms of efficiency, a less than optimal "% of truck/cargo load capacity utilized" leads to high costs.

Q5. *Are customers satisfied? if not, why?* Analyzing the "Customer satisfaction index" the manager discovers that different causes exist. First there is delay in the delivery of products (analyzed in Q4); then there is unavailability of stocks at customer's first request (due to a bad organization of the safety stock) and an high "# of products returned" (see Q6).

Q6. *What is the actual number of products returned? What is the most probable cause of it?* The Indicator "# of products returned" is used. Figure 7 shows that the main cause is the "# of products damaged" and, in particular, those products damaged during the delivery (as shown by the "# of products damaged during delivery" indicator). Reducing such issues, will help the manager with the "Sales improved" goal for which he/she is responsible for.

Based on these analytic results, the management team can use the BIM to explore new strategies, and to make trade-offs among competing alternatives. For example, the team may modify the BestTech business schema to include a strategy that outsources delivery to a more reliable delivery company to optimize cargo loads and to reduce damages in shipping. This initiative will reduce the cost of delivery and, at the same time, increase sales and customer satisfaction. According to the business schema this will ultimately improve BestTech's image and profit.

Unlike in current BI practice, these analytics are supported by an explicit enterprise model that supports reasoning about business strategies and operations, with direct connections to actual enterprise data.

7 Discussion and Related Work

Enterprise modeling techniques have been used to help understand business operations and processes, and to lead to the development of IT systems (e.g., [19]).

The Business Intelligence Model aims to extend enterprise modeling to provide business users with more direct access to enterprise data through enterprise models, so that the data can be interpreted and analyzed in terms of familiar business concepts, enabling timely and effective decision making and action.

Modeling techniques in information systems, including most data and process modeling languages as well as UML, focus primarily on static and dynamic ontologies, but not the intentional or social ontologies (with concepts such as actors, goals, or objectives) that are needed for business reasoning [20].

The Zachman framework [21] has long pointed to the need to include motivation ("Column 6") in enterprise modeling, though few modeling techniques have addressed this need specifically. A proposal to include intentional social modeling in enterprise architecture modeling, based on the i* framework, was described in [22].

Most enterprise architecture frameworks today include performance indicators (e.g., the Performance Reference Model in the Federal Enterprise Architecture [23]), and can benefit from more powerful modeling techniques and tools that support business reasoning with connection to enterprise-wide data.

Recent work has incorporated goal modeling in design methodologies for data warehousing [24]. The BIM proposal aims to provide business users query facilities for reasoning about business strategies and operations, with analysis on the data accessible via mappings to databases and data warehouses.

Among recent enterprise modeling approaches, BMM [11] is closest in spirit to BIM. In BIM, concepts adopted from BMM and other sources are placed on an ontological foundation based on DOLCE [12], and integrated with state-of-the-art abstraction mechanisms.

Some BI tools are beginning to include representations of strategies (e.g., [14]), but provide little or no reasoning support.

Other work has also extended i* [7] and related frameworks (e.g., URN [8]) towards enterprise and business modeling, e.g., [25,26]. A recent extension of URN includes indicators [27]. Strategy Maps are modeled in [28] using a modified version of i*.

The BIM aims to unify these various modeling concepts into a coherent framework with reasoning support and connection to enterprise data, built upon a firm conceptual modeling foundation.

8 Conclusions

We have articulated a vision for the next generation of business intelligence in which enterprise modeling provides the foundation for business users to have more direct access and control over enterprise data, their analyses and meaningful interpretation, by using familiar business concepts. The approach aims to address concerns that current BI solutions are costly to develop, requiring

significant IT involvement, and are therefore reaching only a small segment of the potential user population – those who are technology savvy. The proposed approach combines the use of familiar business concepts with well founded modeling technologies, as well as mapping technologies to link to databases. Work is underway to test the BIM with the CIO and executive team at a hospital which is currently undergoing a BI initiative. As another line of future work, we are planning to extend the BIM to incorporate uncertainty in strategic modeling and analysis through the use of Bayesian networks [29] in the Indicators Graph. This will enable BIM to support statistical decision making [30] and will complement the logic-based analysis techniques currently within BIM's scope.

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References

1. Davenport, T.H., Harris, J.G.: Competing on Analytics: The New Science of Winning. Harvard Business School Press, Boston (2007)
2. Barone, D., Mylopoulos, J., Jiang, L., Amyot, D.: Business Intelligence Model, version 1.0. Technical Report CSRG-607, `ftp://ftp.cs.toronto.edu/csri-technical-reports/INDEX.html` University of Toronto (March 2010)
3. Saxena, P.K.: Principles of Management: A Modern Approach. Global India Publications Pvt Ltd (2009)
4. Kaplan, R.S., Norton, D.P.: Balanced Scorecard: Translating Strategy into Action. Harvard Business School Press, Boston (1996)
5. Kaplan, R.S., Norton, D.P.: Strategy maps: Converting intangible assets into tangible outcomes. Harvard Business School Press, Boston (2004)
6. Dardenne, A., van Lamsweerde, A., Fickas, S.: Goal-directed requirements acquisition. Sci. Comput. Program 20(1-2), 3–50 (1993)
7. Yu, E.: Towards modelling and reasoning support for early-phase requirements engineering. In: Proc. 3rd IEEE Int. Symp. on Requirements Engineering, Washington, USA (1997)
8. International Telecommunication Union: Recommendation Z.151 (11/08): User Requirements Notation (URN) – Language definition, `http://www.itu.int/rec/T-REC-Z.151/en`
9. Howard, R., Matheson, J.: Influence diagrams. Readings on the Principles and Applications of Decision Analysis II (1984)
10. Dealtry, T.R.: Dynamic SWOT Analysis. Dynamic SWOT Associates (1994)
11. Business Rules Group: The Business Motivation Model: Business Governance in a Volatile World (2007), `http://www.businessrulesgroup.org/bmm.shtml` Ver. 1.3.
12. Gangemi, A., Guarino, N., Masolo, C., Oltramari, A., Schneider, L.: Sweetening ontologies with DOLCE. In: Gómez-Pérez, A., Benjamins, V.R. (eds.) EKAW 2002. LNCS (LNAI), vol. 2473, pp. 223–233. Springer, Heidelberg (2002)

13. Rizzolo, F., Kiringa, I., Pottinger, R., Wong, K.: The conceptual integration modeling framework: Abstracting from the multidimensional model. Technical report, SITE, University of Ottawa (2010)
14. Quinn, K.: How Business Intelligence should work. Information Builders White Papers (2009)
15. Giorgini, P., Mylopoulos, J., Sebastiani, R.: Goal-oriented requirements analysis and reasoning in the Tropos methodology. Eng. App. Artif. Intel. 18, 159–171 (2005)
16. BusinessWeek: Toyota drops in auto-quality survey; Ford makes top 5 (update1) (June 2010), http://www.businessweek.com/
17. List, B., Korherr, B.: An evaluation of conceptual business process modelling languages. In: Biham, E., Youssef, A.M. (eds.) SAC 2006. LNCS, vol. 4356, pp. 1532–1539. Springer, Heidelberg (2007)
18. Business Process Management Initiative: Business process management notation. Specification Version 2.0 (June 2010), http://www.bpmn.org/
19. Stirna, J., Persson, A.: Ten Years Plus with EKD: Reflections from Using an Enterprise Modeling Method in Practice. In: Proceedings of the Workshop on EMMSAD 2007, held in conjunction with the 19th CAiSE 2007 (2007)
20. Mylopoulos, J.: Information modeling in the time of the revolution. Inf. Syst. 23(3-4), 127–155 (1998)
21. Zachman, J.A.: A framework for information system architecture. IBM Systems Journal 26(3), 277–293 (1987)
22. Yu, E., Strohmaier, M., Deng, X.: Exploring intentional modeling and analysis for enterprise architecture. In: Proceedings of the EDOC Workshop on Trends in Enterprise Architecture Research (October 2006)
23. Office of Management and Budget: FEA Practice Guide. (November 2007), http://www.whitehouse.gov/omb/asset.aspx?AssetId=471
24. Mazón, J.N., Trujillo, J.: A hybrid model driven development framework for the multidimensional modeling of data warehouses. SIGMOD Record 38(2) (2009)
25. Bleistein, S.J., Cox, K., Verner, J.M., Phalp, K.: B-SCP: A requirements analysis framework for validating strategic alignment of organizational IT based on strategy, context, and process. Information & Software Technology 48(9), 846–868 (2006)
26. Andersson, B., Johannesson, P., Zdravkovic, J.: Aligning goals and services through goal and business modelling. Inf. Syst. E-Business Management 7(2) (2009)
27. Pourshahid, A., Amyot, D., Peyton, L., Ghanavati, S., Chen, P., Weiss, M., Forster, A.J.: Business process management with the User Requirements Notation. Electronic Commerce Research 9(4), 269–316 (2009)
28. Babar, A., Zowghi, D., Chew, E.: Using goals to model strategy map for business IT alignment. In: Proceedings of the Workshop on BUSITAL 2010, held in conjunctiun with the 22th CAiSE (2010)
29. Barone, D., Stella, F., Batini, C.: Dependency discovery in data quality. In: Pernici, B. (ed.) Advanced Information Systems Engineering. LNCS, vol. 6051, pp. 53–67. Springer, Heidelberg (2010)
30. Koller, D., Friedman, N.: Probabilistic Graphical Models: Principles and Techniques. MIT Press, Cambridge (2009)