The Business Intelligence Model

Representation, Reasoning, and Application

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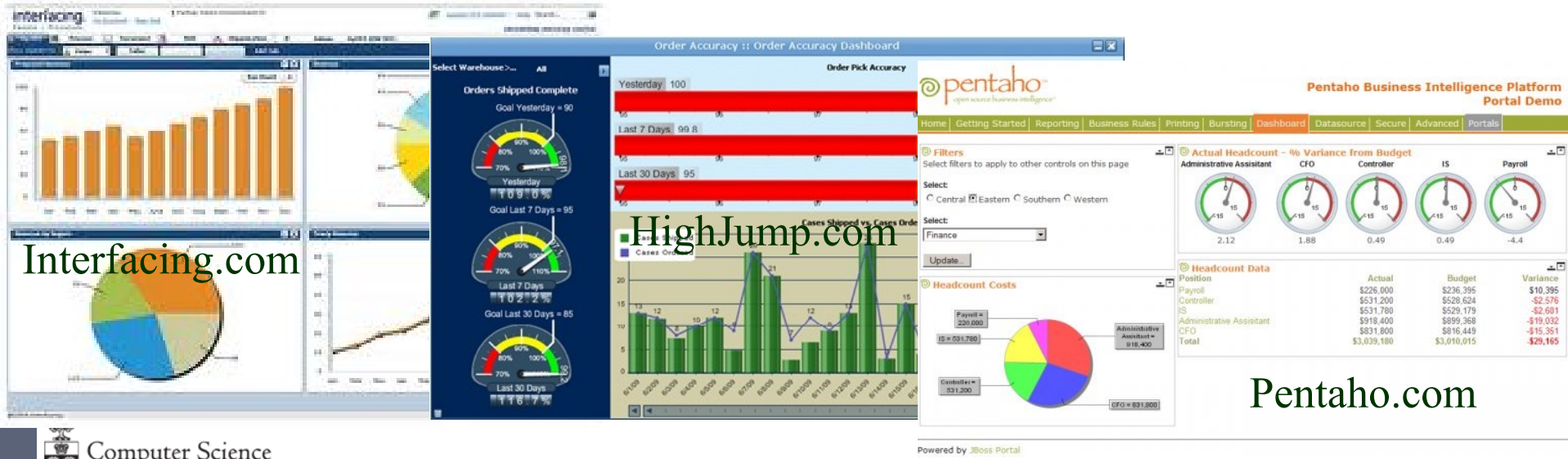
Outline

- Business Intelligence Model Aims
- Previous Work ("Stage 1")
- BIM Concepts and Reasoning Consolidation ("Stage 2")
  - Hybrid Reasoning
- BIM Language Semantics and Reasoning ("Stage 3")
  - Metamodel
  - Definition and metaproperties
  - Additional Reasoning Capabilities
- BIM in Action: A Hospital Case Study
- Conclusions

Business Intelligence

- (from Wikipedia) **Business intelligence** (**BI**) is the ability for an organization to take all its capabilities and convert them into knowledge, ultimately, getting the right information to the right people, at the right time, via the right channel.
- This produces large amounts of information which can lead to the development of new opportunities for the organization.
- When these opportunities have been identified and a strategy has been effectively implemented, they can provide an organization with a competitive advantage in the market, and stability in the long run (within its industry).



Business Intelligence Model Aims

- BI Systems are widely used, but
  - Systems are still very technical and data-oriented
  - Hard to understand what the data means
  - Hard to design queries or make new reports without technical knowledge or a knowledge of the underlying data structure
  - Gap between business and IT-supplied data
- Business people would rather reason using their own terms:
  - Strategic objectives, business models and strategies, business processes, markets, trends and risks
- Raise the level of abstraction of BI systems using a modeling language
  - Uses concepts more familiar to business

Business Intelligence Network

- BIM is part of the Business Intelligence Network*, a Canadian project for the definition of the next generation of Business Intelligence Technologies.
- *http://bin.cs.toronto.edu

Business Intelligence Model (BIM) Development

- May existing languages and techniques for capturing business strategy
  - Strategy Maps and Balanced Scorecards (Kaplan & Norton)
  - Business Motivation Model (OMG)
  - Dynamic SWOT (Strength, Weakness, Opportunity, Threat) Analysis (Dealtry)
  - Goal Models
- These techniques offer many useful concepts, but often not clearly defined
  - visions, objectives, goals, means, strategies, plans, metrics, indicators, measures, strengths, weaknesses, threats, vulnerabilities, opportunities, etc..
- BIM aims to select a consolidated set of core concepts

BIM Development: "Stage 1"

- When I joined the project September 2011
- BIM Tech report, PoEM'10
  - Concepts, background, more detail
- ER'11: Jiang et al.
  - BIM concepts
  - Application of existing analysis procedures (goal modeling, decision analysis) through mapping to BIM
- ER'11, PoEM'11 Barone et al.
  - Composite indicators
  - Reasoning with indicators: unit conversion, normalization, performance levels

Barone et al., "Enterprise Modeling for Business Intelligence," *PoEM'10*
Jiang et al., "Strategic Models for Business Intelligence: Reasoning About Opportunities and Threats," *ER'11*
Barone et al., "Composite Indicators for Business Intelligence," *ER'11*
Barone et al., "Reasoning with Key Performance Indicators," *PoEM'11*

BIM Concepts and Reasoning Consolidation: "Stage 2"

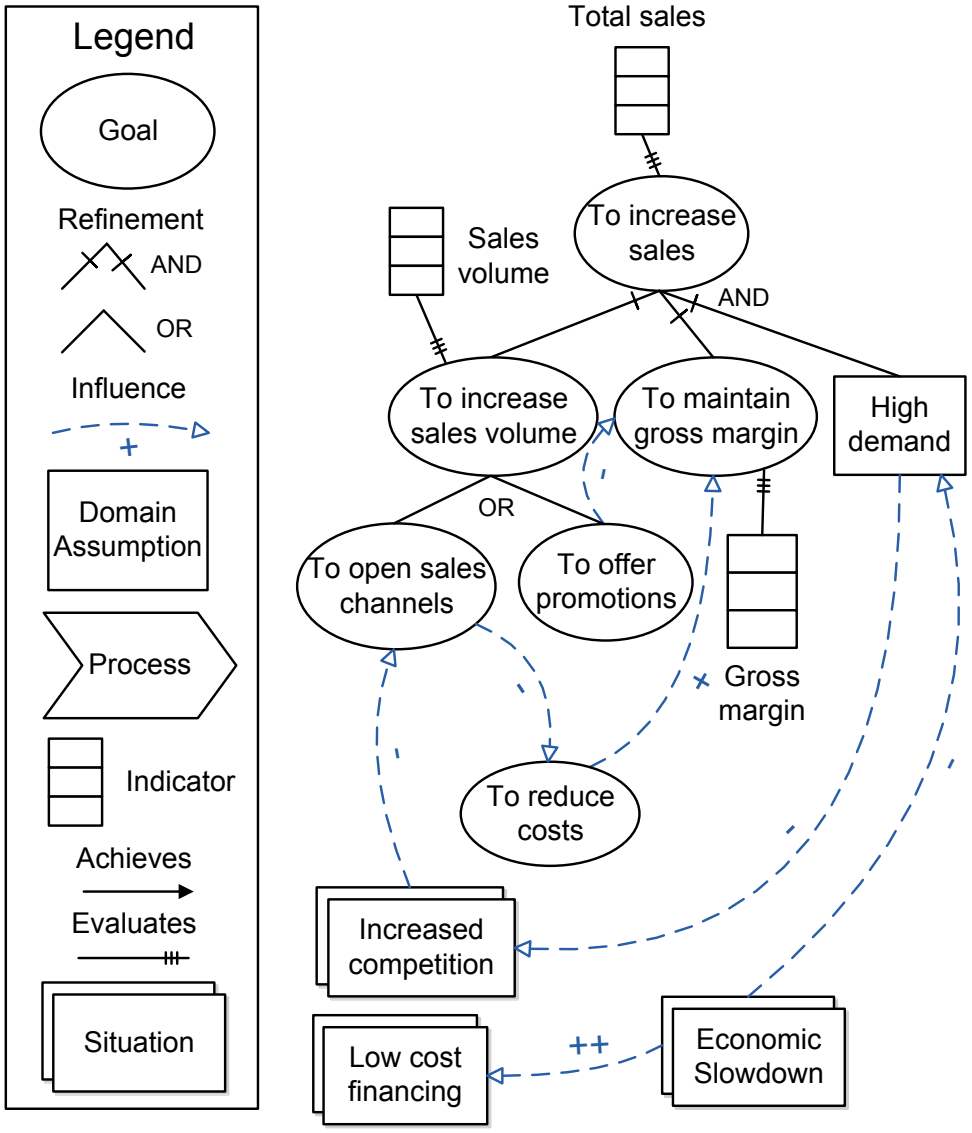
- One consistent description of BIM concepts
  - Merging of concept descriptions from existing papers
- Consistent "picture" or narrative of BIM reasoning
  - Introducing hybrid reasoning

Horkoff et al. "Strategic Business Modeling: Representation and Reasoning", *SoSym* (to appear)

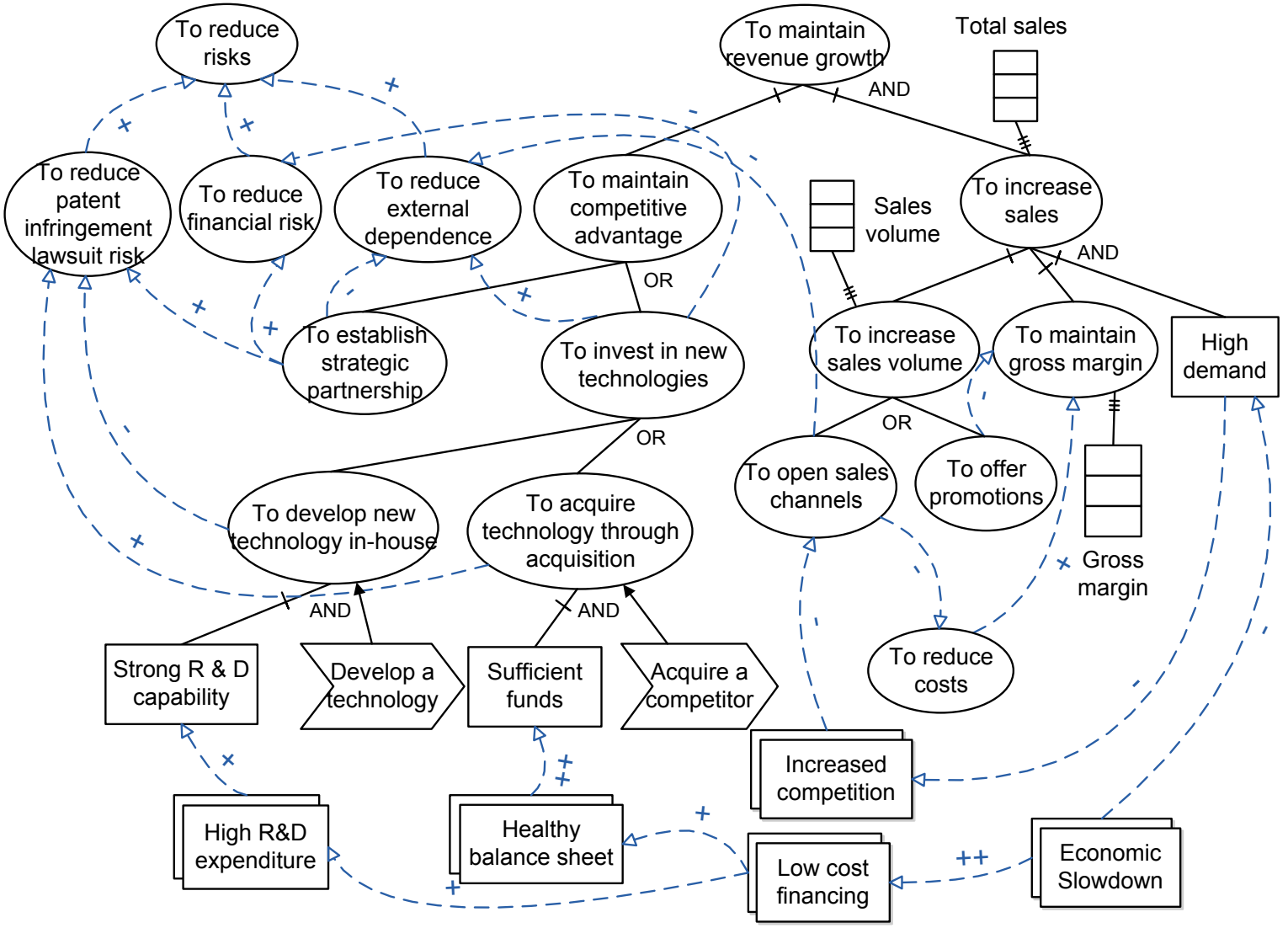
Consolidated BIM Concepts

- Goal: an objective of a business
  - Can be AND/OR refined
- Process: achieves goals
- Domain Assumption: properties required for goal satisfaction
- Situation: internal or external factors influencing fulfillment of goals
  - Could be SWOT for a particular goal
- Influence: situations/goals influence situations/goals
  - Can be logical (implication) or probabilistic (P(A|B))
- Indicator: performance measure, quantifies aspects of strategic activities (KPI)

Simple BIM Example



Less Simple Example

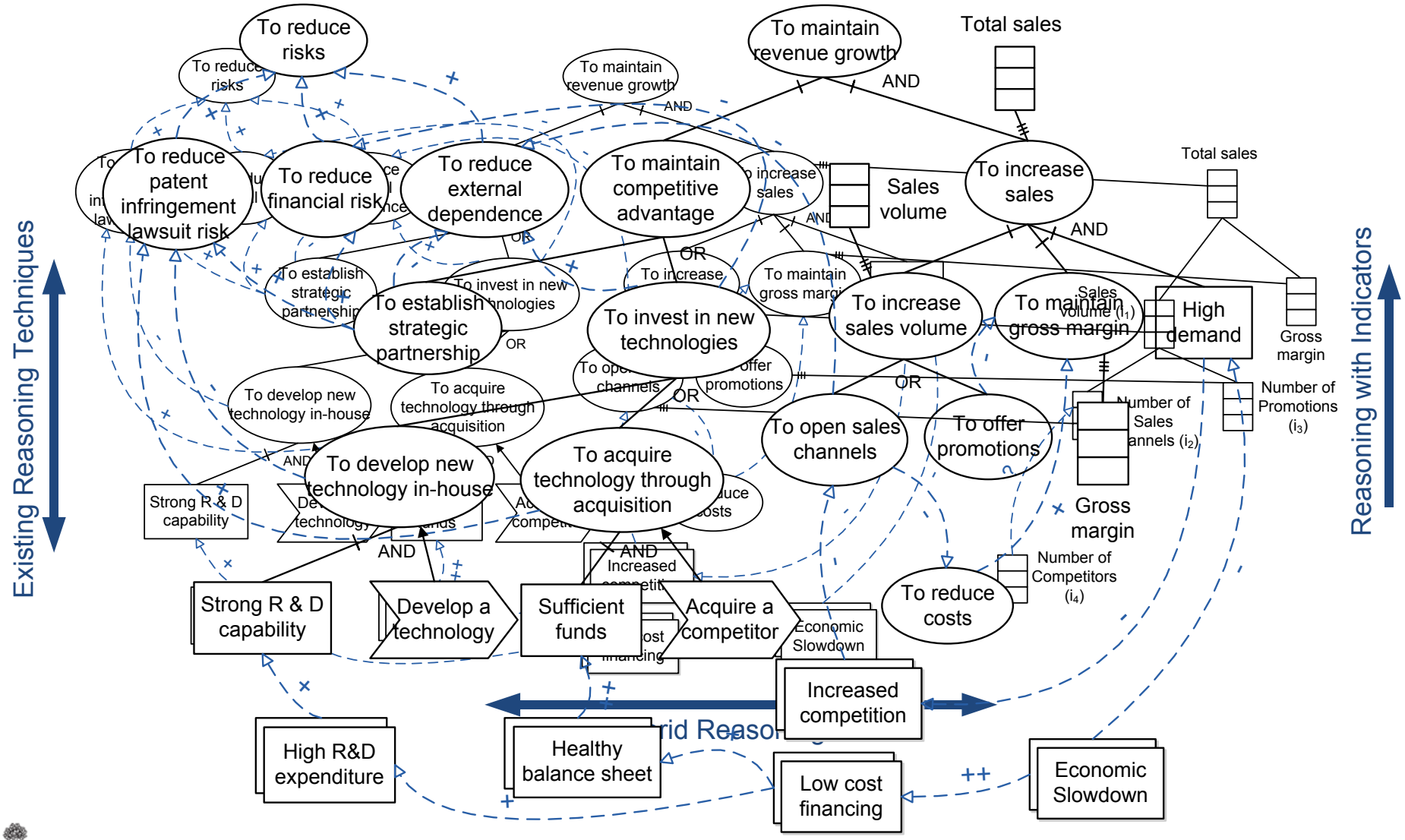


BIM Reasoning

- Reasoning with BIM allows an organization to answer strategic or monitoring questions. For example, BestTech may want to pose the following questions:
  - *Should we develop technology in-house or acquire technology through acquisition? Which option is better for maintaining revenue growth and reducing risks?*
  - *Is it possible to maintain revenue growth while reducing risks? What strategies can achieve these goals?*

Reasoning Technique	Required Information
Goal Model Reasoning	Initial Reasoning Values
Probabilistic Decision Analysis	Conditional Probability Tables, Utility Functions
Reasoning with Indicators	Atomic Indicator Values, Business Formulae, Unit conversion factors
Hybrid Reasoning (Reasoning with Incomplete Indicators)	Atomic Indicator Values, (Optional) Business Formulae, (Optional) Unit conversion factors, (Optional) Initial Reasoning Values

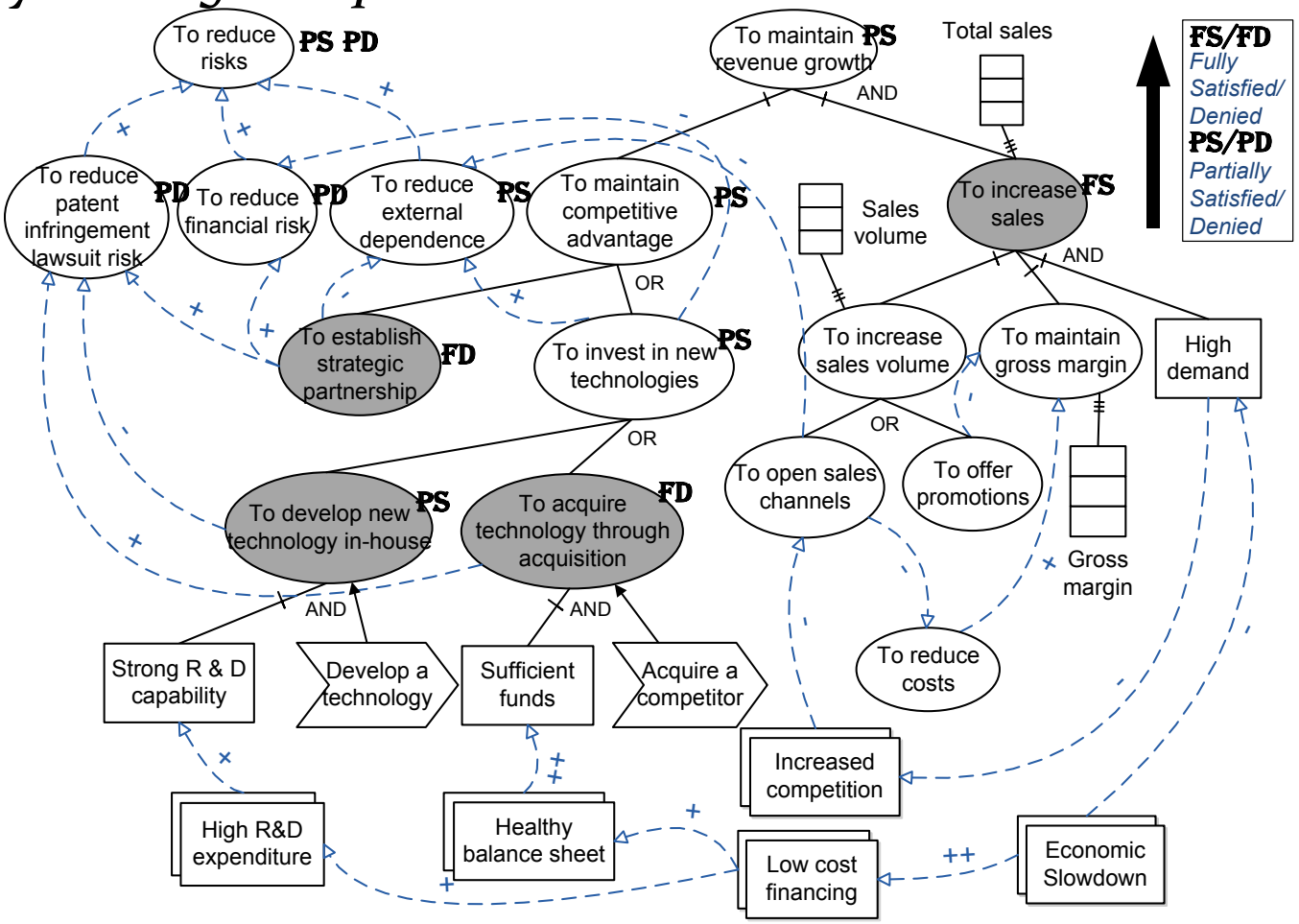
Reasoning Overview



Evaluation of Specific Strategies

- *Should we develop technology in-house or acquire technology through acquisition?*

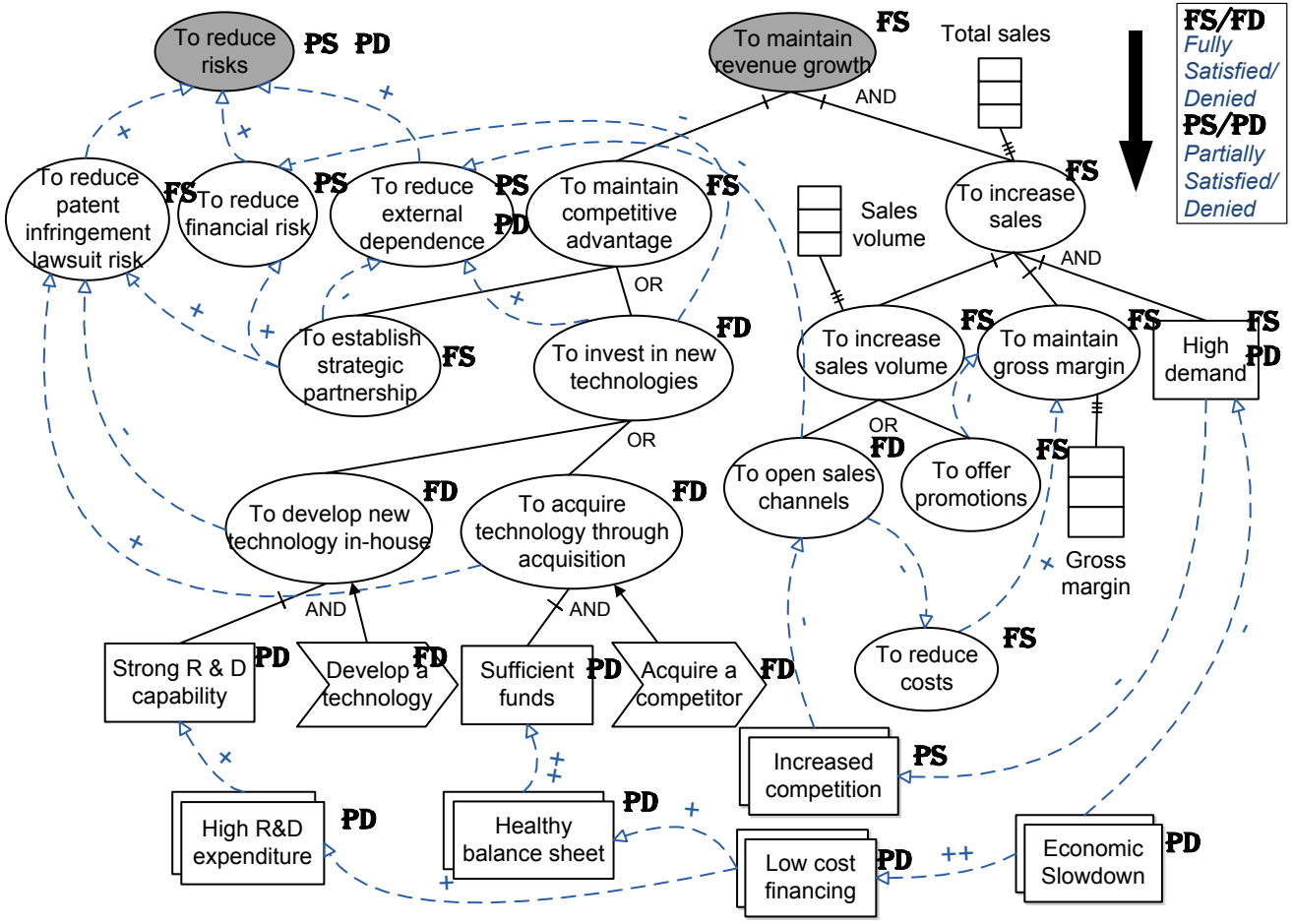
Goal Model Reasoning (Giorgini et al.), mapped to BIM



Discovery of Alternative Strategies

- *Is it possible to maintain revenue growth while reducing risks? What strategies can achieve these goals?*

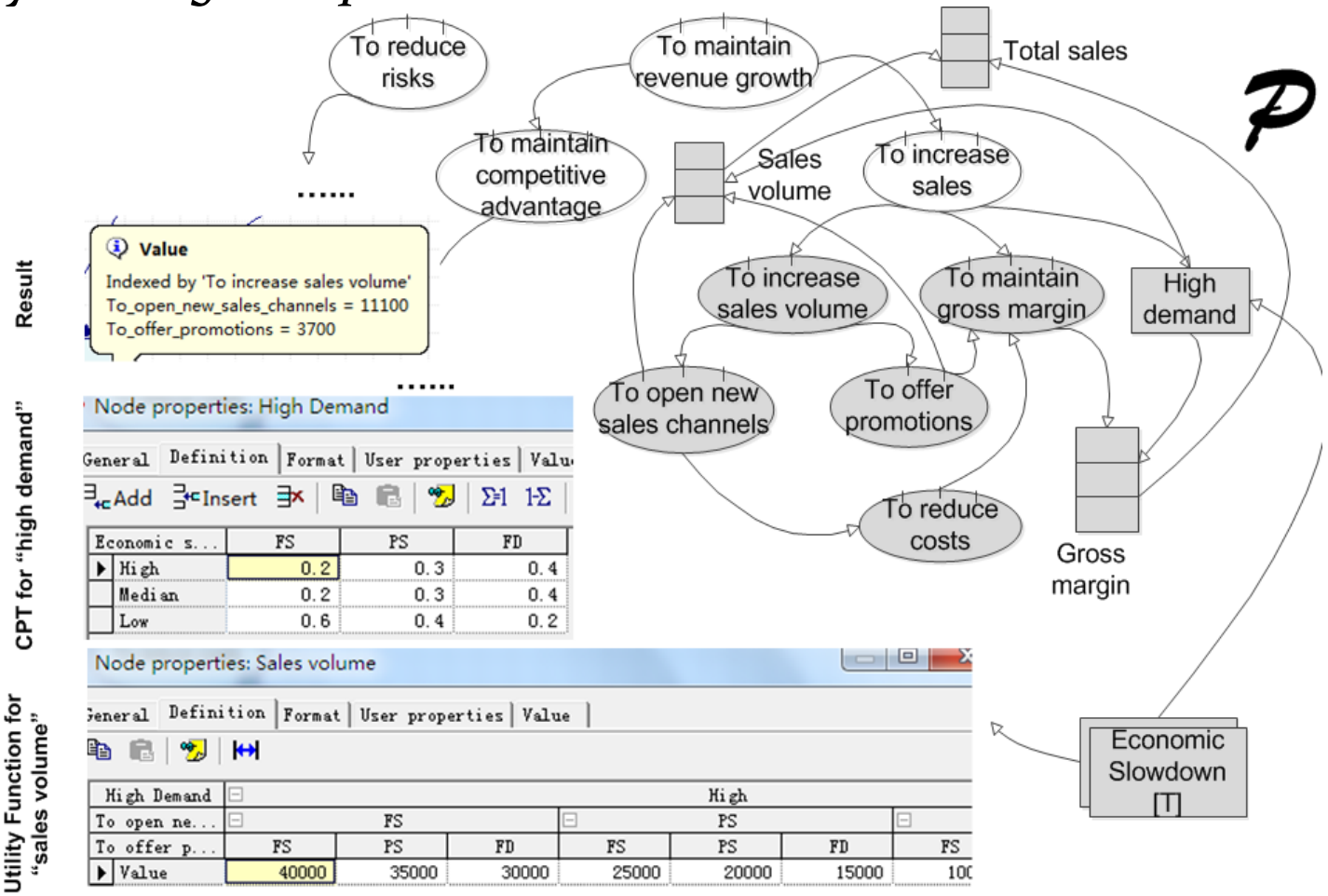
Goal Model Reasoning (Giorgini et al.), mapped to BIM



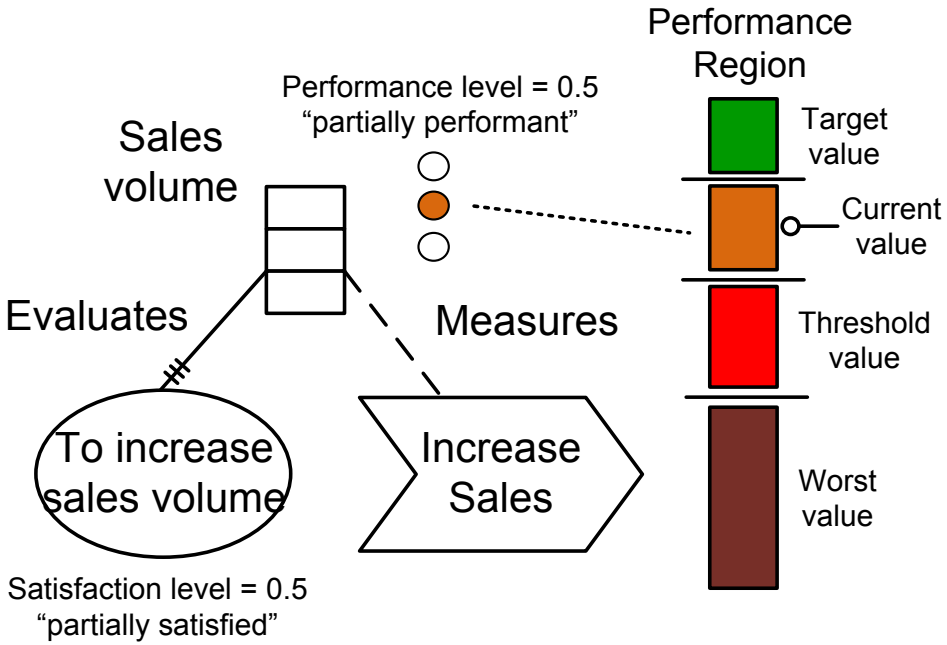
Probabilistic Evaluation of Strategies

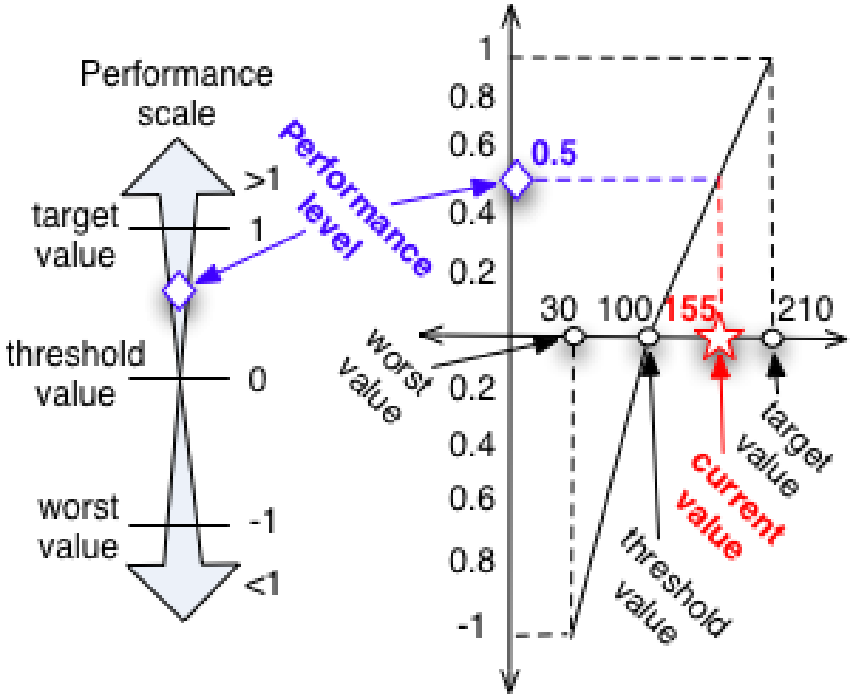
- *Should we develop technology in-house or acquire technology through acquisition?*

Influence diagrams (Howard & Matheson), mapped to BIM



Reasoning with Indicators





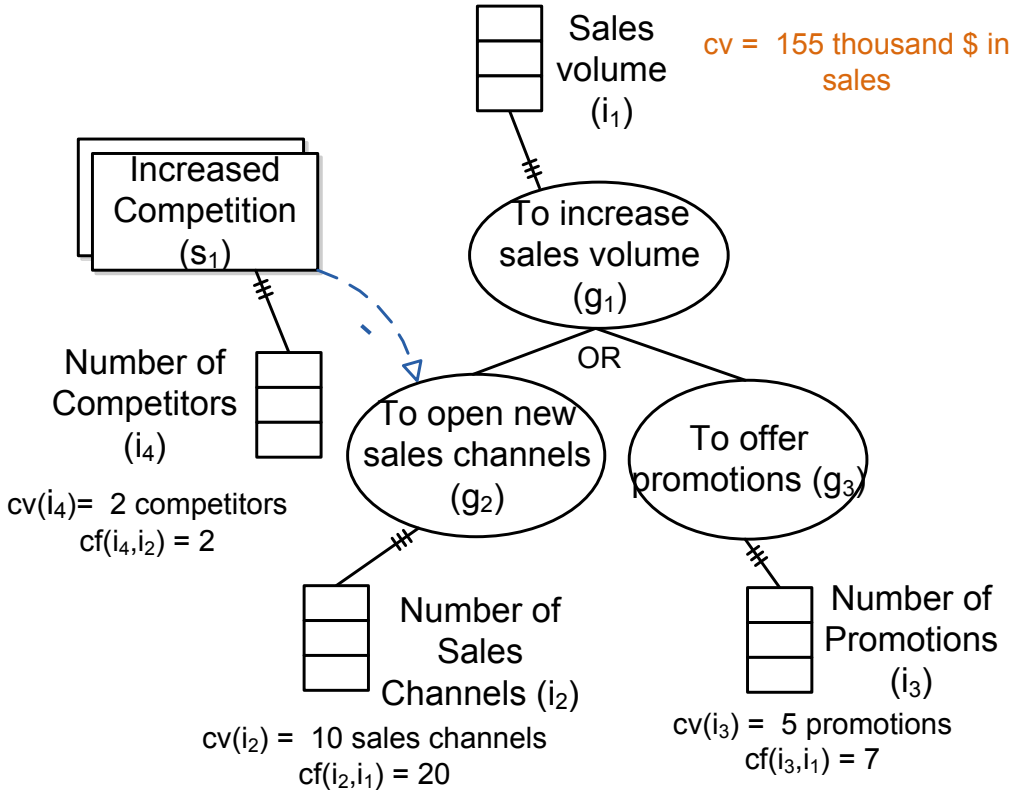
Indicator Reasoning with Varying Levels of Information

Reasoning Type	Unit Conversion	Required Information
Indicator Reasoning using Unit Conversion	Unit conversion factors	Atomic Indicator Values, Business Formulae, Unit conversion factors
Indicator Reasoning using Performance Levels	Unit Normalization (Performance Levels)	Atomic Indicator Values, Business Formulae
Indicator reasoning without Business Formula	Unit Normalization (Performance Levels)	Atomic Indicator Values
Hybrid Reasoning (with Incomplete Indicators)	Qualitative Normalization	Atomic Indicator Values, (Optional) {Business Formulae, Unit conversion factors, Initial Reasoning Values}

More Information Less

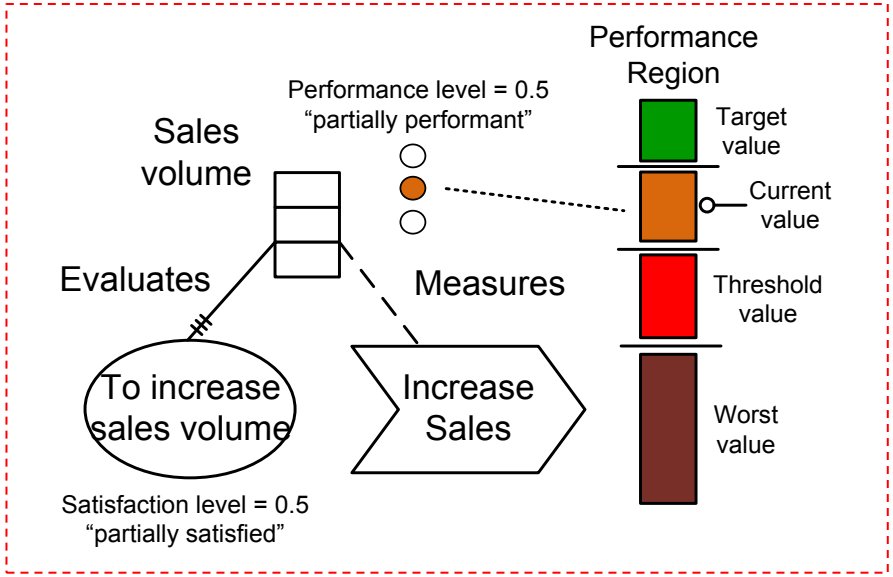
More Accuracy Less

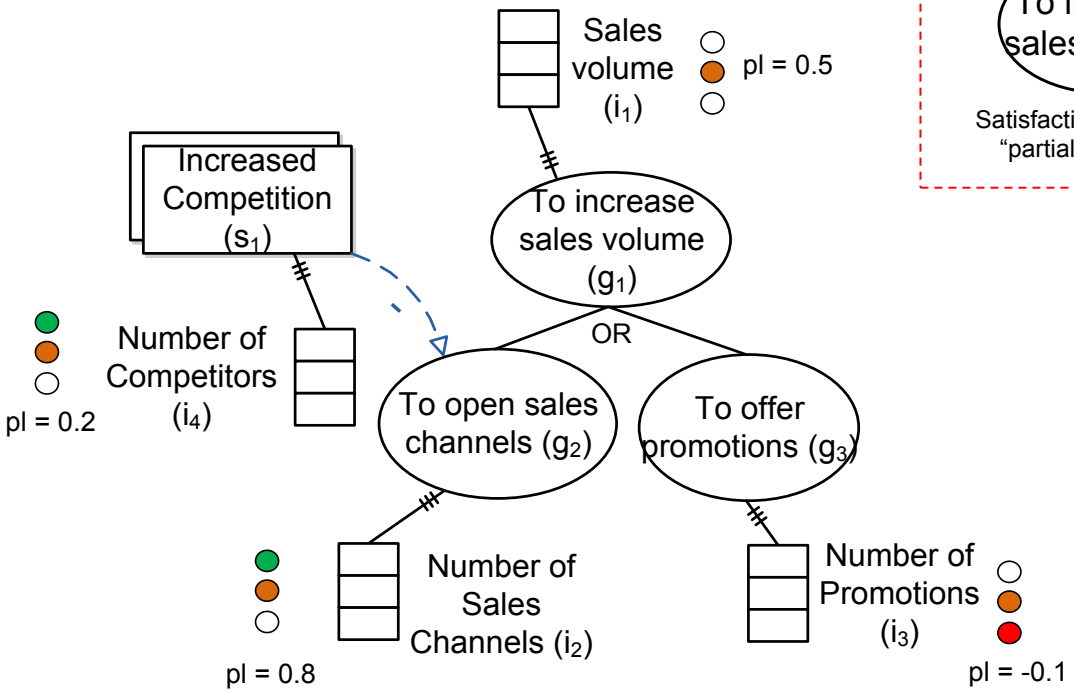
Indicator Reasoning using Business Formulae and Unit Conversion



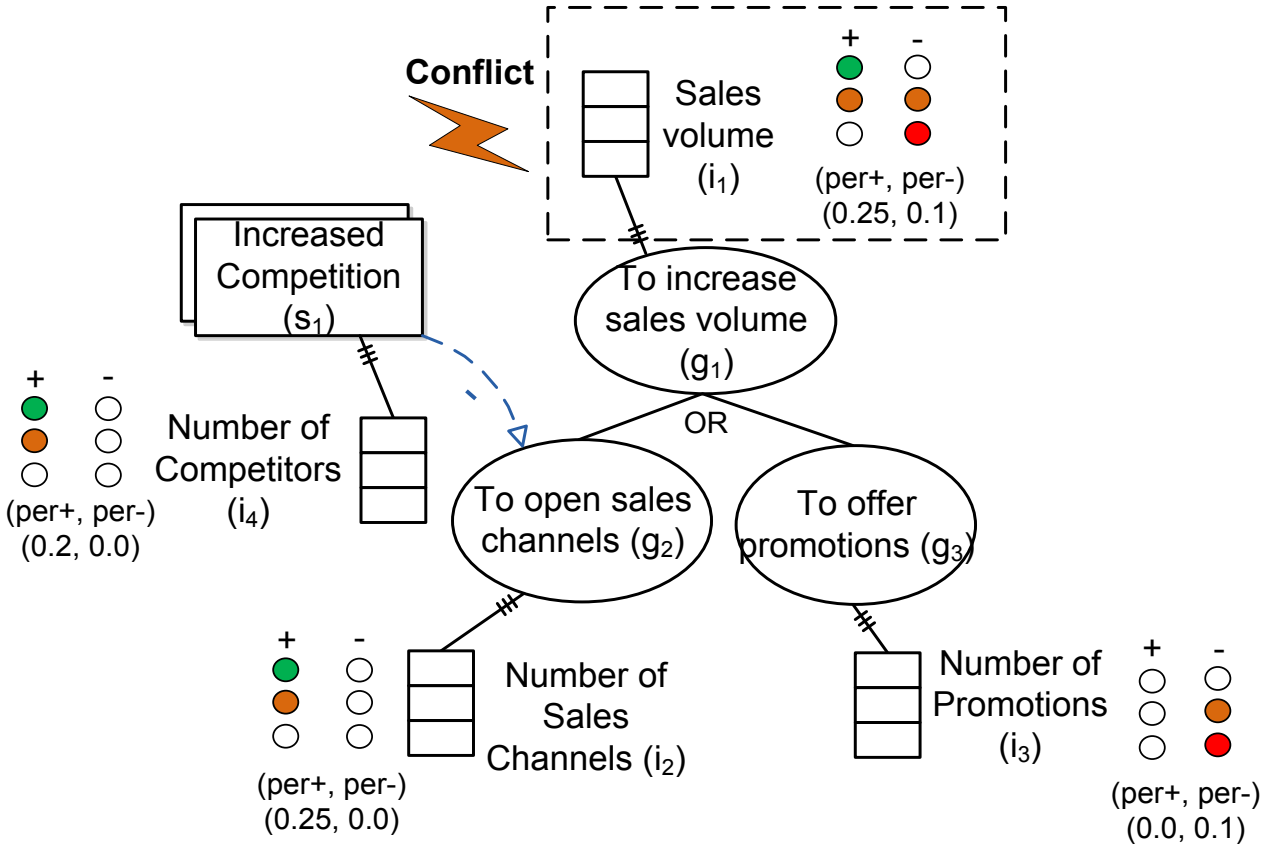
$$(cv(i_2) - cv(i_4)cf(i_4, i_2))\, cf(i_2, i_1) + cv(i_3)\, cf(i_3, i_1) = 20(cv(i_2) - 2cv(i_4)) + 7cv(i_3)$$

Indicator Reasoning using Business Formulae and Performance Levels

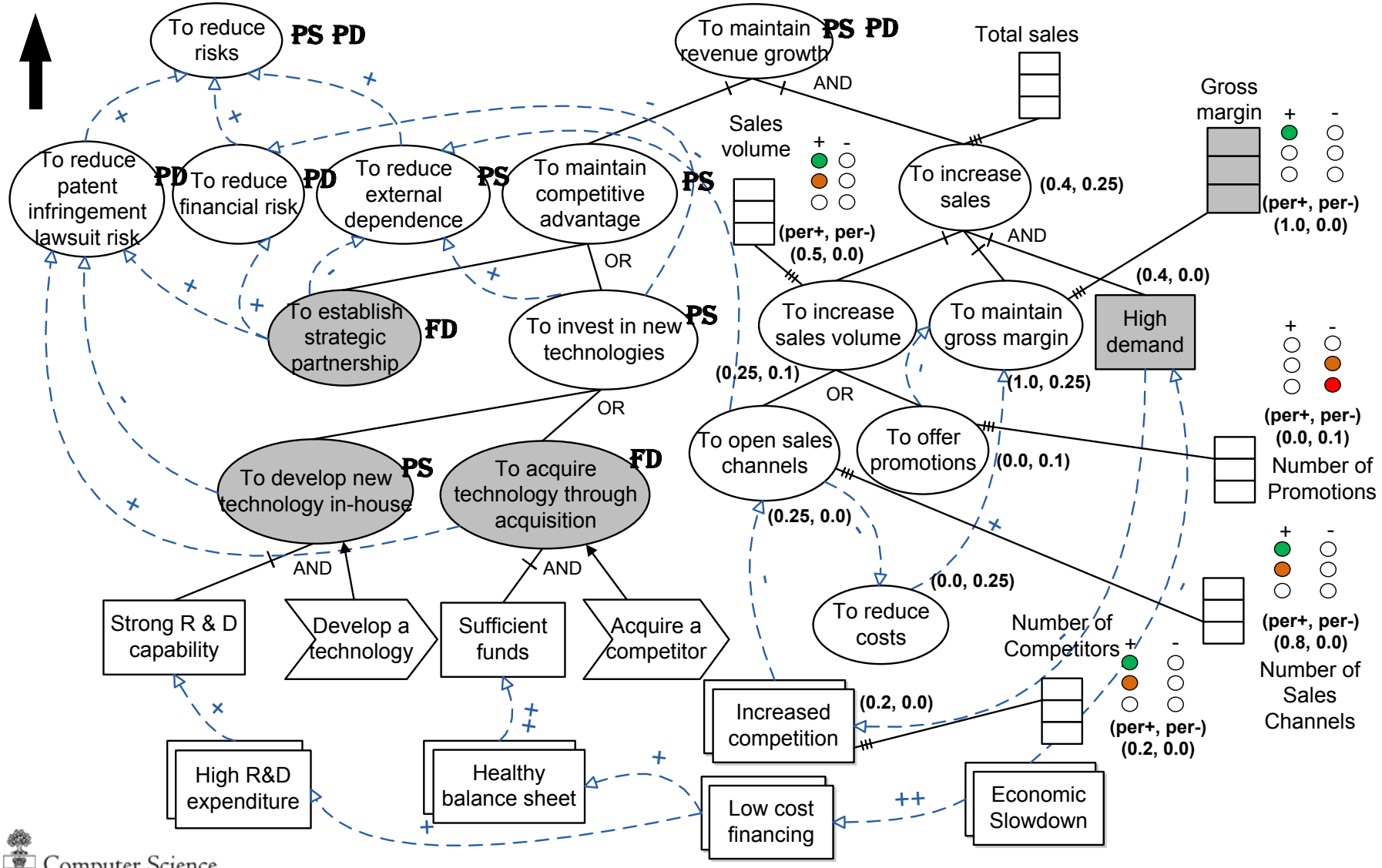




Indicator Reasoning without Business Formulae



Hybrid Reasoning (Reasoning with Incomplete Indicators)



BIM Language Semantics and Reasoning ("Stage 3")

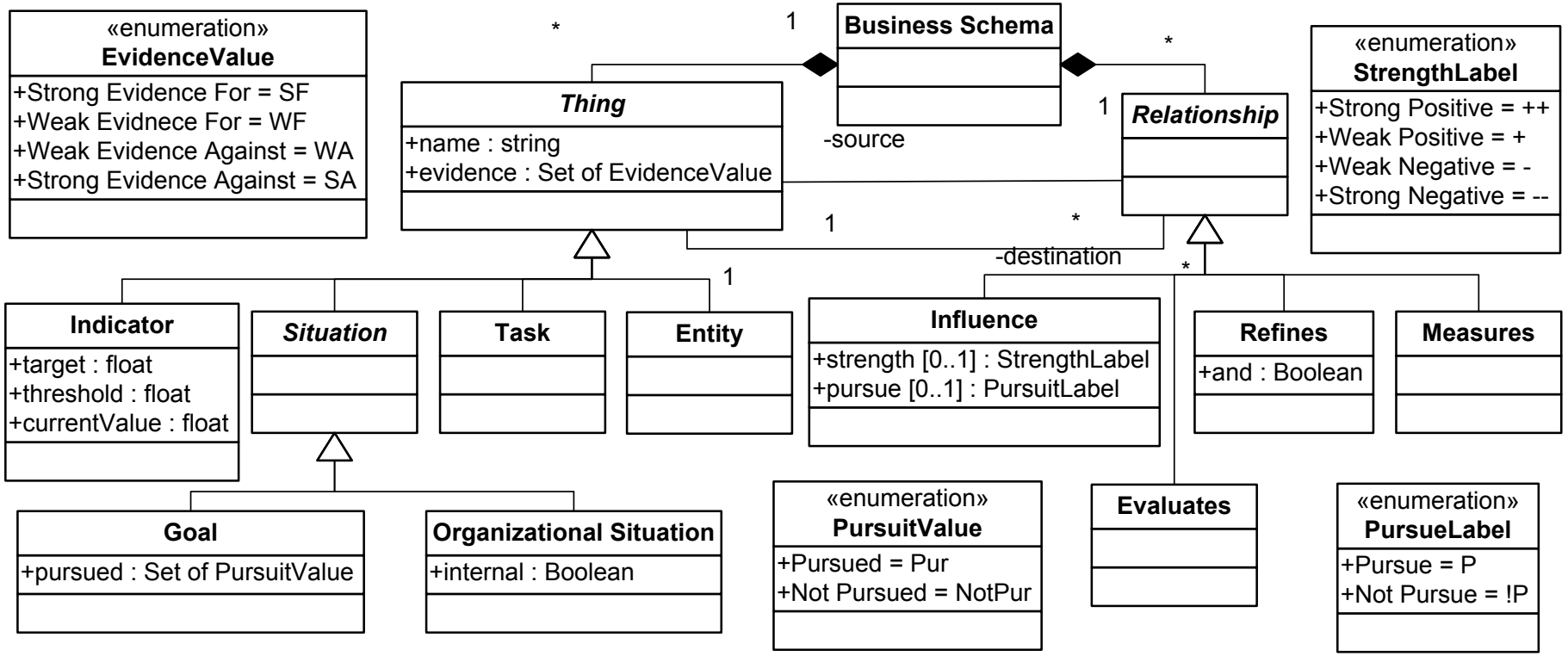
- Review concepts introduced in existing business and goal model languages
  - BMM, SWOT, BSc, GMs, SM
- Review all concepts previously introduced as part of BIM
- Select set of "core" BIM concepts and relationships
- Determine how concepts and relationships interact
  - What is allowed, what is not?
- Iterative process of language (re)design

- Define concepts formally using description logic

Horkoff et a. "Making data meaningful: The Business Intelligence Model and its Formal Semantics in Description Logics", ODBASE (to appear)

BIM Language Semantics and Reasoning: Metamodel

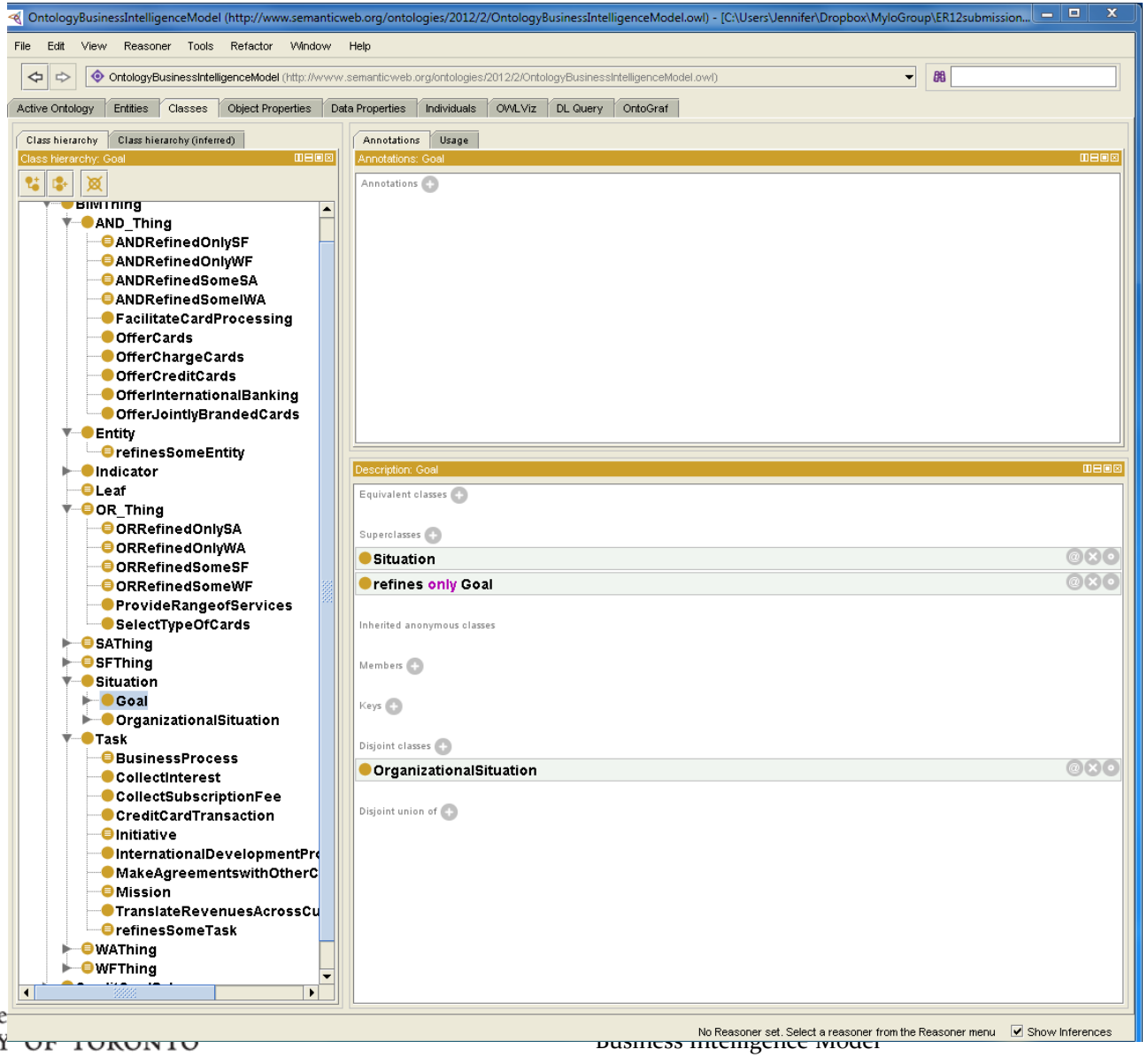
- Consolidated language "metamodel"/upper-level ontology



BIM Language Semantics and Reasoning: Definition and Metaproperties

- Formal definition of language concepts and relationships
  - Using description logic, e.g.,
    - **Class:** Goal **SubClassOf**: Situation
    - **Property**: influences **Domain**: Situation **Range**: Situation **InverseOf**: infBy
- More specialized concepts representing using metaproperties
  - *duration* (long-term/short-term), *likelihood of fulfillment* (high/low), *nature of definition* (formal/informal), *scope* (broad/narrow), *number of instances* (many/few), and *perspective* from BSC (financial/ customer/ internal/ learning and growth)
  - E.g., **Vision** is a "goal with a long duration, broad scope, low chance of fulfillment, informal definition, and few instances"

OWL Protégé Implementation



BIM Language Semantics and Reasoning: Additional Reasoning Capabilities

- Description of BIM in DL
  - Is easily extensible
  - Allows publishing of generic BIM models as ontologies on the semantic web
- DL allows reasoning capabilities beyond the application of existing approaches in previous work:
  - Can support "What if?" type reasoning from GM, but now inherent to the language, no mapping
    - Tested using an OWL encoding in Protégé
  - Introduced reasoning with pursuit
  - Detecting inconsistencies in BIM Schemas
  - Automatically classify defined concepts relative to existing concepts, organizing the model
  - Allowing more detailed conceptual modeling of entities, tasks, etc.

Selected slides from…

Business Intelligence Modeling in Action: A Hospital Case Study

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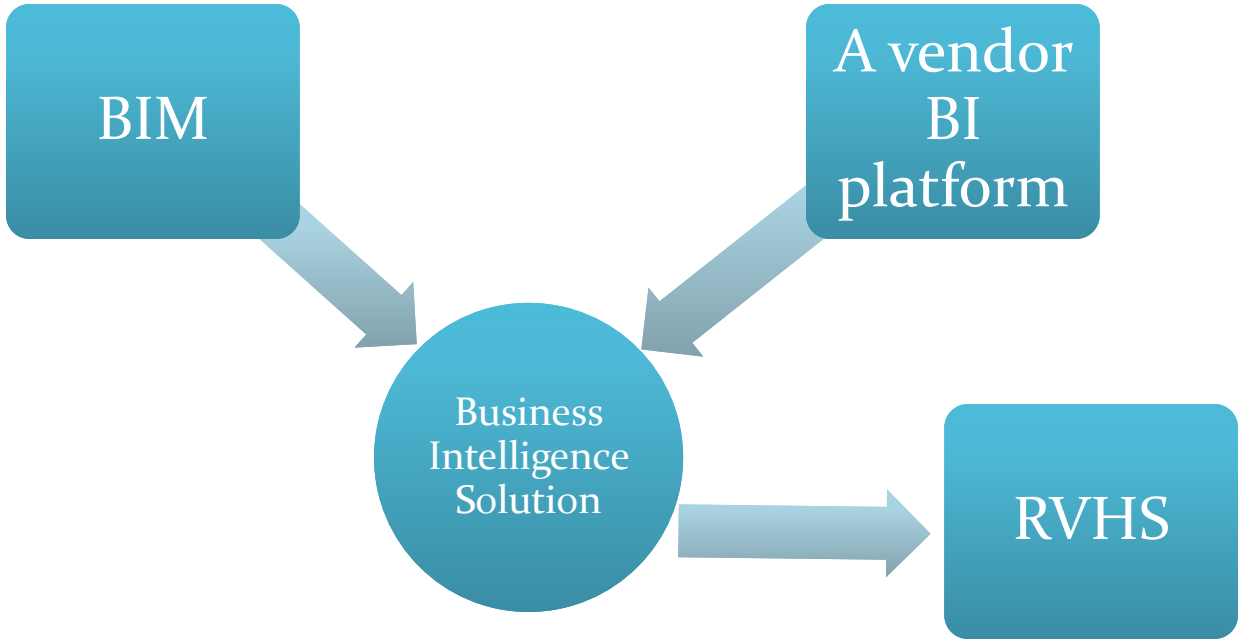
Abstract

- We present results of using the **Business Intelligence Model (BIM)** in the definition of **requirements** for a Business Intelligence (BI) Solution currently undertaking at the **Rouge Valley Health System (RVHS)**



Case Study Questions and Method

- Questions:
  - What is the value of BIM in a BI implementation?
  - Is the initial BIM language sufficient to support the business modeling needs of the case study?
  - Who are the users of BIM?
  - Is there a development methodology that matches with BIM?
  - How does BIM map to data?
- Method:
  - in situ case study in a healthcare organization during BI implementation.
  - researchers worked side-by-side with a BI development team.
  - shadow the implementation effort and generate models that capture the requirements and design choices of the implementation.

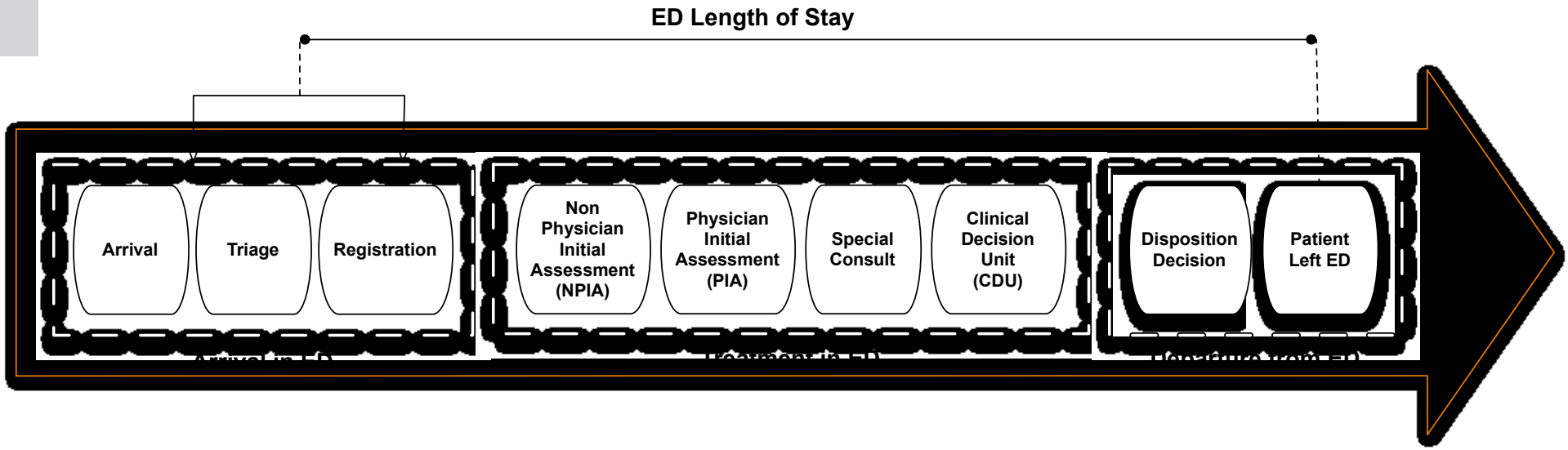
Rouge Valley Health System

- RVHS is a two site hospital with 479 beds in the east greater Toronto area
- Key facts
  - 2700 employees
  - Over 500 physicians and 1000 nurses
  - 109,190 Emergency Department (ED) visits in 2010-11
  - 24,100 admissions
  - 23,900 surgeries
  - 3,700 births
  - over 189,000 clinic visits
- Has a corporate performance mgmt framework and corporate scorecard
- In 2010-11, RVHS launched two transformative IT initiatives to
  - create a competency center in business process management, and
  - develop an enterprise Business Intelligence system

Business Intelligence Vision at RVHS

- Business Need
  - RVHS generates/collects a wealth of data which contain revealing facts about the quality and efficiency of RVHS's **processes**, utilization of **resources** and **outcomes**.
  - RVHS aims to gain insights into **operating performance** in order to improve efficiencies and the quality of **patient care**.
  - Managers need timely access to synchronized data from all levels.
  - The BI system needs to provide an **integrated repository** of data from disparate sources organized to meet the needs of business and clinical users.
  - The BI system must provide a **data access interface** that will enable business users and to access information on their own.

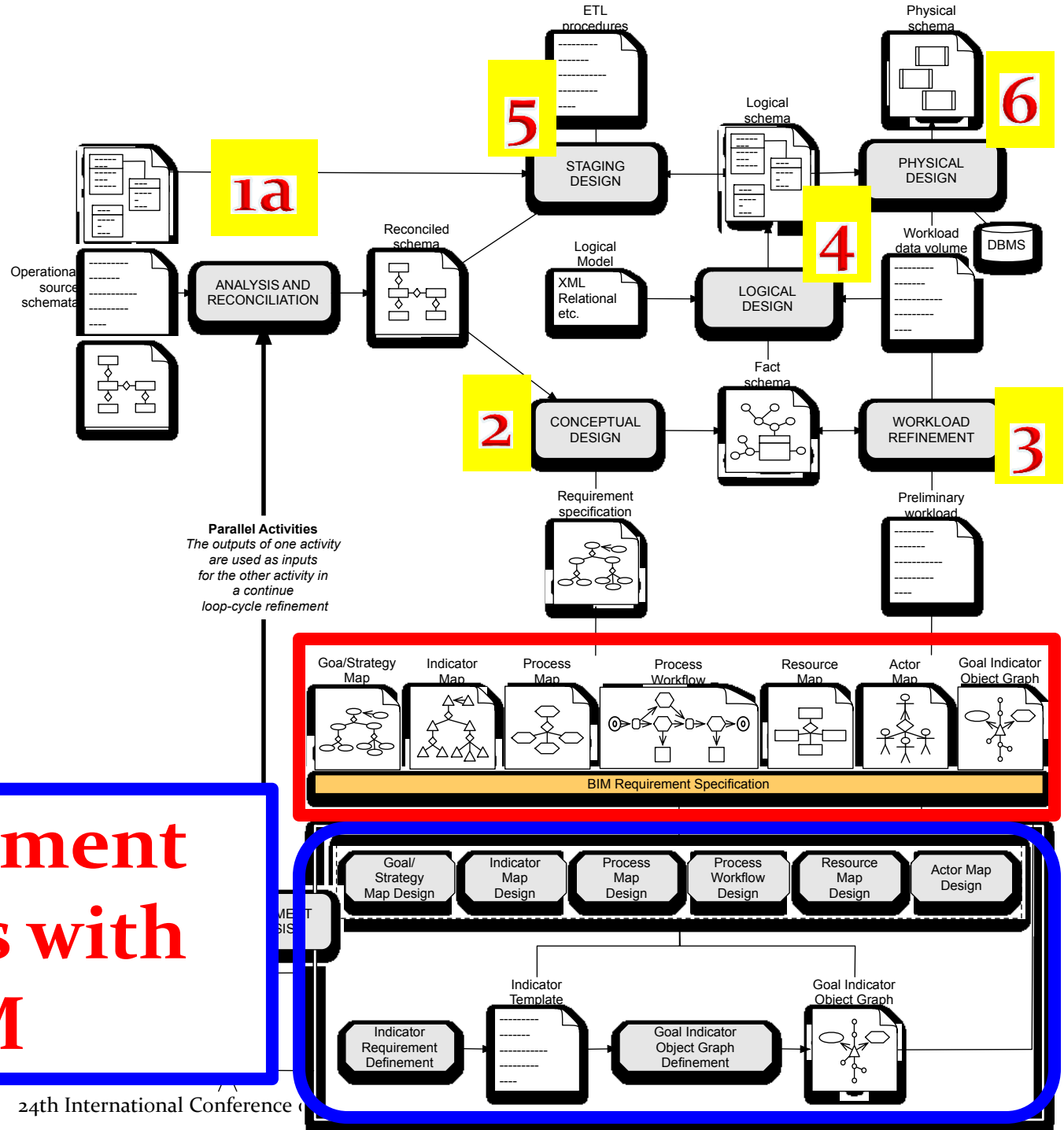
Business Problem: Emergency Department Patient Flow



The **Emergency Room National Ambulatory Initiative (ERNI)** measures and reports how long patients spend in Emergency Departments. Clinicians (will) collect **38 data elements** (*DART)* related to the **patient journey** through the Emergency Department from arrival to departure.

Improve the quality of Patient care

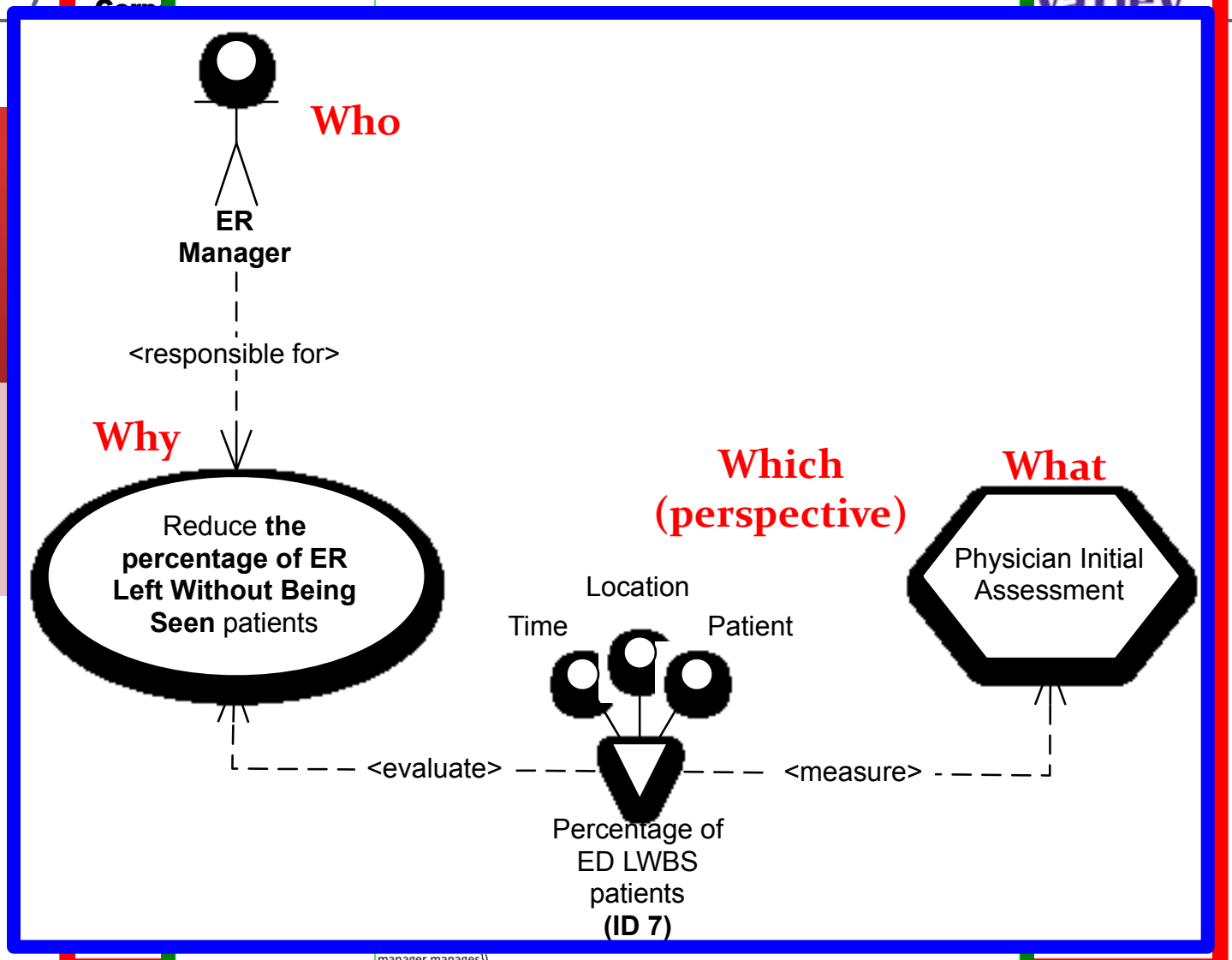
The Seven Phases for the Design of the Emergency Department Data Mart:
A Mixed approach



Requirement Analysis with BIM

Requireme Object (AGIO)

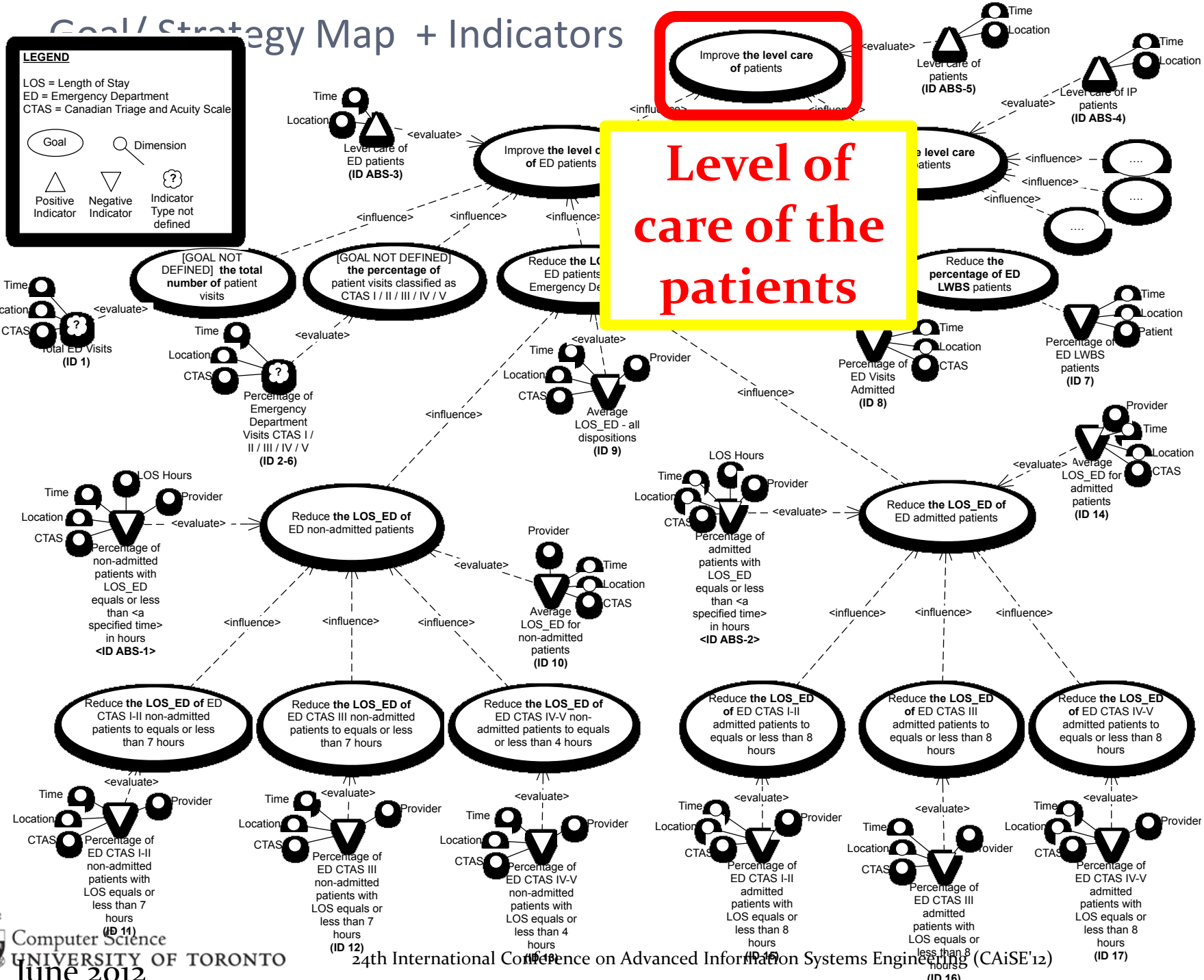
Technical Term	Non-technical user description
General Description	
ID	7
Name	Percentage of Emergency Department Patients left without being seen (LWBS)
Description	The indicator calculates the percentage of Emergency Department Patients that leave the ER department without seen by the doctor
Scorecard(s)	Daily DART Report
	manager manages})
Information and Data Quality	
Issues	Not relevant issues are documented



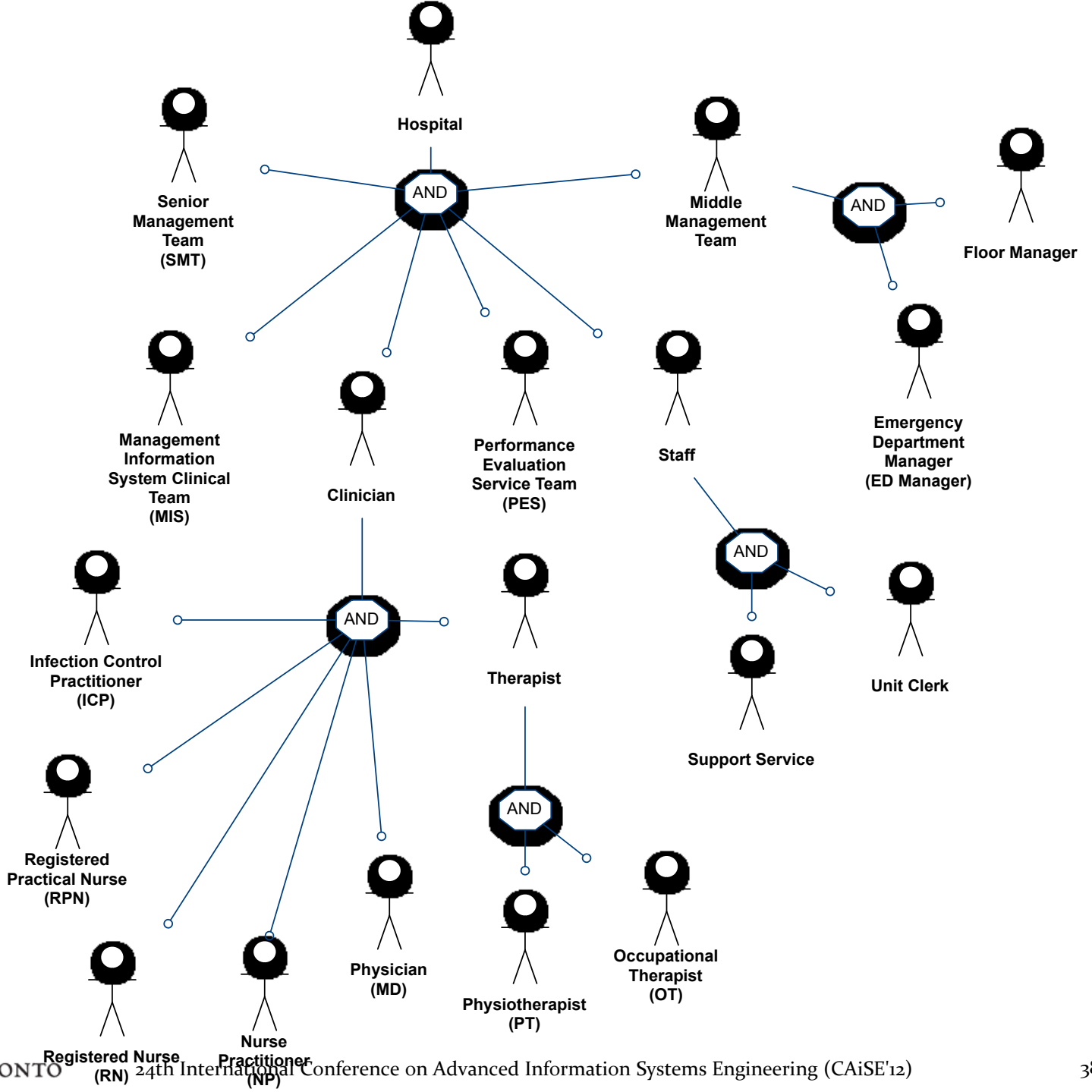
From AGIO Sheet and AGIO Graph

- Extrapolate:
  - Actor Map
  - Goals/Strategy Map
  - Indicator Map
  - Process and Workflow Map
  - Resource Map
- Whatever combination of the above:
  - e.g., Goal/Strategy Map + Indicator Map

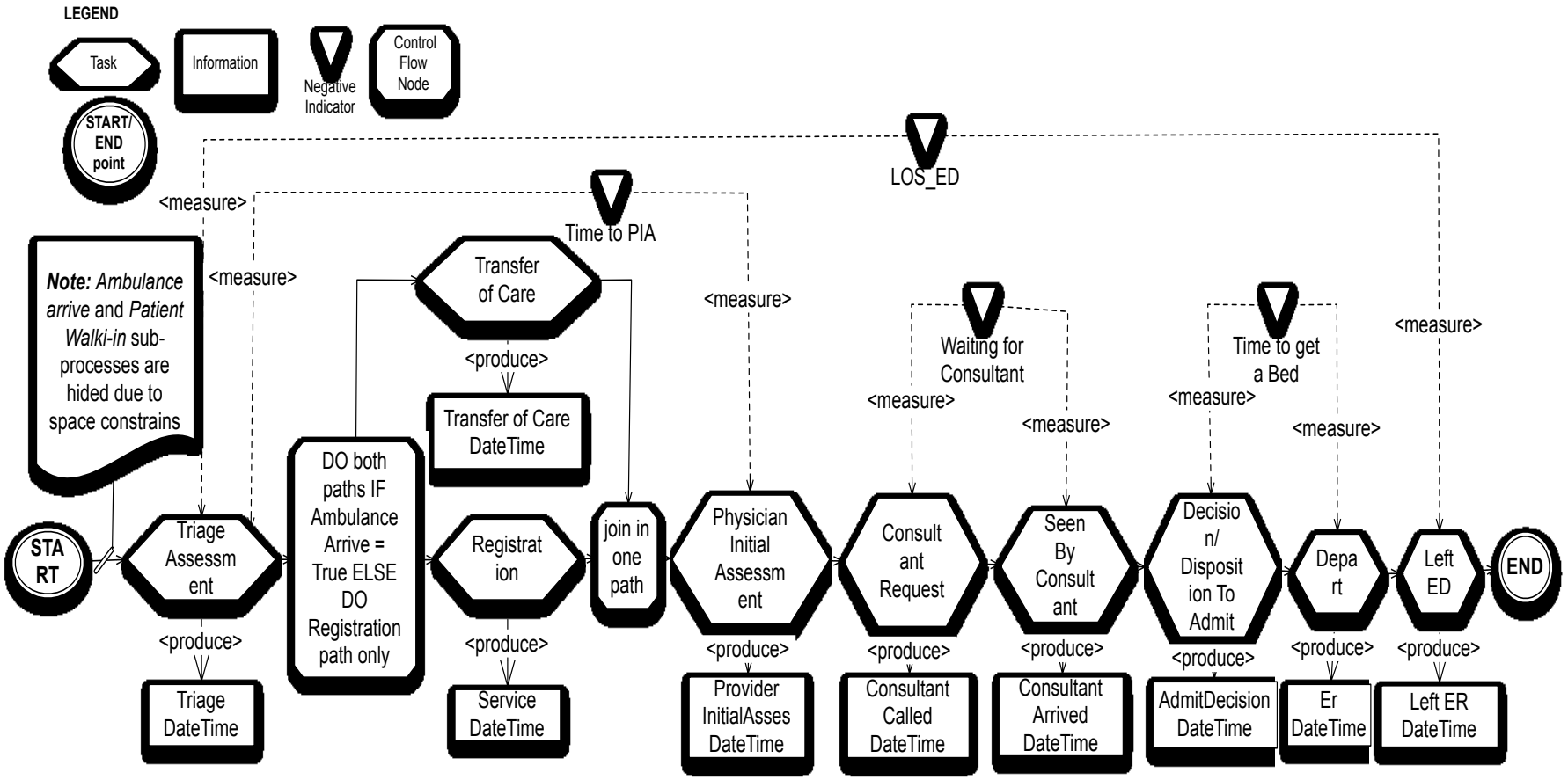
Goal/ Strategy Map + Indicators



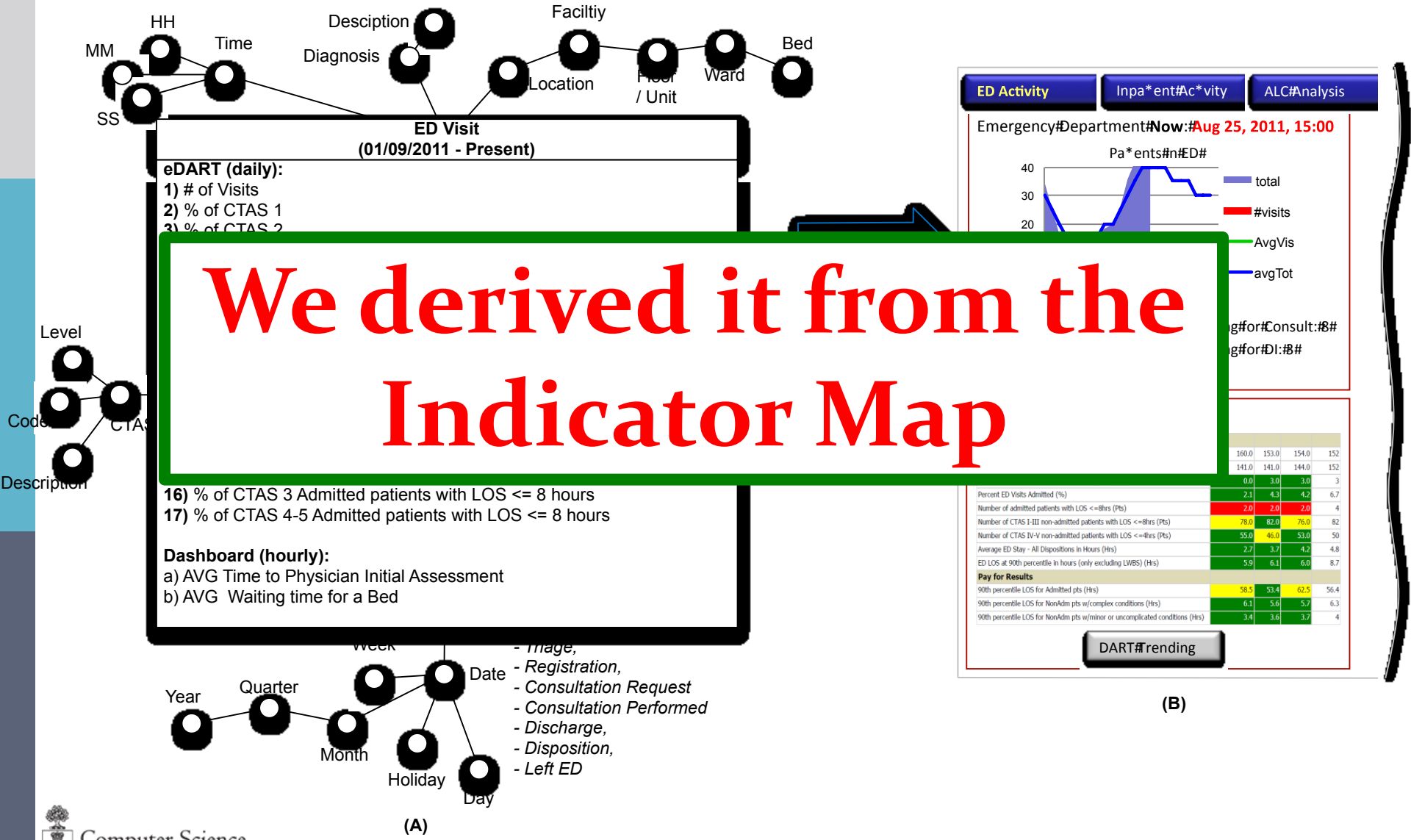
Actor Map


Hospital
AND
Senior Management Team (SMT)
Middle Management Team
AND
Floor Manager
Management Information System Clinical Team (MIS)
Clinician
Performance Evaluation Service Team (PES)
Staff
Emergency Department Manager (ED Manager)
AND
Infection Control Practitioner (ICP)
Therapist
AND
Unit Clerk
Support Service
Registered Practical Nurse (RPN)
AND
Physician (MD)
Occupational Therapist (OT)
Physiotherapist (PT)
Registered Nurse (RN)
Nurse Practitioner (NP)

Emergency Department Process + Indicators



ED Fact Schema and a Dashboard



We derived it from the Indicator Map

Lessons Learnt

- What is the value of BIM in a BI implementation?
  - BIM concepts enhance communication and collaboration between designers and domain experts
  - Provide a roadmap for project team
- Is the initial BIM language sufficient to support the business modeling needs of the case study?
  - Used concepts such as stakeholders, goals, processes, KPIs, scorecard, resources, etc …
  - Some concepts and methods not used (situations, reasoning, …)
- Who are the users of BIM?
  - Business analysts and not business managers
  - Designers and domain experts understood and used the models for communication

Lessons Learnt

- Is there a development methodology that matches with BIM?
  - Extended widely practiced BI solution development techniques by enriching them with BIM concepts
- How does BIM map to data?
  - Indicator maps used to derive fact schemas, map current indicators to objectives
- Future WORK: Toward a Model for Performance Management Solution
  - Performance management enables organizations to monitor performance across the business, linking performance to business cycles and strategies that govern their overall direction.
  - Use the formal requirements output of our Requirement analysis as input for **Performance Management Frameworks in BI platforms** to validate our BIM model as **a Performance Management Solution** Model

* WebFOCUS Performance Management Framework v5, Information Builders (2009)

Conclusions

- Business Intelligence Model
  - Fill the gap between BI data and business strategy
- Language and reasoning consolidation
  - Consistent "story" or use cases for all types of BIM reasoning
  - Hybrid reasoning with incomplete indicators
- BIM Language Semantics and Reasoning
  - Language (re)design, formal definition, use of metaproperties, expanded reasoning
- BIM in Action
- Future Work
  - Expanded description of semantics and reasoning

Thank you!

- Questions?

- Contact:

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