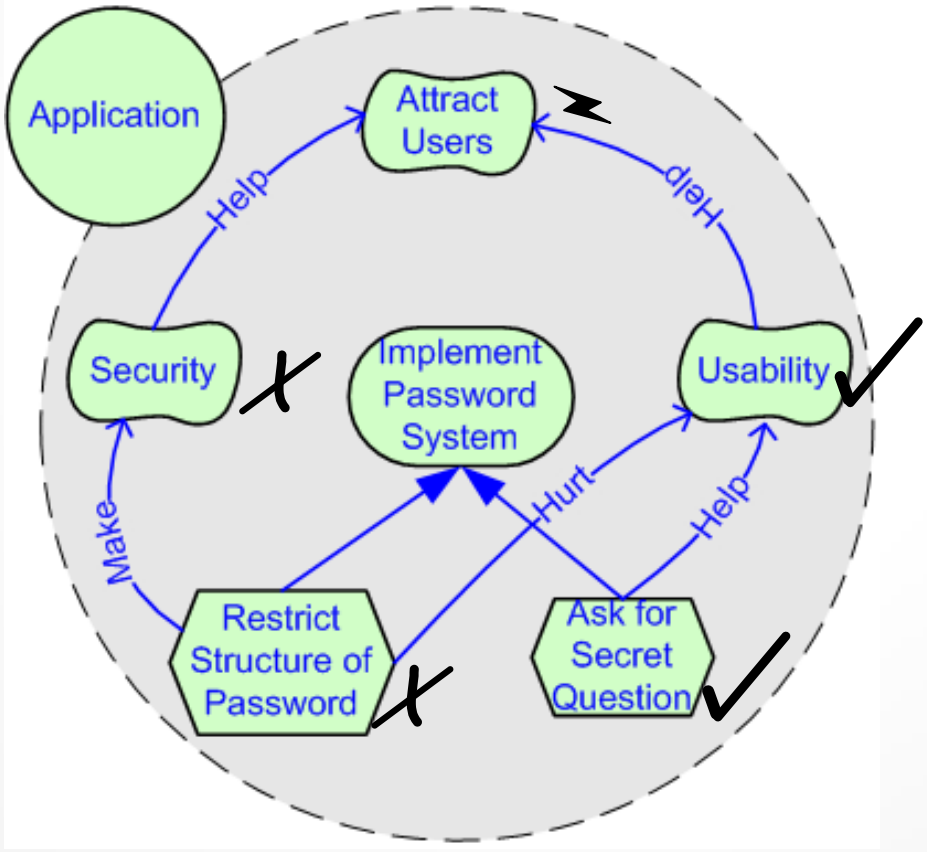
11. "Advanced" i* & BIM Goal Model Reasoning



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Part 1: Reasoning with i*

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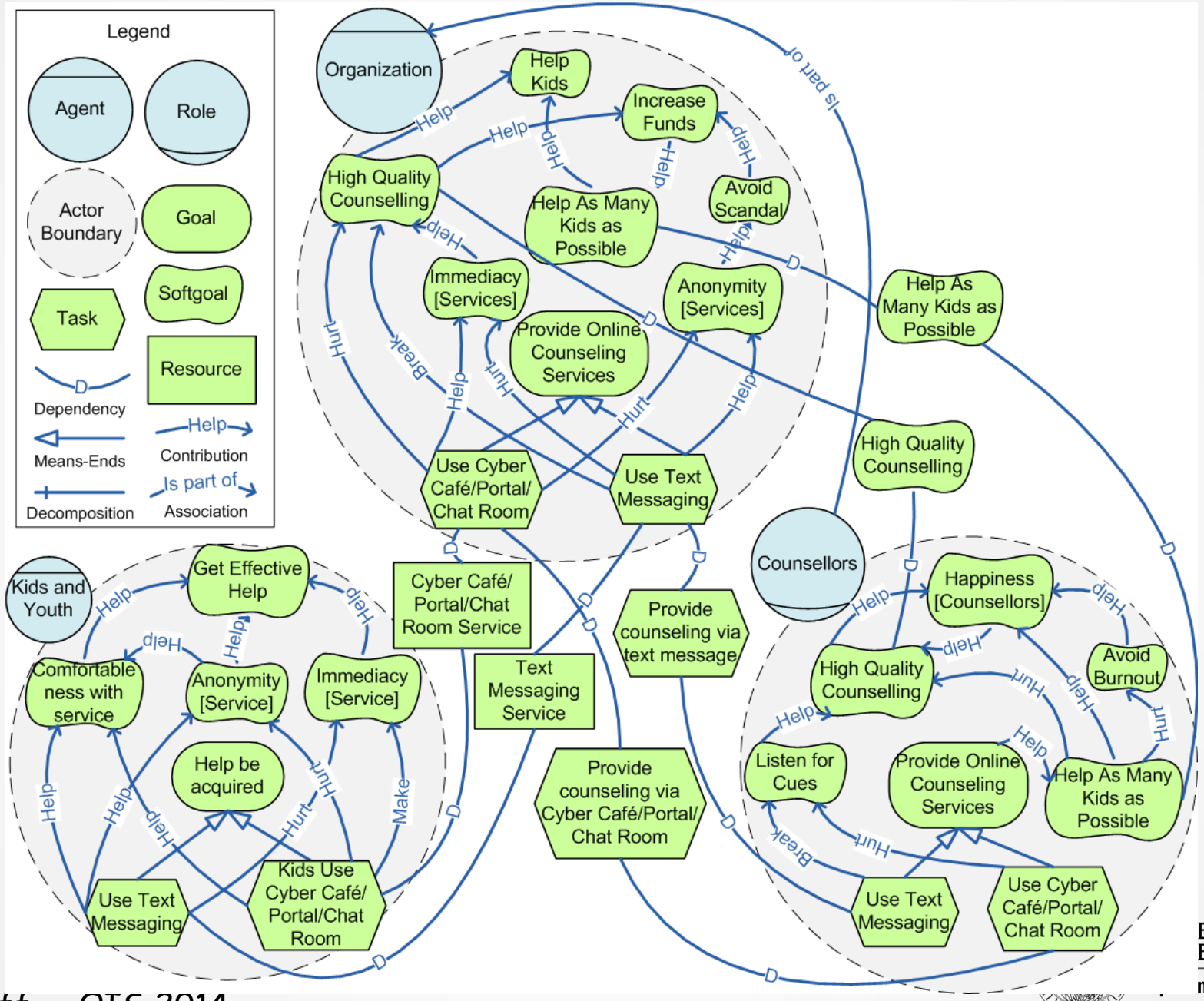
Recap: i*


Legend
Agent
Role
Actor Boundary
Goal
Softgoal
Task
Resource
Dependency
Means-Ends
Decomposition
Contribution
Is part of
Association
Organization
Help Kids
Increase Funds
High Quality Counselling
Help As Many Kids as Possible
Avoid Scandal
Immediacy [Services]
Anonymity [Services]
Provide Online Counseling Services
Use Cyber Café/Portal/ Chat Room
Use Text Messaging
Help As Many Kids as Possible
High Quality Counselling
Kids and Youth
Get Effective Help
Comfortableness with service
Anonymity [Service]
Immediacy [Service]
Help be acquired
Use Text Messaging
Kids Use Cyber Café/ Portal/Chat Room
Cyber Café/ Portal/Chat Room Service
Text Messaging Service
Provide counseling via text message
Provide counseling via Cyber Café/Portal/ Chat Room
Counsellors
Happiness [Counsellors]
High Quality Counselling
Avoid Burnout
Listen for Cues
Provide Online Counseling Services
Help As Many Kids as Possible
Use Text Messaging
Use Cyber Café/Portal/ Chat Room

How can we use the model to answer questions?

What if….

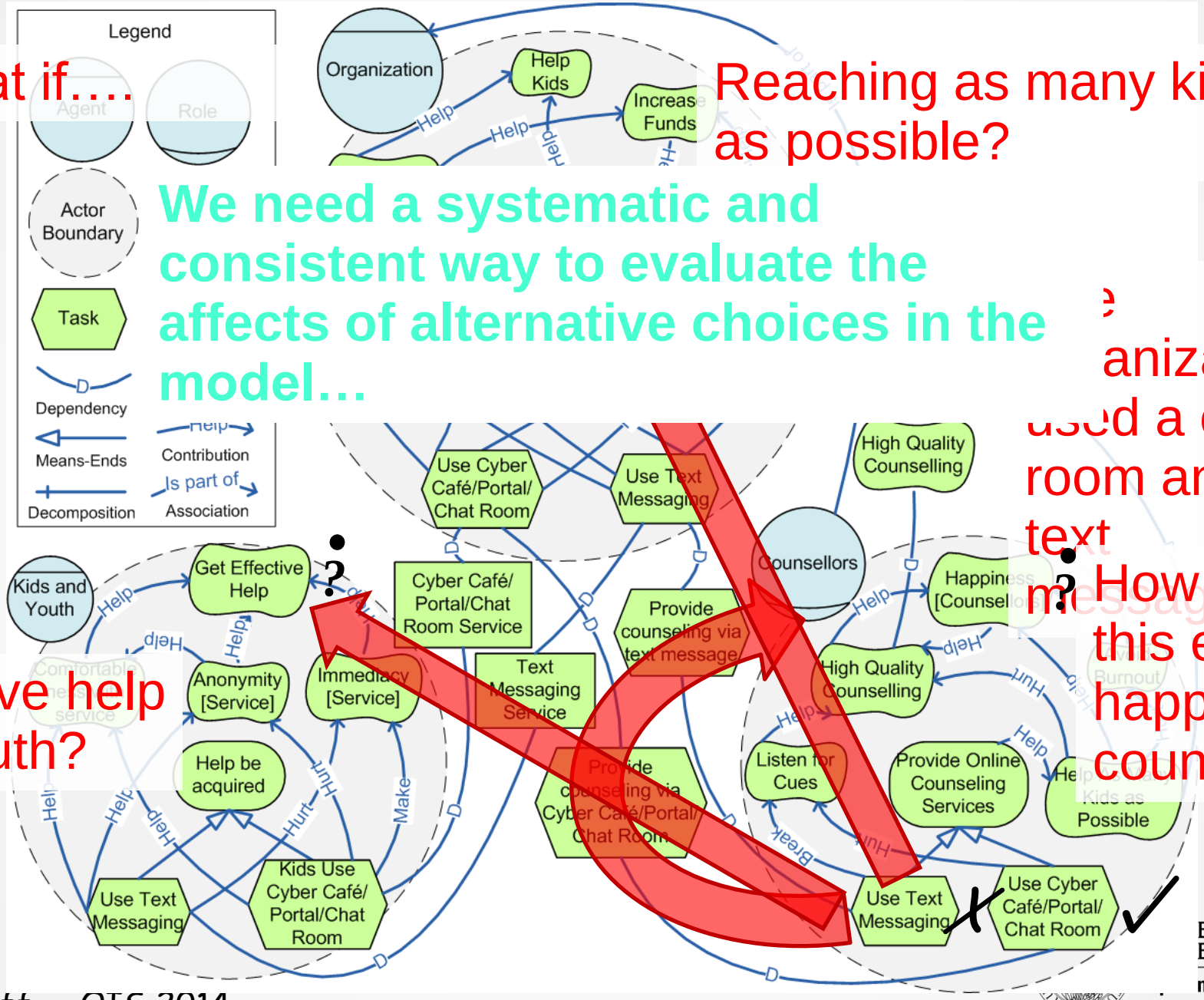
Reaching as many kids as possible?

We need a systematic and consistent way to evaluate the affects of alternative choices in the model…

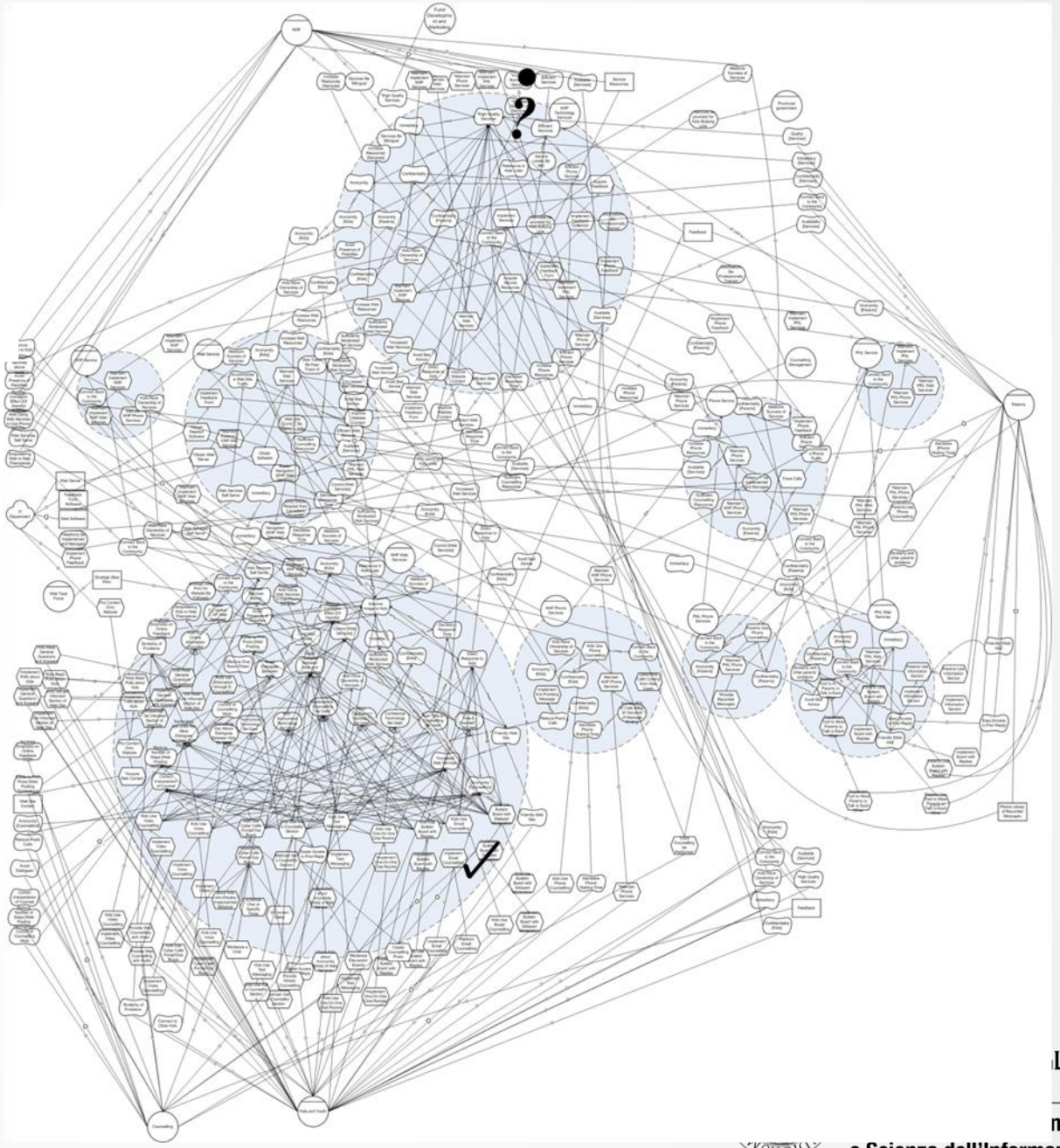
anization
used a chat
room and not
text
messaging?

How would this effect the happiness of counselors?

Effective help for Youth?



…especially for large models



Outline

- Reasoning with Goal Models
- Qualitative Forward Reasoning
- Backward Reasoning
- Reasoning Visualizations in OpenOME
- Quantitative Reasoning
- Recall: BIM
- Reasoning in BIM

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A2

- The first objective is to analyse the chosen organization so as to identify weaknesses, bottlenecks, and under-performance. You will do so by using the analysis and simulation components of ADONIS.
- …Ideally, the system will overcome the identified limitations. In order to do so, you will use a technology or a modelling/reasoning framework of your choice among those presented in the second part of the course.
- 2. Analyse your i* models or BIM/t-BIM models to determine goal satisfaction or denial. What organisational changes can be made to better achieve goals? Describe how these changes affect your business processes.
- ….Revise your models to address identified bottlenecks (in terms of cost, time, security, risk, …). Re-run some of the previous analyses to show that the new models outperform the previous ones.

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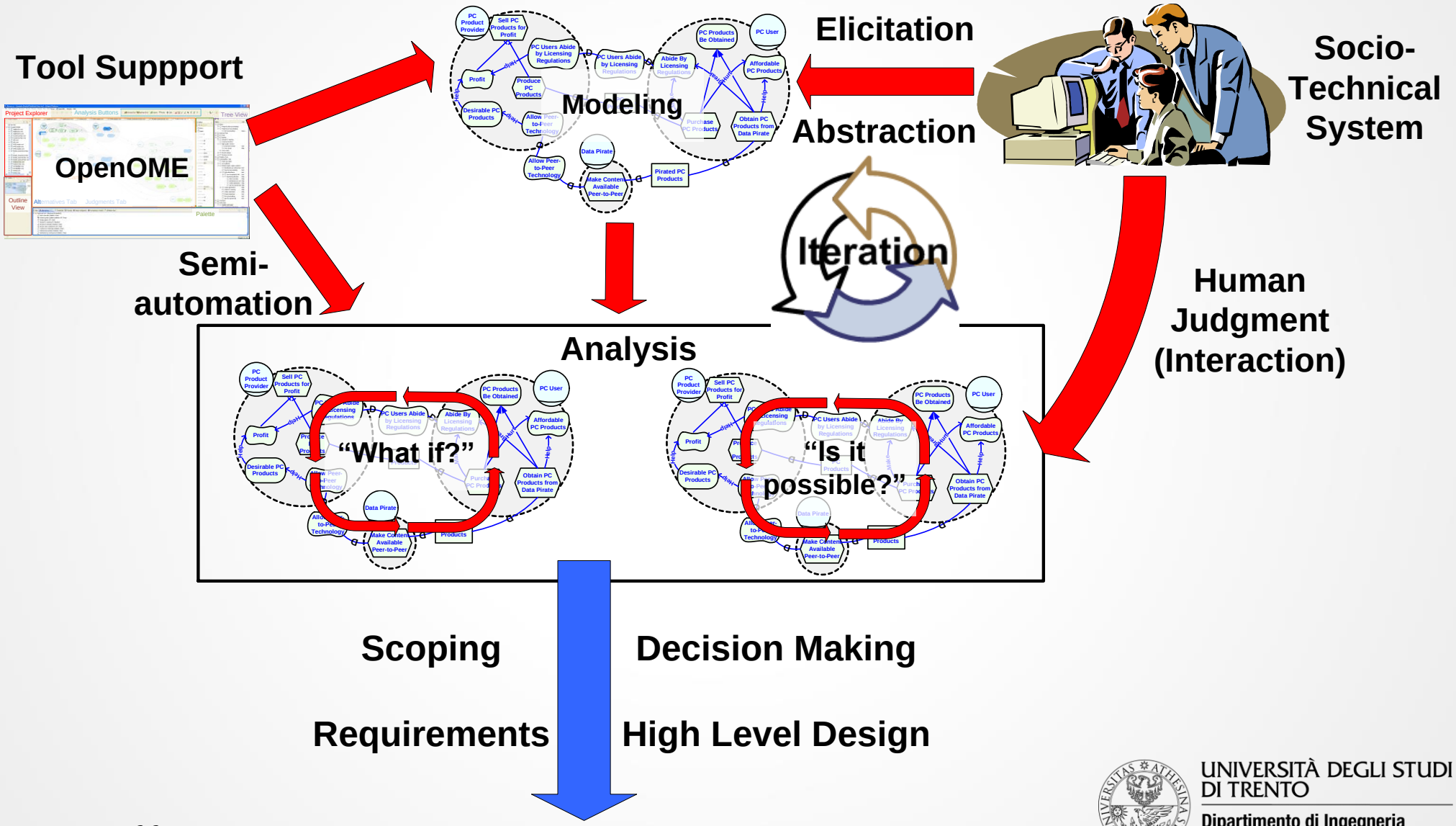
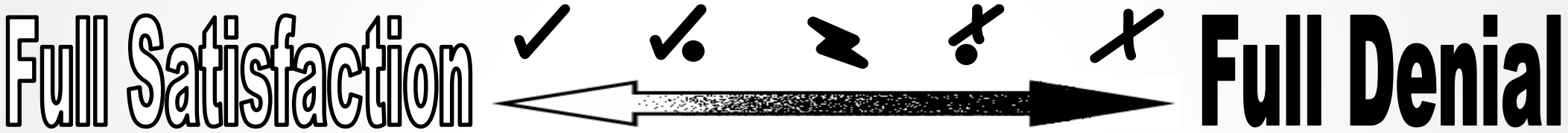
Iterative, Interactive Analysis of Agent-Goal Models for Early Requirements Engineering



Model Analysis

- Several approaches to analysis in GORE
- Example approach: Use labels to represent degree of satisfaction

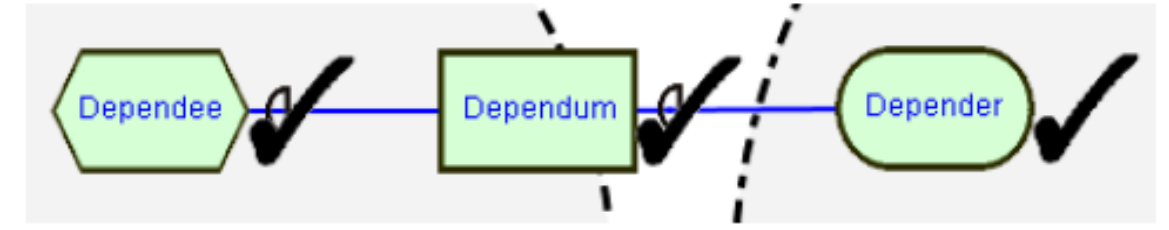


- Use algorithms to propagate labels throughout the model using propagation rules
- Use human judgment to resolve conflicts

Propagation Rules

Dependency

- Direct transfer of the evaluation value from dependee to dependum to depender.



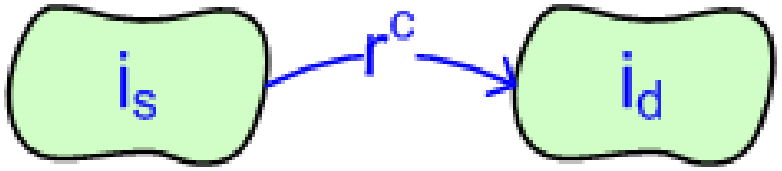
Decomposition/Means-Ends

- Decomposition: And relationship, used to indicate the selection of the "minimum" value amongst the values of all of the contribution elements.
- Means-Ends: Or evaluation relationship, taking the "maximum" value of its children.

Propagation Rules

Contribution Links

- Source label, link type, Destination label
- Positive links (Make, Some+, Help) propagate the same polarity evidence, possibly weakening evidence
- Negative links (Brea, Some-, Hurt) propagate the inverse polarity, possibly weakening evidence

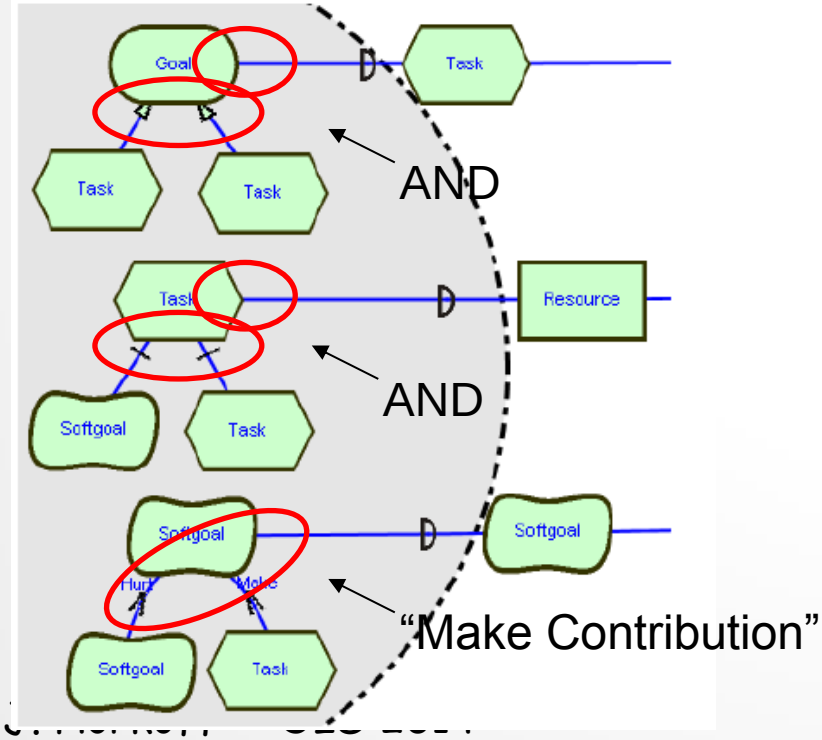


Source Label (e_s.v)		*Contribution* Link Type *(l.type)*						
	Name	Make	Help	Some+	Break	Hurt	Some-	Unkn.
✓	Satisfied (S)	✓	✓.	✓.	✗	✗.	✗.	?
✓.	Partially Satisfied (PS)	✓.	✓.	✓.	✗.	✗.	✗.	?
↯	Conflict (C)	↯	↯	↯	↯	↯	↯	?
?	Unknown (U)	?	?	?	?	?	?	?
✗.	Partially Denied (PD)	✗.	✗.	✗.	✓.	✓.	✓.	?
✗	Denied (D)	✗	✗.	✗.	✓.	✓.	✓.	?

Propagation Rules

Contributions from a Mixture of Link types

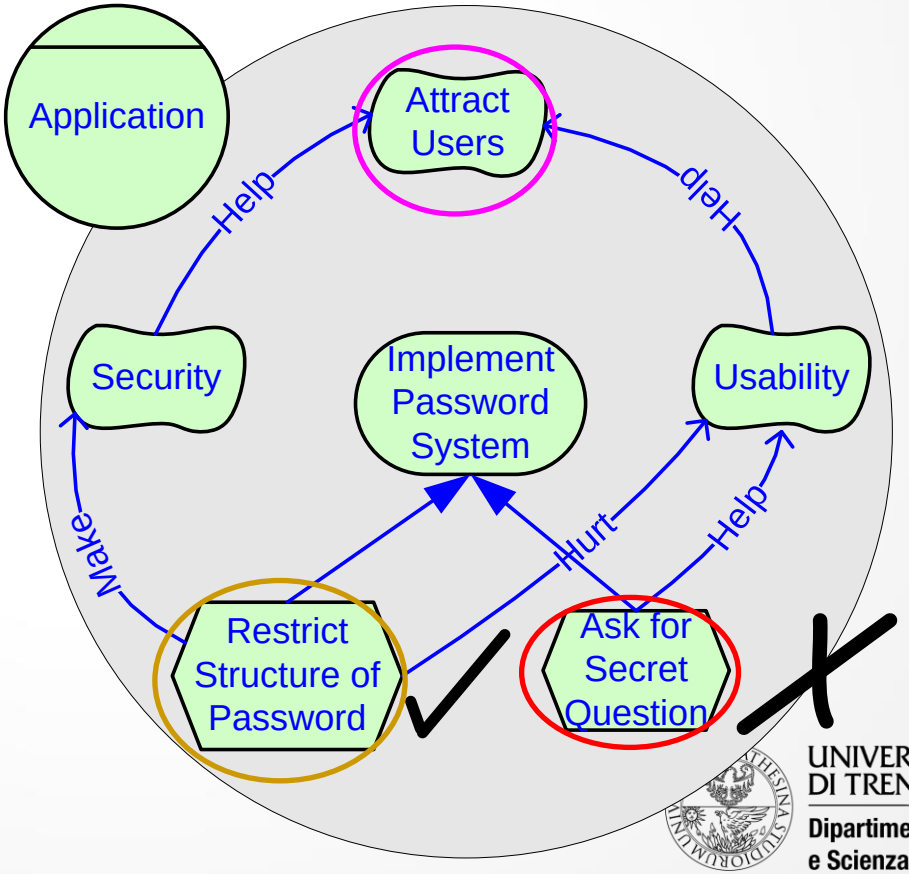
- It is common in i* to see a single element involved in more than one type of link relationship.
- When dependency links are mixed with means-ends or decomposition links the results of each individual link type are combined with an And relationship.



- In the case of mixing contribution links and dependency links it is recommended that the dependency is treated as an additional contribution, such as would be made by a make link.

Example: Forward i* Evaluation

- evaluation based on an analysis question:
  - If the Application implements Restrict Structure of Password, but not Ask for Secret Question, what effect will this have on Attract Users?
- Place Initial Labels reflecting Analysis Question



Example: Forward i* Evaluation

- Propagate labels
- Resolve labels
- Iterate on the above steps until all labels have been propagated

Human Intervention

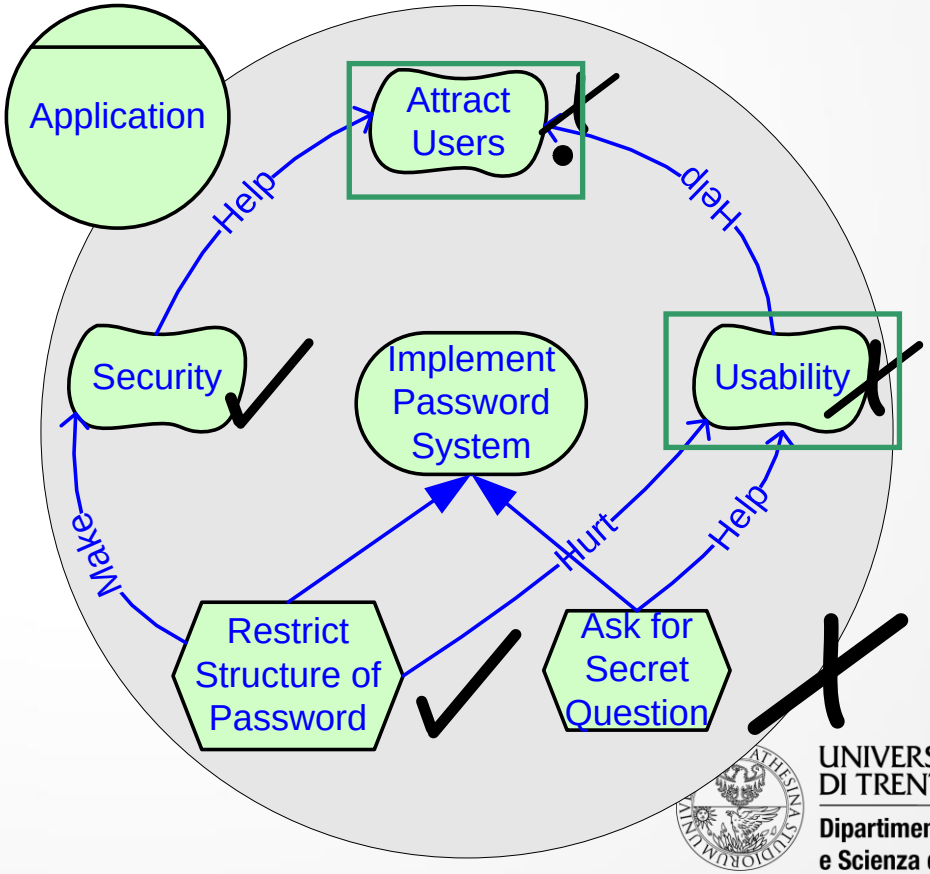
Usability Receives the following Labels:

Partially denied from **Restrict Structure of Password**

Partially denied from **Ask for Secret Question**

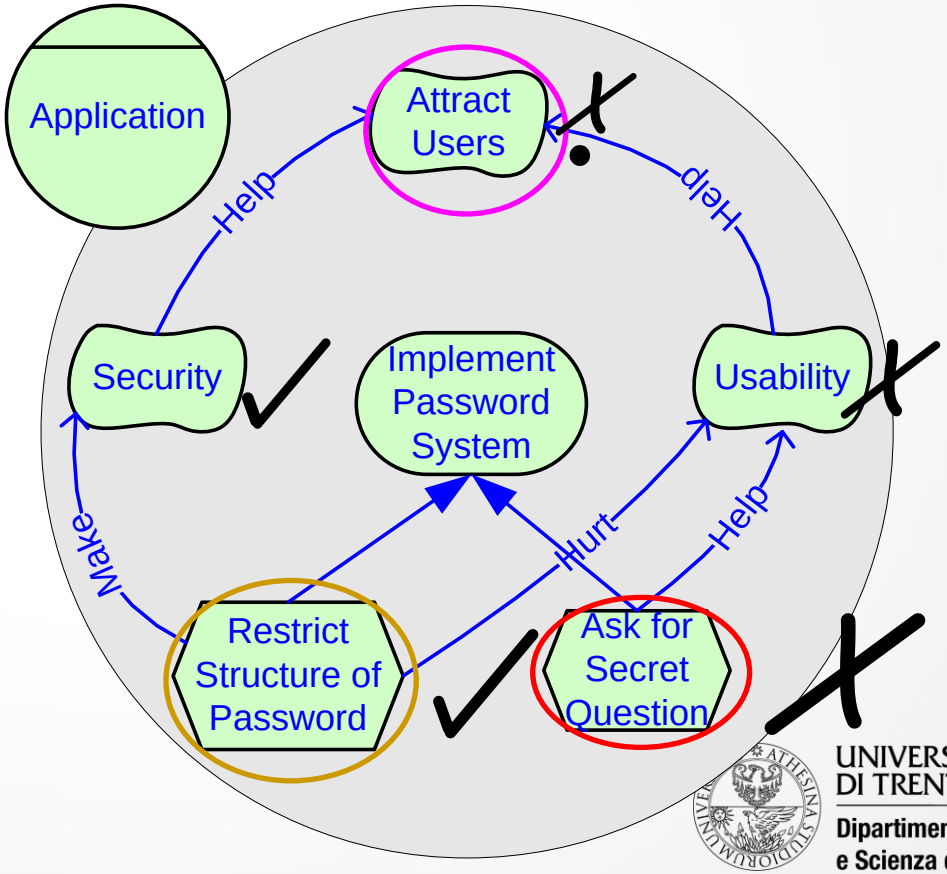
Select Label…

Select denied



Example: Forward i* Evaluation

- Analyze result
  - If the Application implements Restrict Structure of Password, but not Ask for Secret Question, Attract Users is partially denied, as Usability, considered important by the evaluator, is denied.
  - This is not a viable design alternative.
- Next Steps:
  - Repeat with new analysis question…



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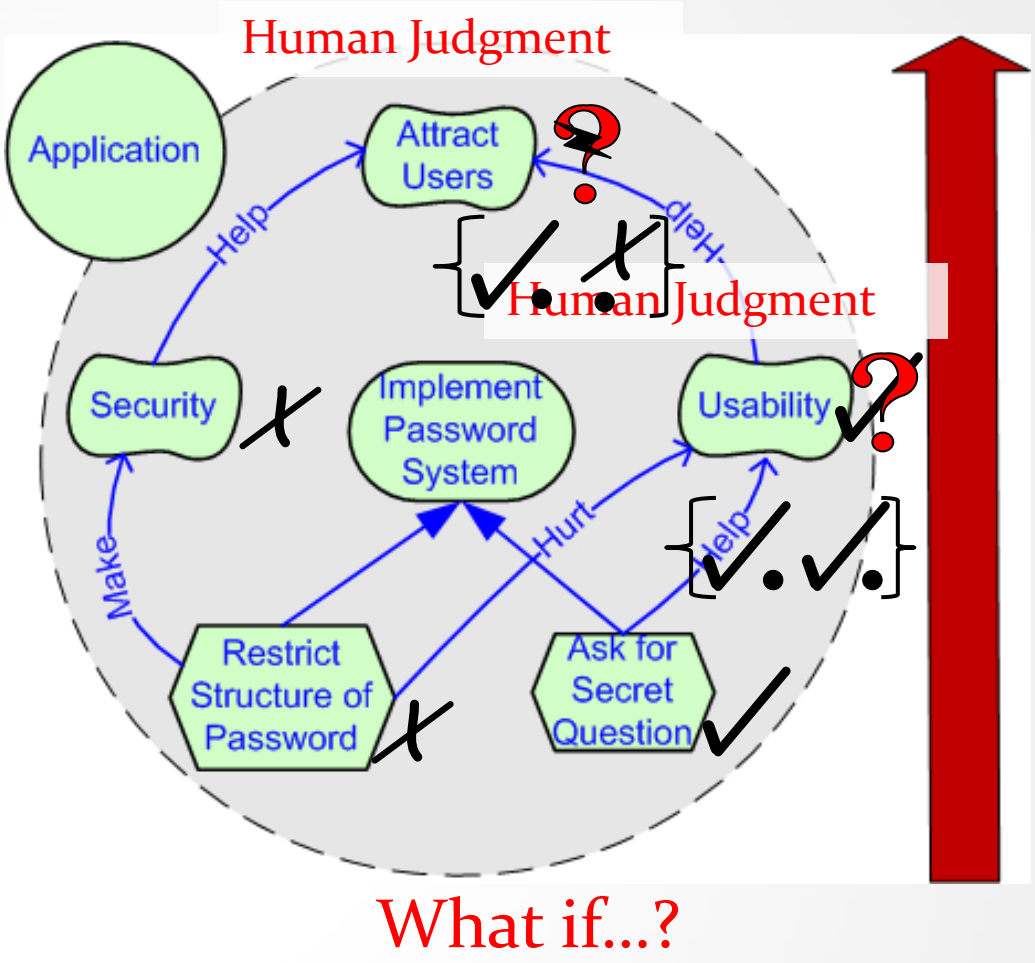
Example 2

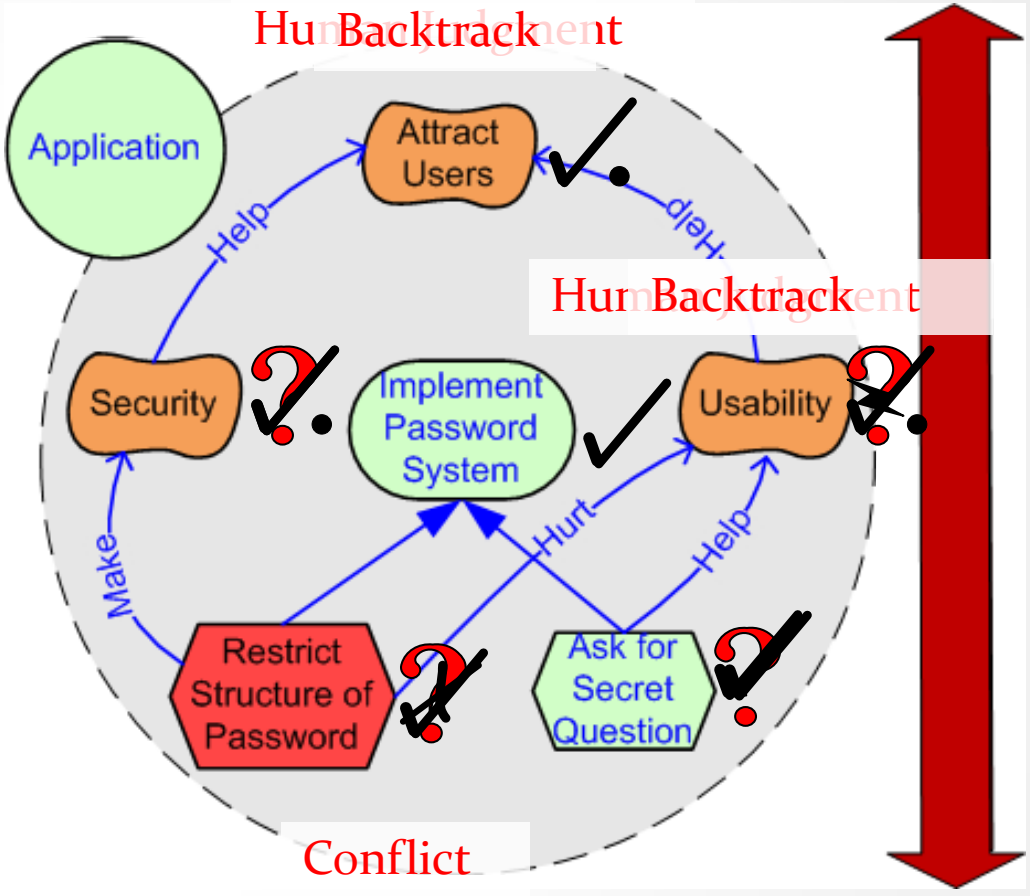
- Analysis question captured via initial labels
- Effects of selection are propagated "forward" through model links
- Interactive: user input (human judgment) is used to decide on partial or conflicting evidence "What is the resulting value?"



[Horkoff & Yu, Caise'09, PoEM'09, IJISMD'10]

Iterative, Interactive, Backward Satisfaction Analysis

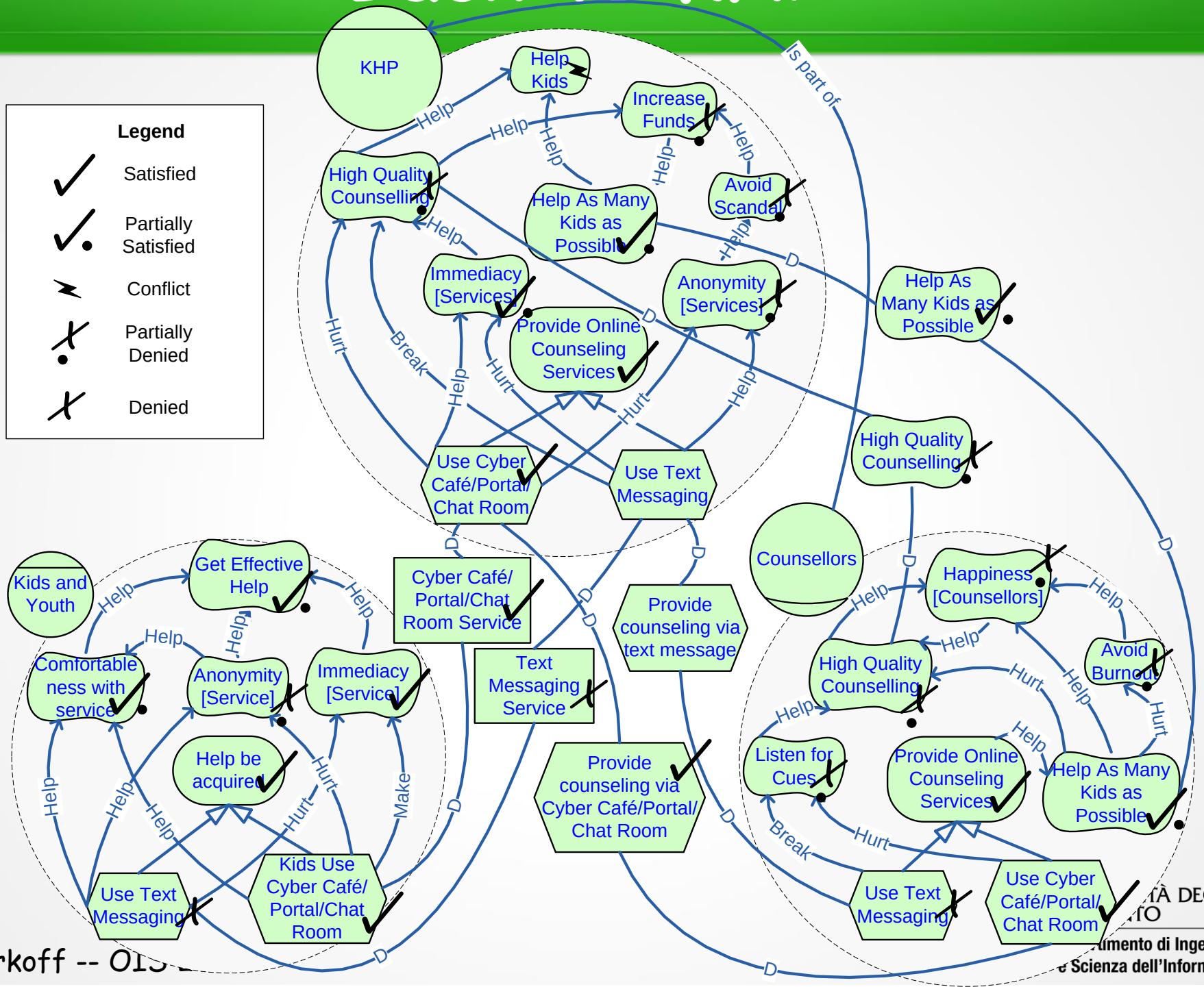
- Target(s) are propagated "backward" through model links
- Asks for human judgment "What incoming values could produce the target value?"
- Model is iteratively encoded in CNF and passed to a SAT solver



Is this possible...? How?

[Horkoff & Yu, iStar'08, ER'10, REJ]

Back to KHP



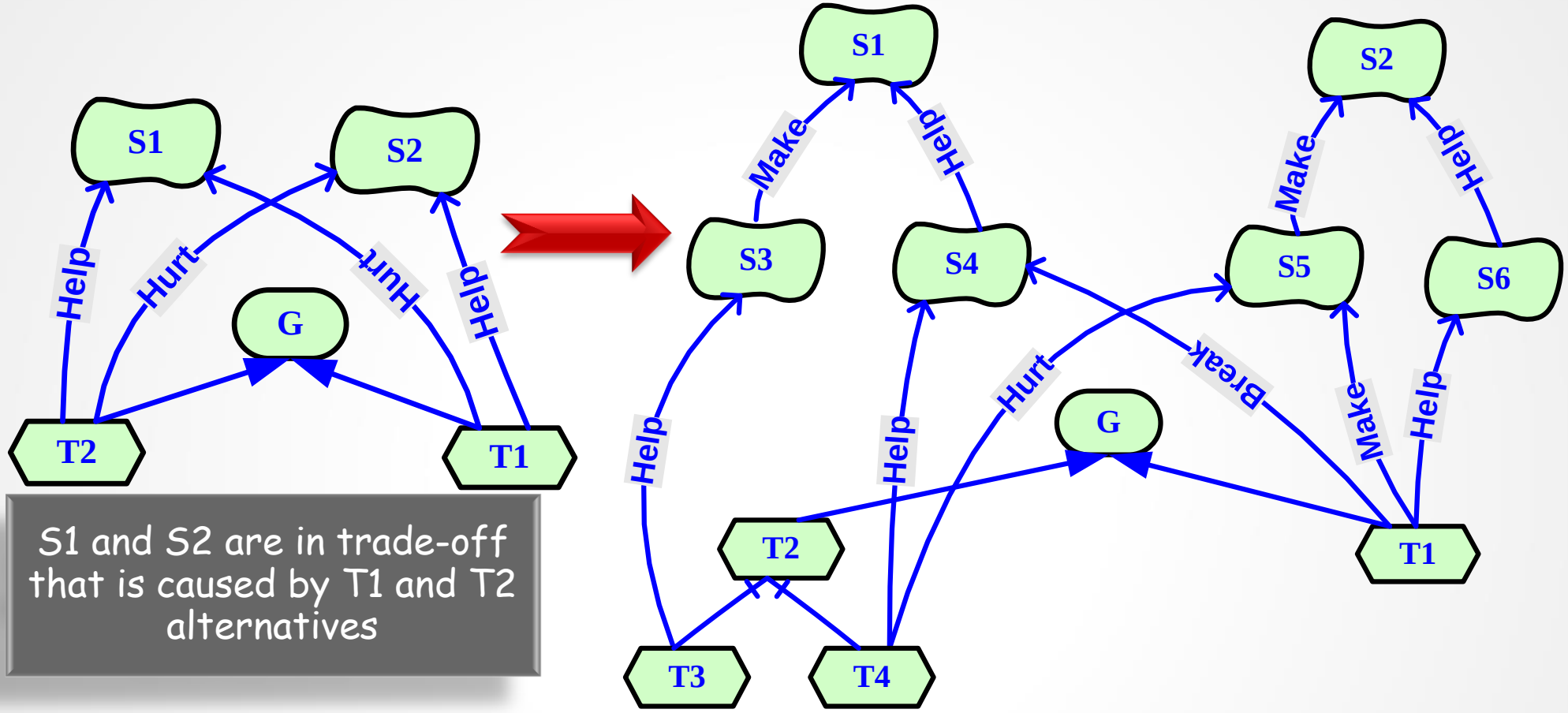
A Methodology for Goal Model Creation and Analysis

Apply the following steps iteratively:

- **Stage 1: Purpose and Elicitation**
  - Identify scope or purpose of the modeling process.
  - Identify modeling participants and/or model sources.
- **Stage 2: Model Creation**
  - Identify relevant actors and associations.
  - Identify relevant dependencies.
  - Identify actor intentions.
  - Identify relationships between intentions.
- **Stage 3: Analysis**
  - Alternative Effects (Forward Analysis)
    - Identify all leaf intentions in the model, evaluate:
      - Implementing as much as possible.
      - Implementing as little as possible:
      - Reasonable Implementation Alternatives.
  - Achievement Possibilities (Backward Analysis)
    - Identify all roots in the model, evaluate:
      - Maximum targets.
      - Minimum targets.
      - Iteration over minimum targets.
  - Domain-Driven Analysis (Mixed)
    - Use the model to answer interesting domain-driven questions.

Horkoff & Yu, PoEM'09, IJISMD'10

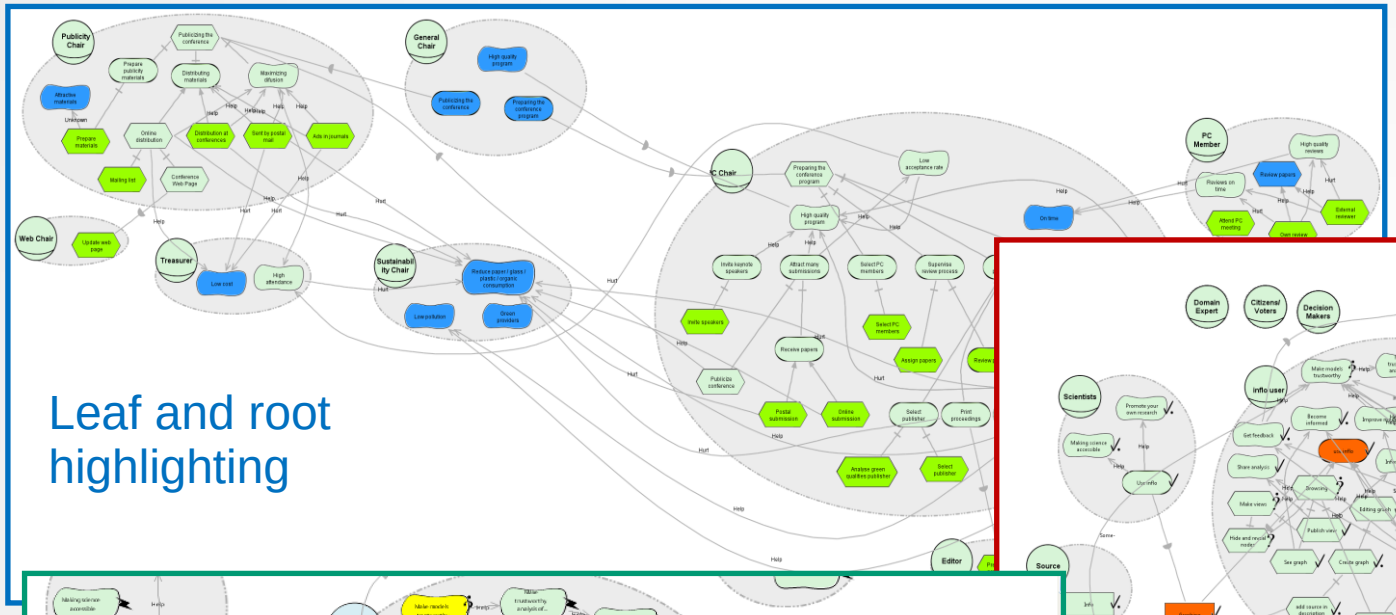
Trade-off Analysis



Alternatives	S1	S2	S3	S4
Depending on WiFi Signals	✓	✓	✗	✓●
Depending on RFID	✓●	✓●	✓	✗

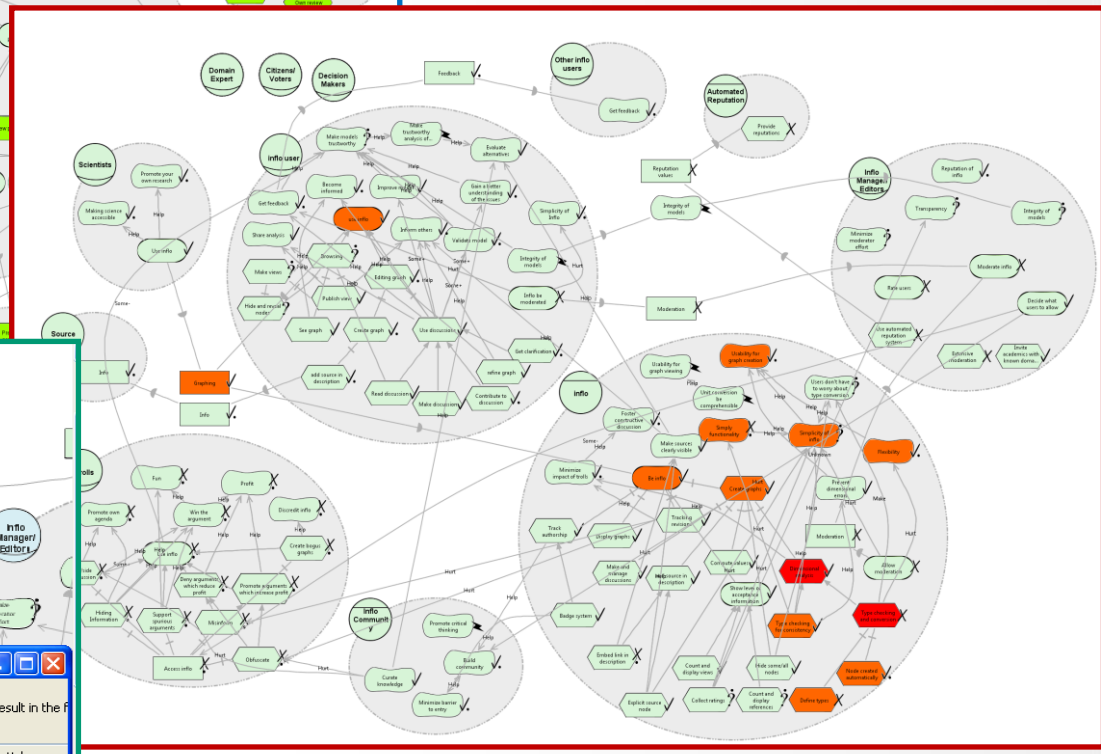
Elahi & Yu

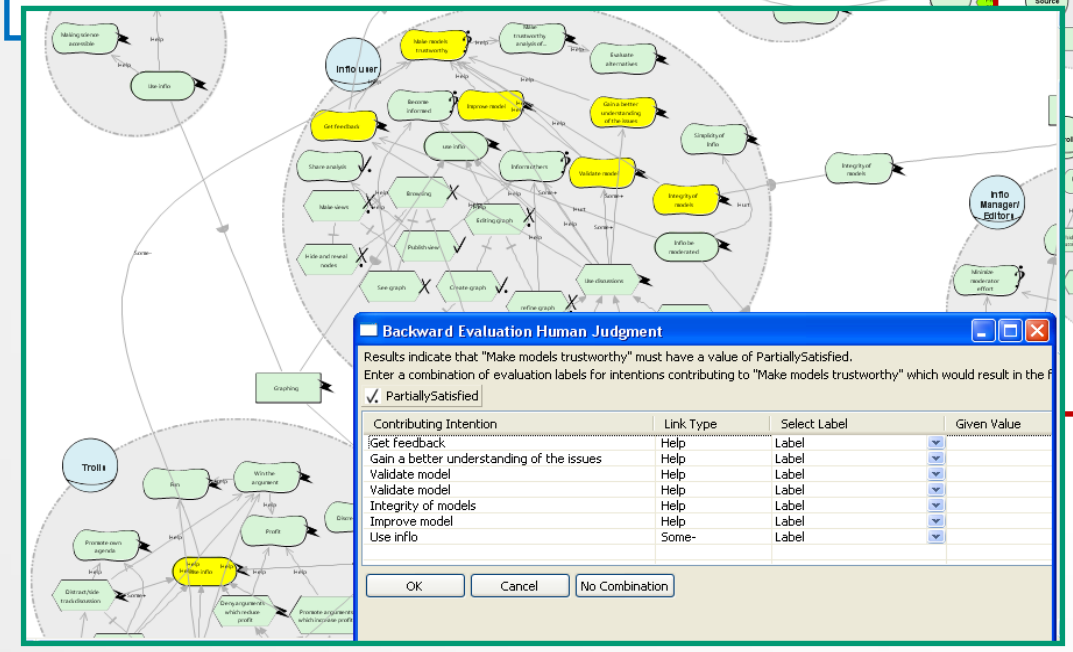
OpenOME: Visualization Techniques for Analysis



Leaf and root highlighting

Conflict highlighting





Human judgment highlighting

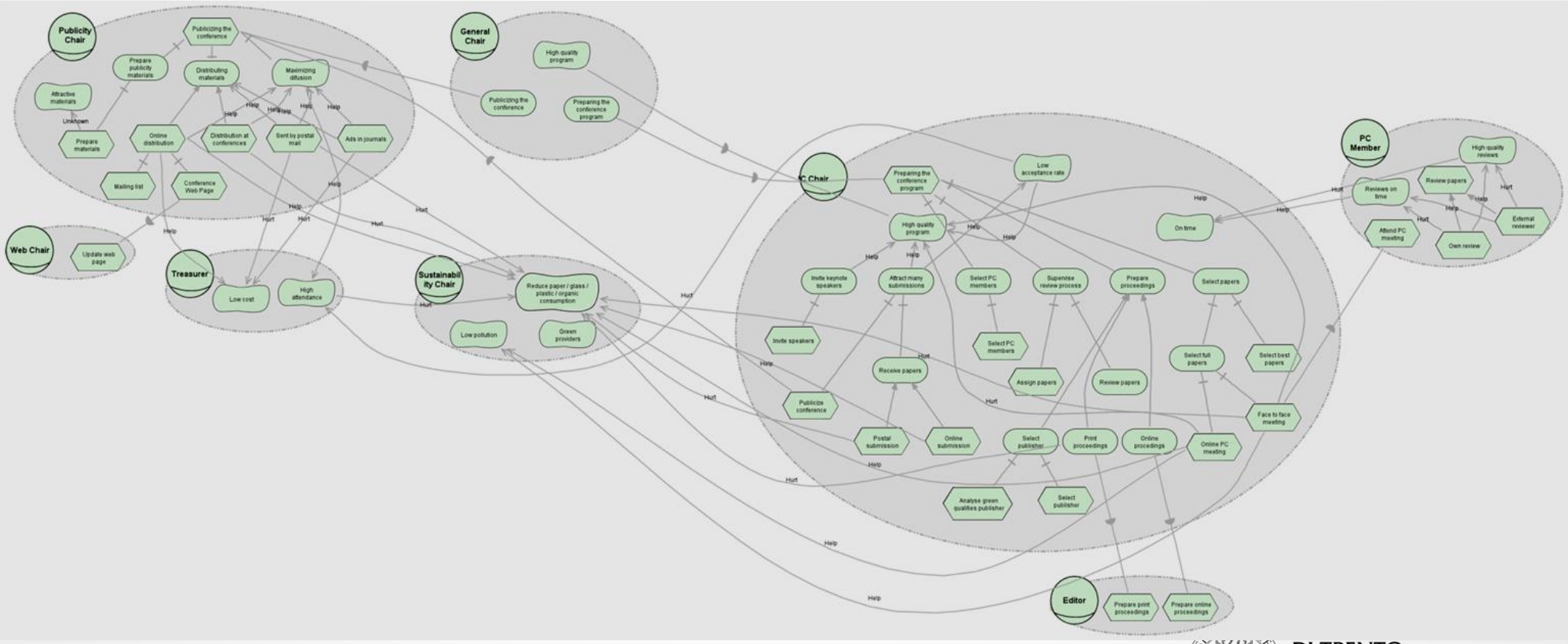
Horkoff & Yu, REV'10

Starting Points for Analysis

- How or where to start analysis
- Suggested analysis methodology
  - Start forward analysis by identifying leaf intentions
  - Start backward analysis by identifying root intentions
  - i* models are not like regular tree-shaped graphs:
    - Some links do not have an obvious direction
    - Easy to ignore links across actor boundaries
    - Cycles leads to non-conventional layout

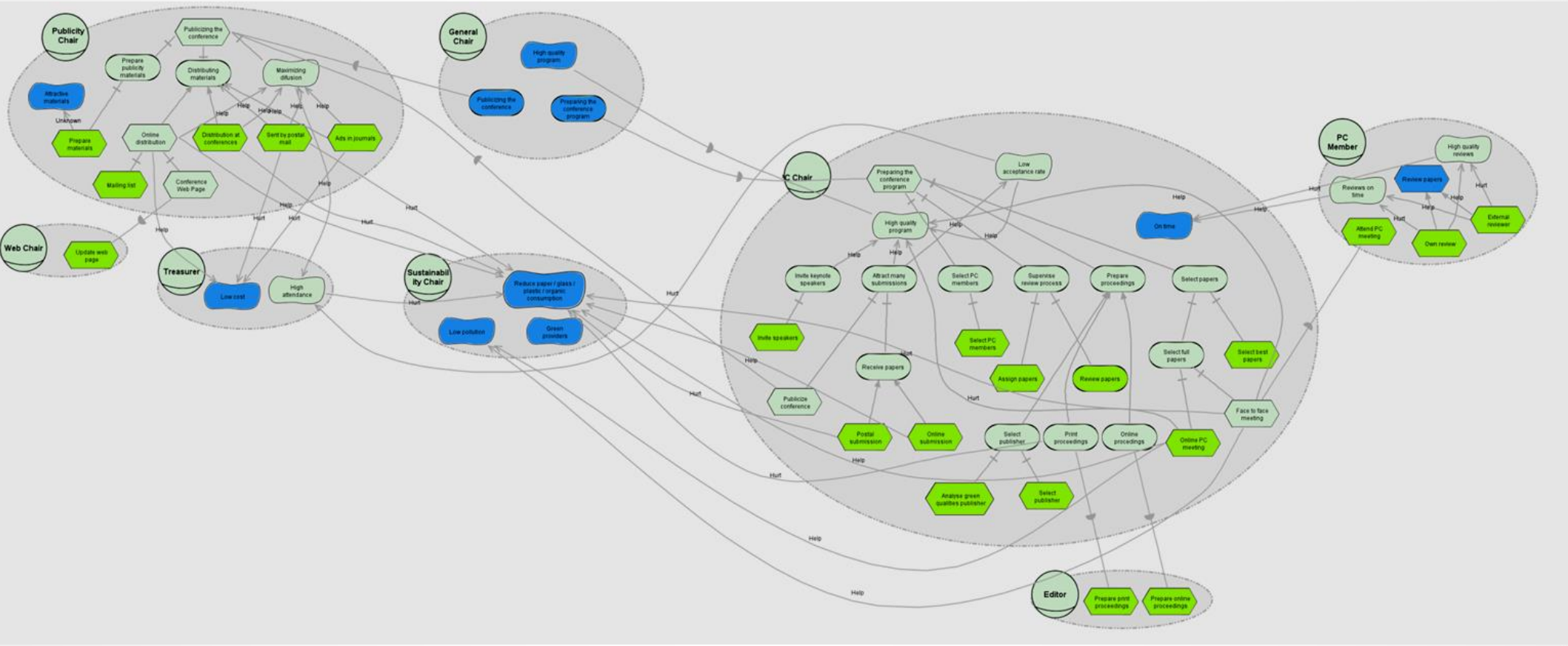
Challenge: Where are the Leaves and Roots?

- Example from individual study: conference sustainability PC and Publicity Chair
- Leaf: an intention that has no "incoming" links



Visual Intervention: Automatic Leaf and Root Intention Highlighting

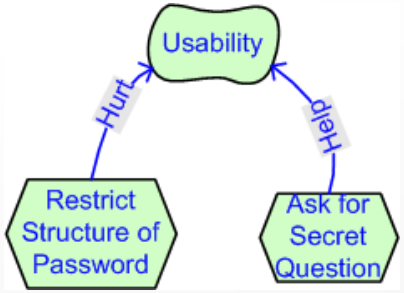
- OpenOME implementation has "Mark Model Leaves" (green) or "Mark Model Roots" (blue) options



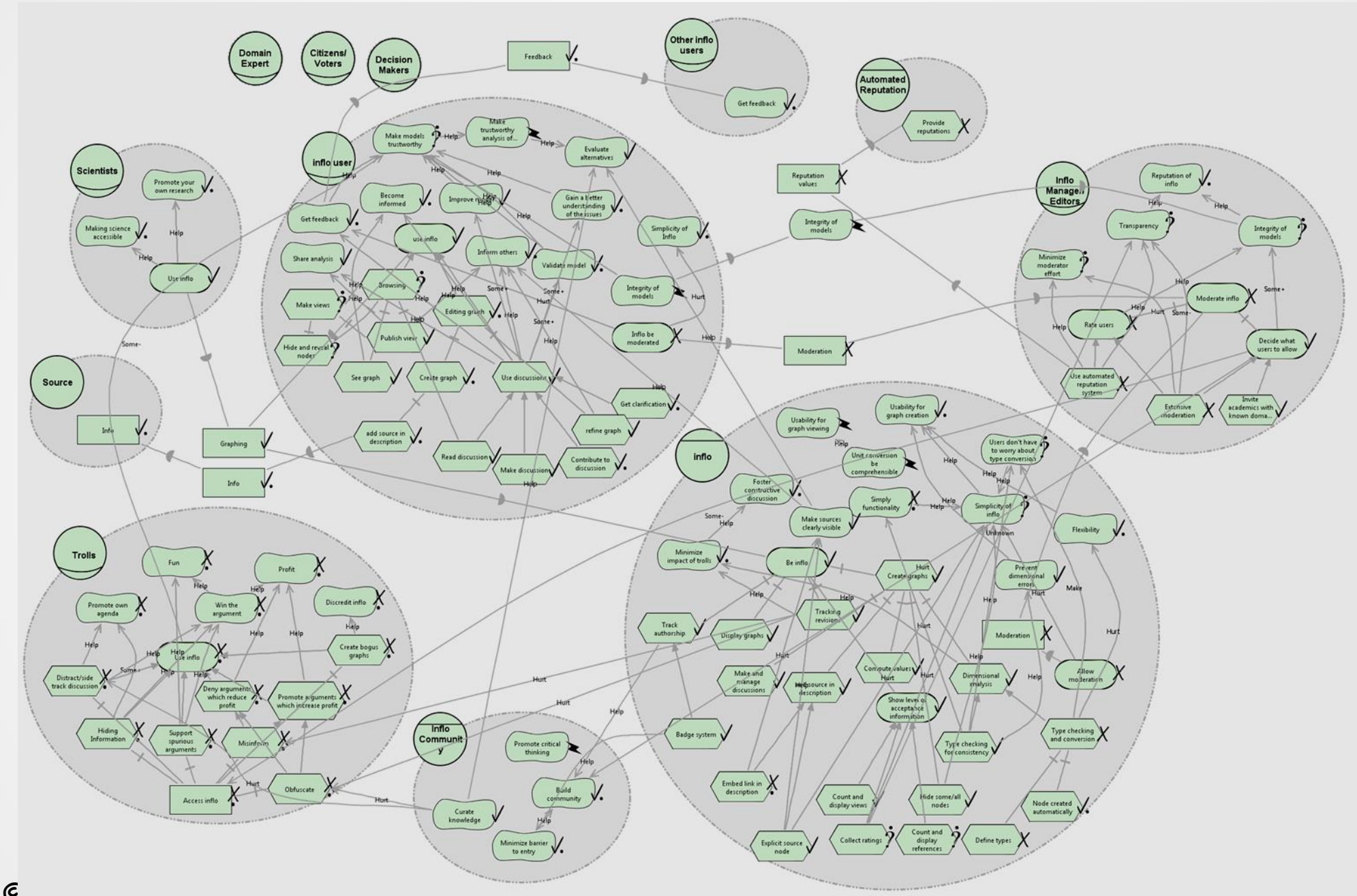
Challenge: Understanding Conflicts

- Conflict: the case where the SAT solver used in the backward analysis procedure cannot find a solution over a CNF model encoding
  - For one or more intentions, i, both v(i) and not v(i) hold, where v is an analysis value, e.g. S(i) and not S(i)

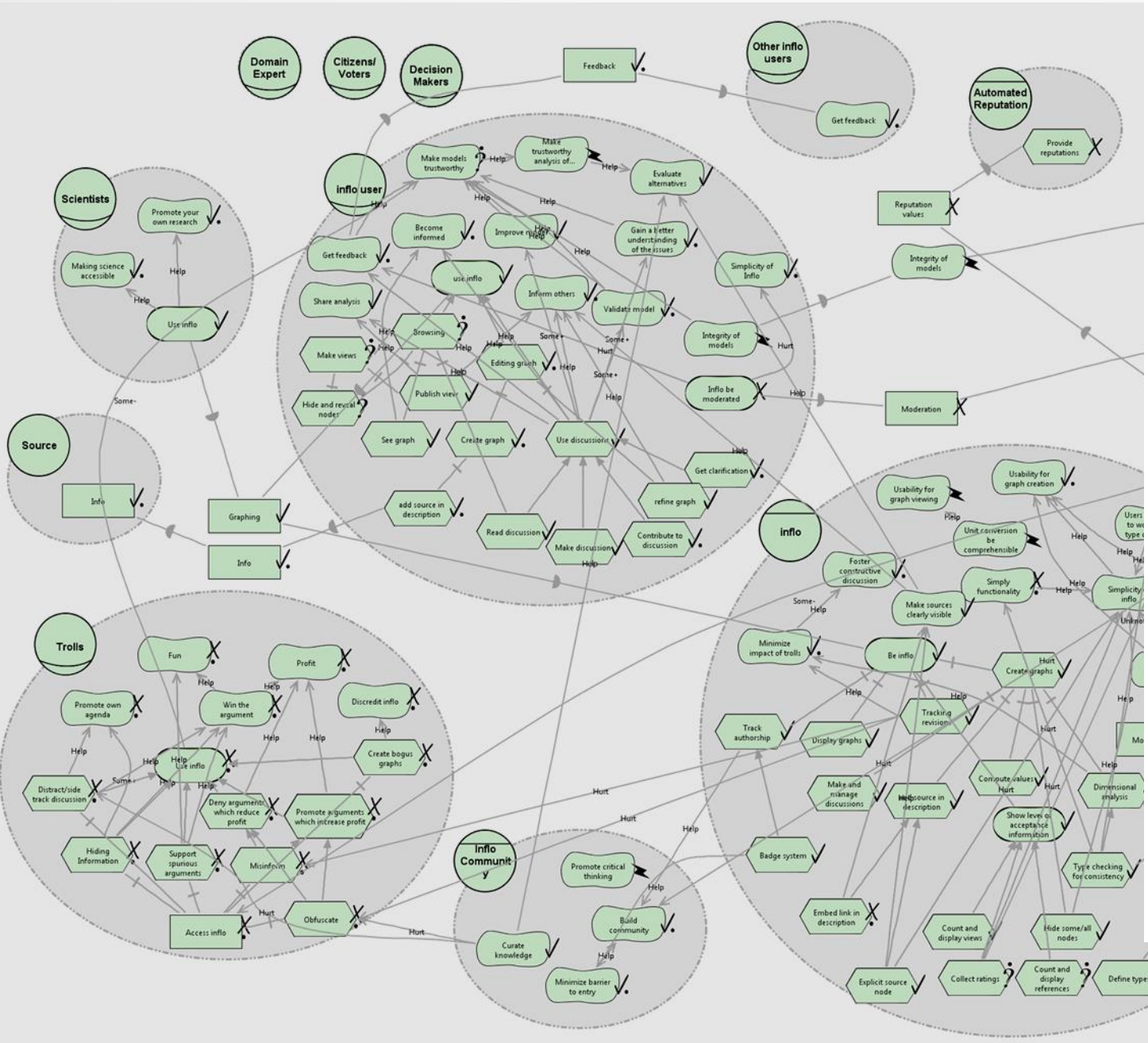
- "Conflict" in goal modeling is an overloaded term
  - There is a conflict label, meaning roughly equal amounts of positive and negative evidence
  - Two alternatives can "conflict" in relation to one goal



Challenge: Where are the Conflicts?



Challenge: Where are the Conflicts?



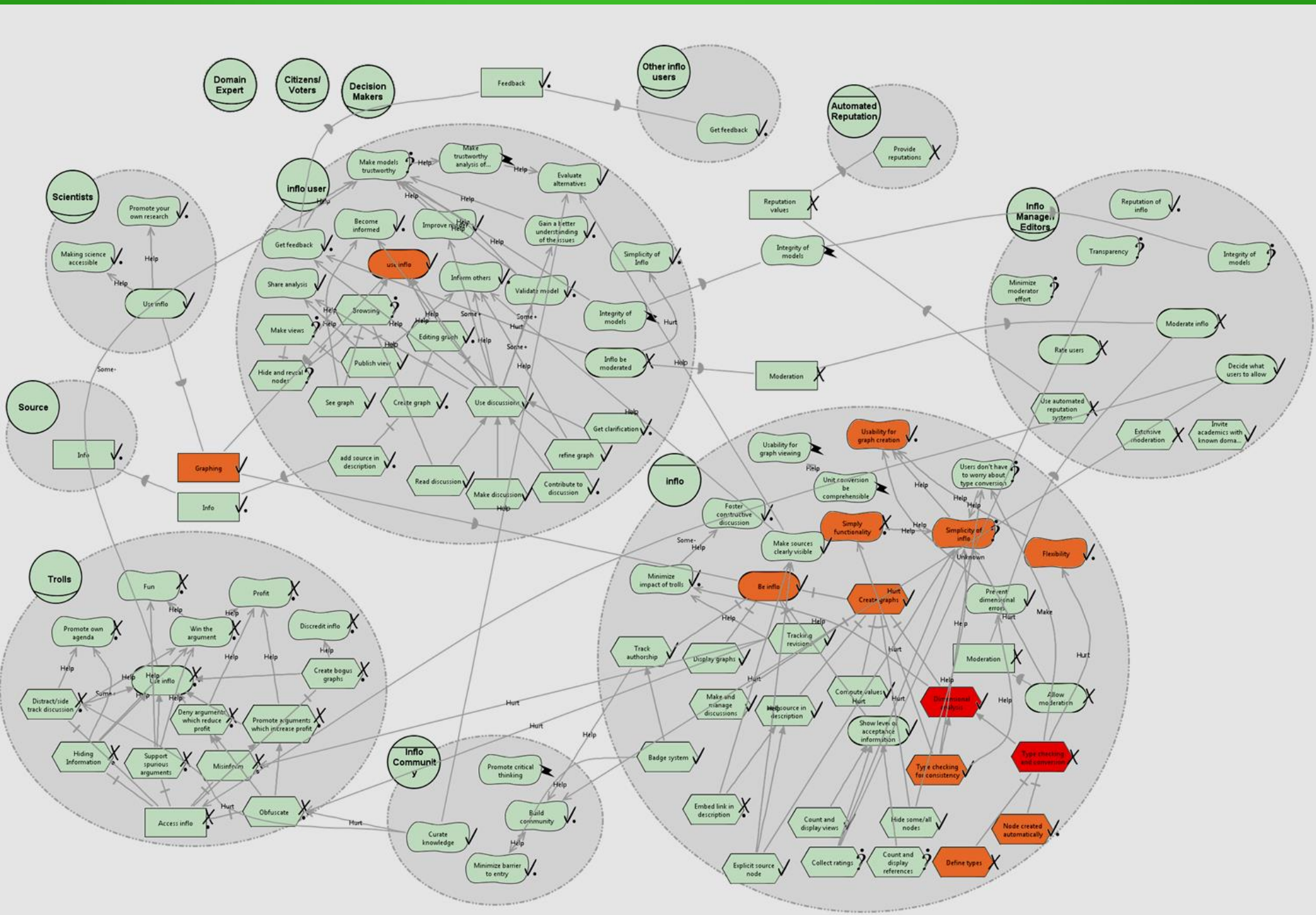
The following intention clauses are conflicting:

not PS(Simple functionality) OR PD(Type checking for consistency)
not PS(Flexibility) OR PD(Type checking and conversion)
not PS(use inflo) OR PS(Graphing)
not PS(Graphing) OR PS(Be inflo)
not PS(Be inflo) OR PS(Create graphs)
not PS(Type checking and conversion) OR PS(Node created automatically)
not PS(Type checking and conversion) OR PS(Define types)
not PD(Type checking and conversion) OR PD(Node created automatically) OR PD(Define types)
not PS(Create graphs) OR PS(Dimensional analysis)
not PS(Dimensional analysis) OR PS(Type checking for consistency) OR PS(Type checking and conversion)
S(use inflo)
PS(Usability for graph creation)
not S(use inflo) OR PS(use inflo)
not PD(Define types) OR not PS(Define types)
not PD(Type checking for consistency) OR not PS(Type checking for consistency)
not PD(Node created automatically) OR not PS(Node created automatically)
not PS(Usability for graph creation) OR PS(Simplicity of inflo)
not PS(Usability for graph creation) OR PS(Flexibility)
not PS(Simplicity of inflo) OR PS(Simply functionality)

Visual Intervention: Conflict Highlighting

- Automatically find all intentions involved in clauses in the UNSAT core
  - Highlight intentions orange in the model
- Find the "logical sources of the conflict", i.e. the intentions for which v(i) is true and not true
  - Highlight intentions red in the model
- Users are presented with a list of intentions involved in the conflict
  - The assigned analysis value in the conflicting situation is displayed

Visual Intervention: Conflict Highlighting



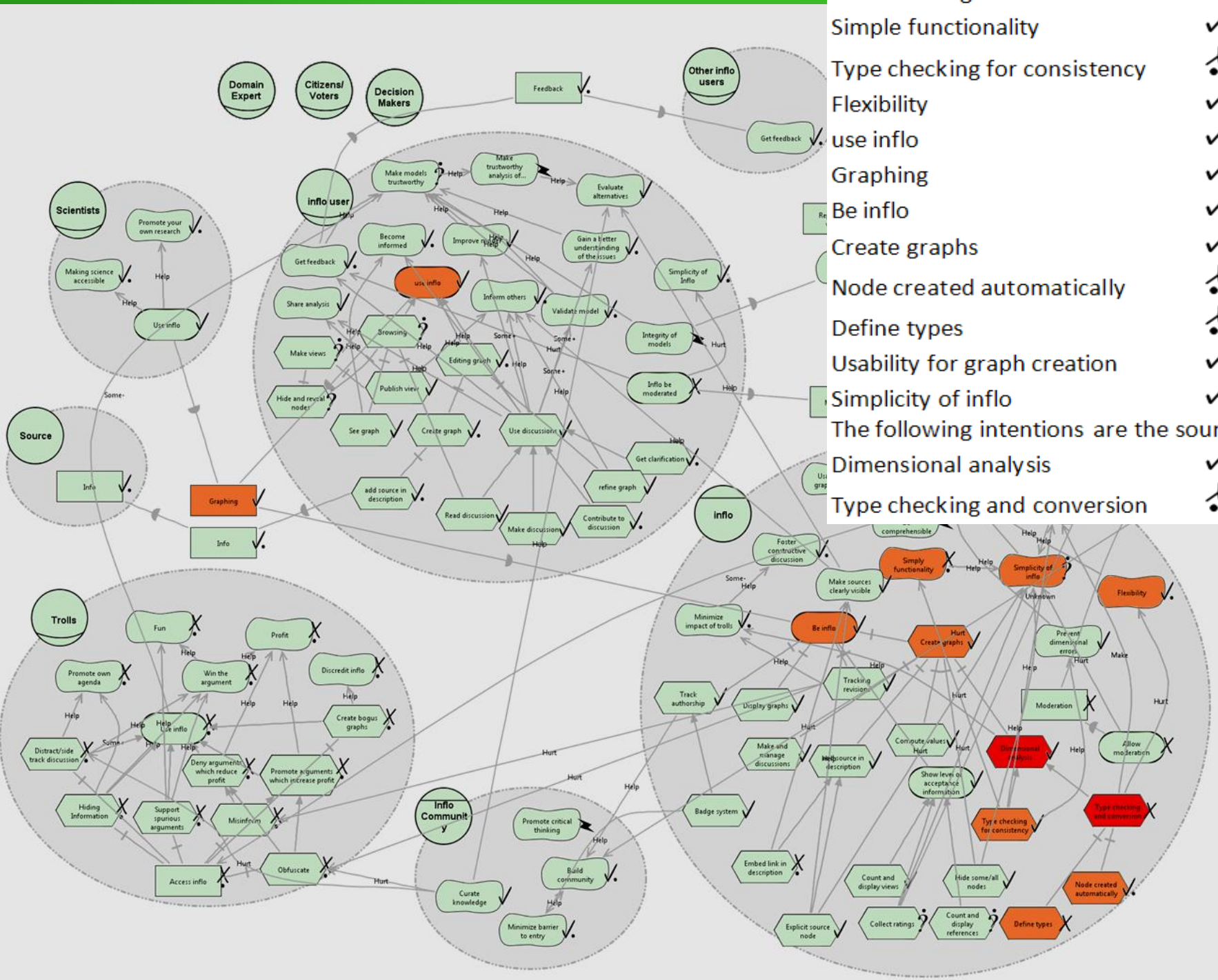
Visual Intervention: Conflict Highlighting

The following intentions are involved in the conflict:

Simple functionality	✓
Type checking for consistency	✗, ¬✓
Flexibility	✓
use inflo	✓, ✓
Graphing	✓
Be inflo	✓
Create graphs	✓
Node created automatically	✗, ¬✓
Define types	✗, ¬✓
Usability for graph creation	✓
Simplicity of inflo	✓

The following intentions are the sources of the conflict:

Dimensional analysis	✓, ¬✓
Type checking and conversion	✗, ¬✓, ✓



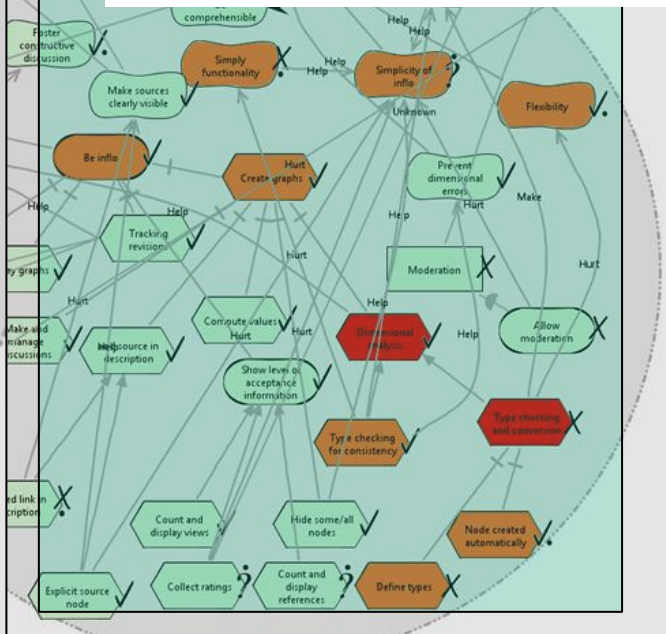
Visual Intervention: Conflict Highlighting

The following intentions are involved in the conflict:

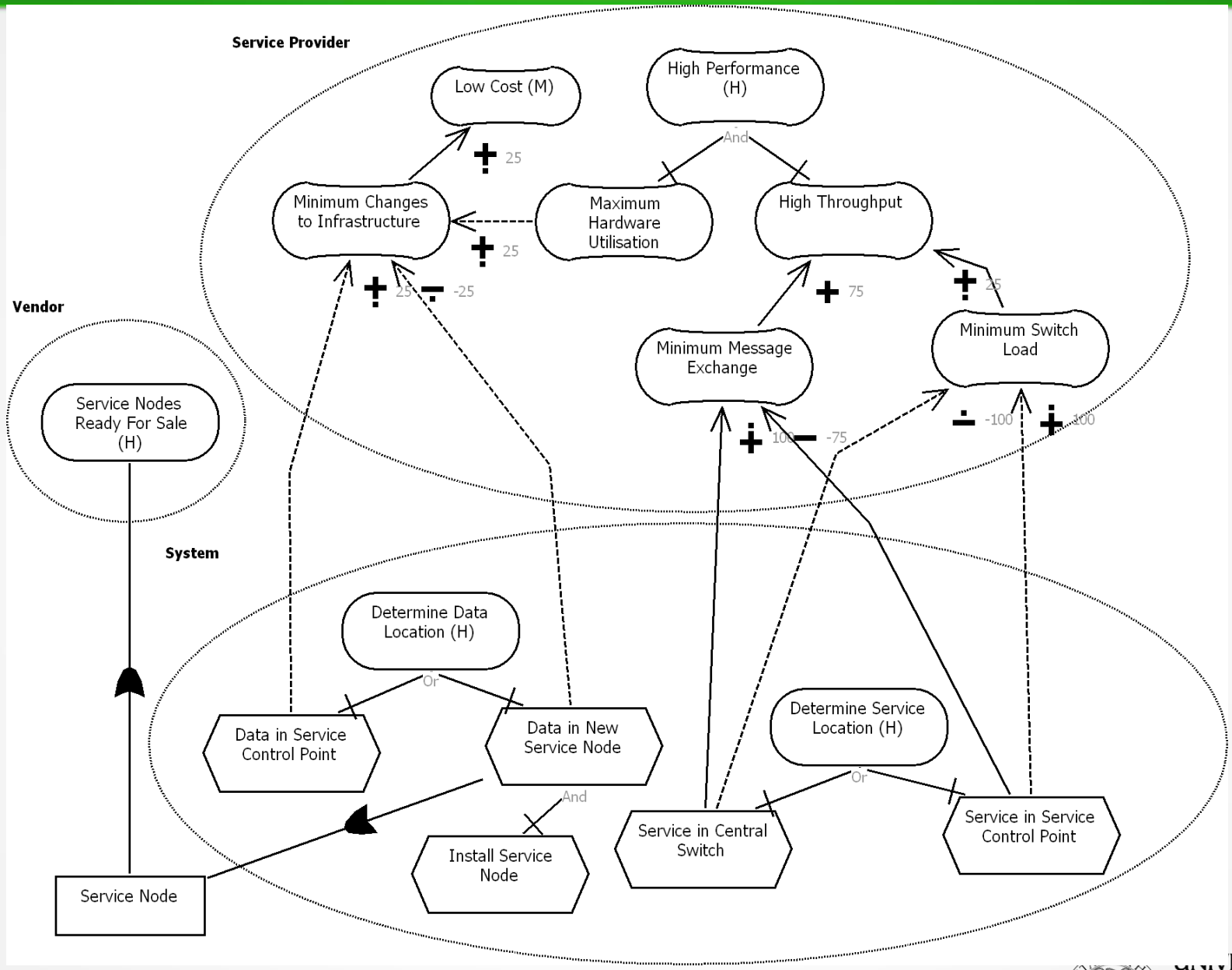
Simple functionality	✓
Type checking for consistency	✗, ¬✓
Flexibility	✓
use inflo	✓, ✓
Graphing	✓
Be inflo	✓
Create graphs	✓
Node created automatically	✗, ¬✓
Define types	✗, ¬✓
Usability for graph creation	✓
Simplicity of inflo	✓

The following intentions are the sources of the conflict:

Dimensional analysis	✓, ¬✓
Type checking and conversion	✗, ¬✓, ✓



Quantitative Evaluation



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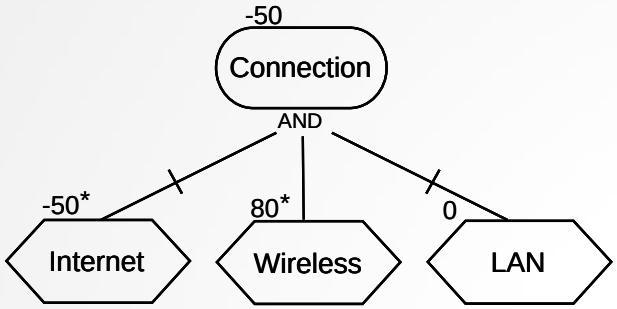
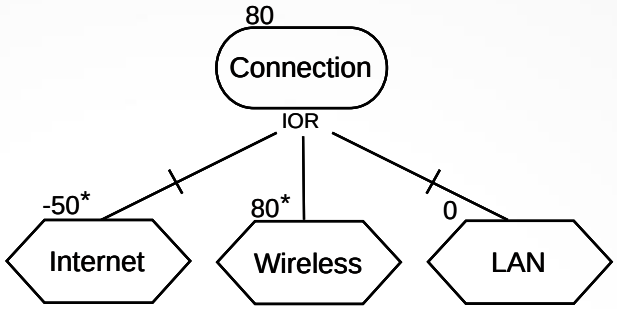
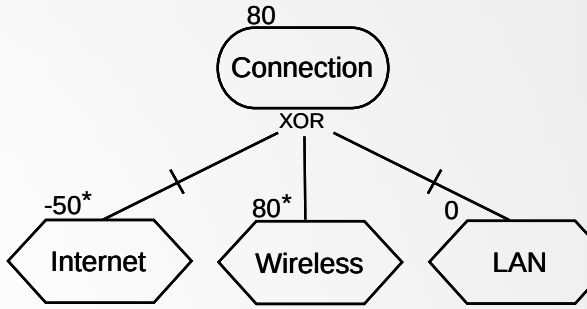
Quantitative Evaluation



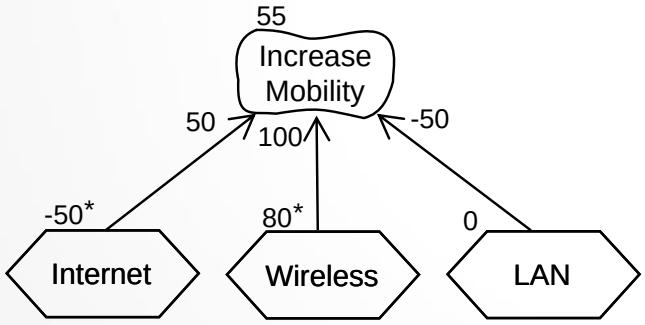
(a) AND decomposition



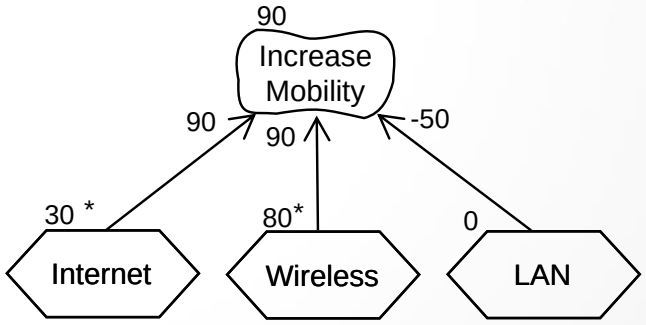
(b) IOR decomposition



(c) XOR decomposition



(a) Contributions



(b) Contributions with a tolerance of 10

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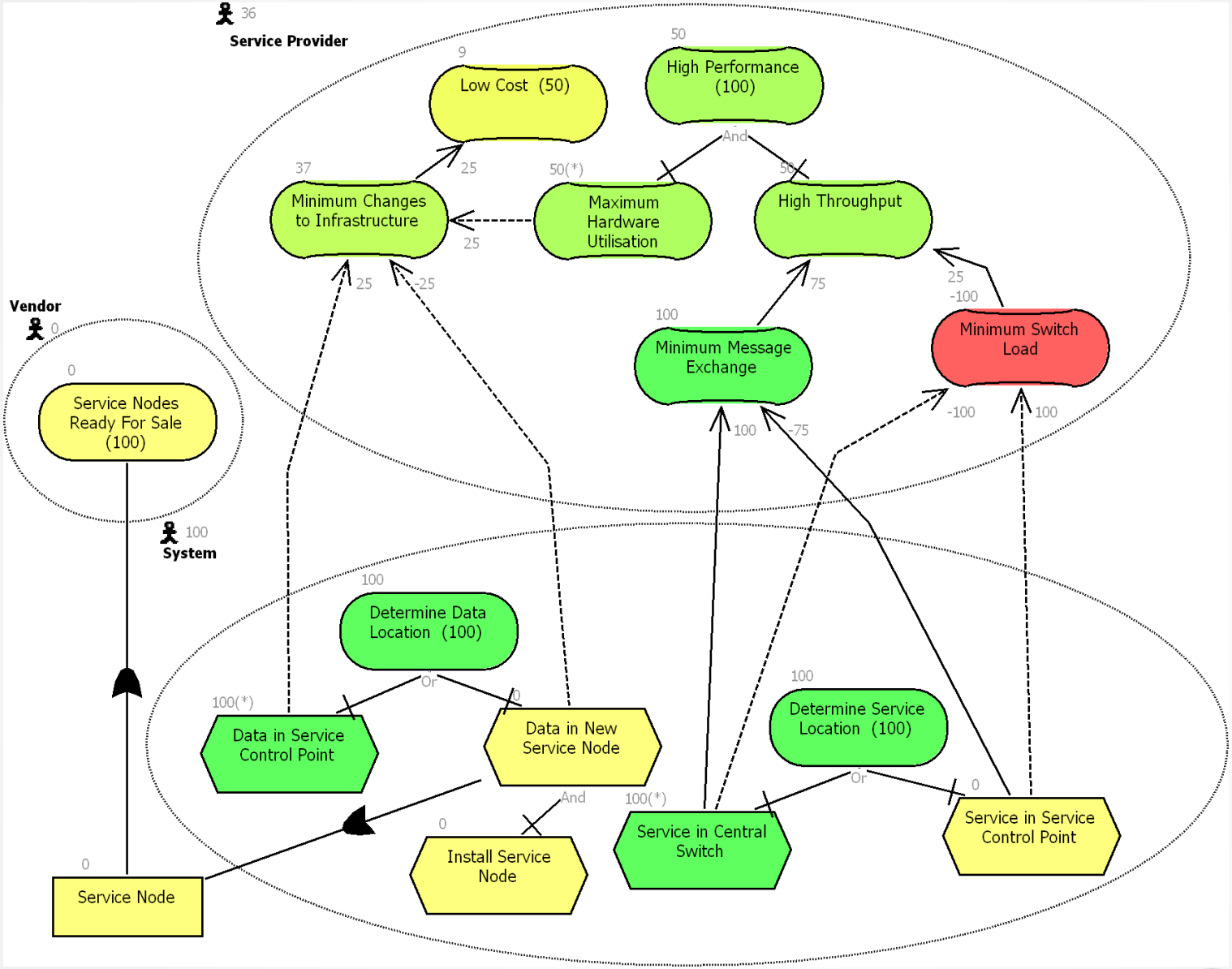
Example Evaluation 1



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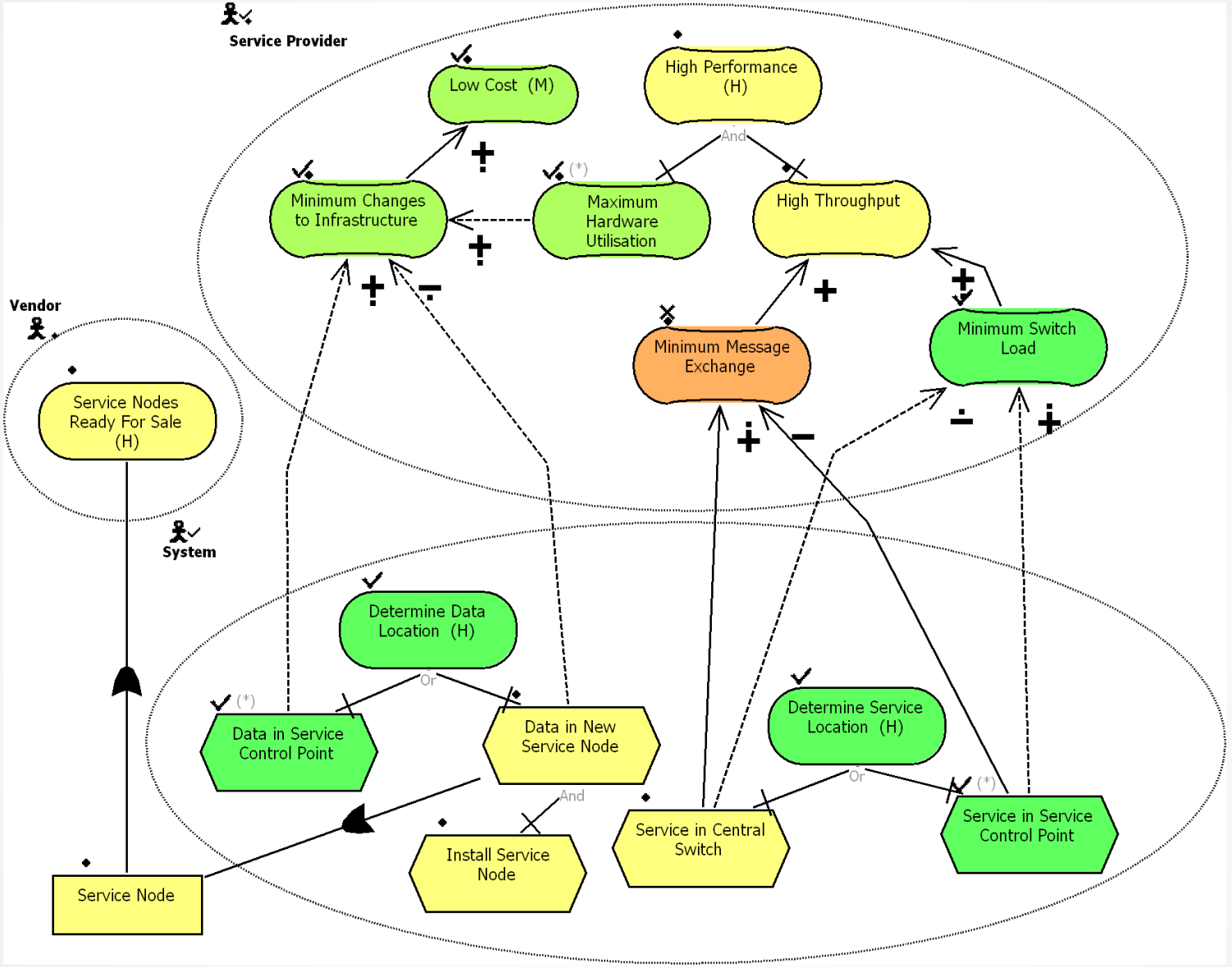
Example Evaluation 2



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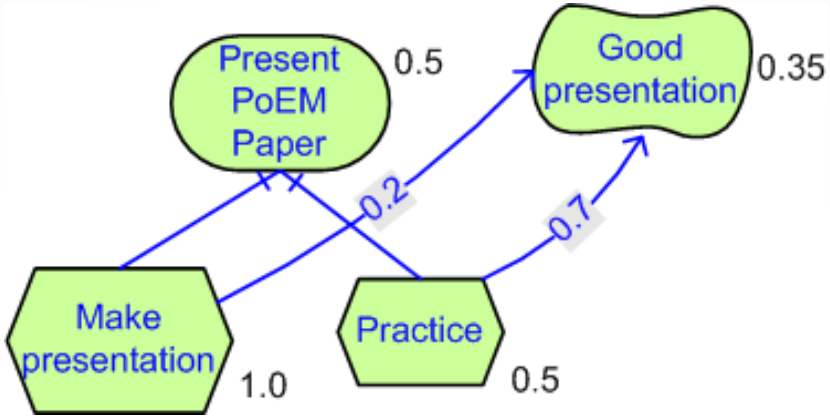
Quantitative vs. Qualitative, Automatic vs. Interactive

- Existing approaches are often:
  - Quantitative: Use numbers to express goal satisfaction
  - Automatic: Set rules are used for all propagation



- Issues:
  - Where do the numbers come from? What do they mean? How are they calculated?
  - Will stakeholders trust or understand results?
  - Will stakeholders assign mathematical precision to numbers?
  - What do we learn from the reasoning process?

Other Methods (1/2)

- Many different analysis techniques for goal models:
- Propagate satisfaction values through the model
  - What is the effect of this alternative?
  - Can this goal be satisfied?
- Measure metrics over the model
  - How secure is the system represented by the model?
  - How risky is a particular alternative for a stakeholder?

Horkoff & Yu, 2010

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Other Methods (2/2)

- Apply planning techniques
  - What actions must be taken to satisfy goals?
  - What are the best plans according to certain criteria?
- Run simulations
  - What happens when an alternative is selected?
  - Are there unexpected properties in a simulation?
- Perform checks over models
  - Is it possible to achieve a particular goal?
  - Is the model consistent?

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Part 2: Reasoning with BIM

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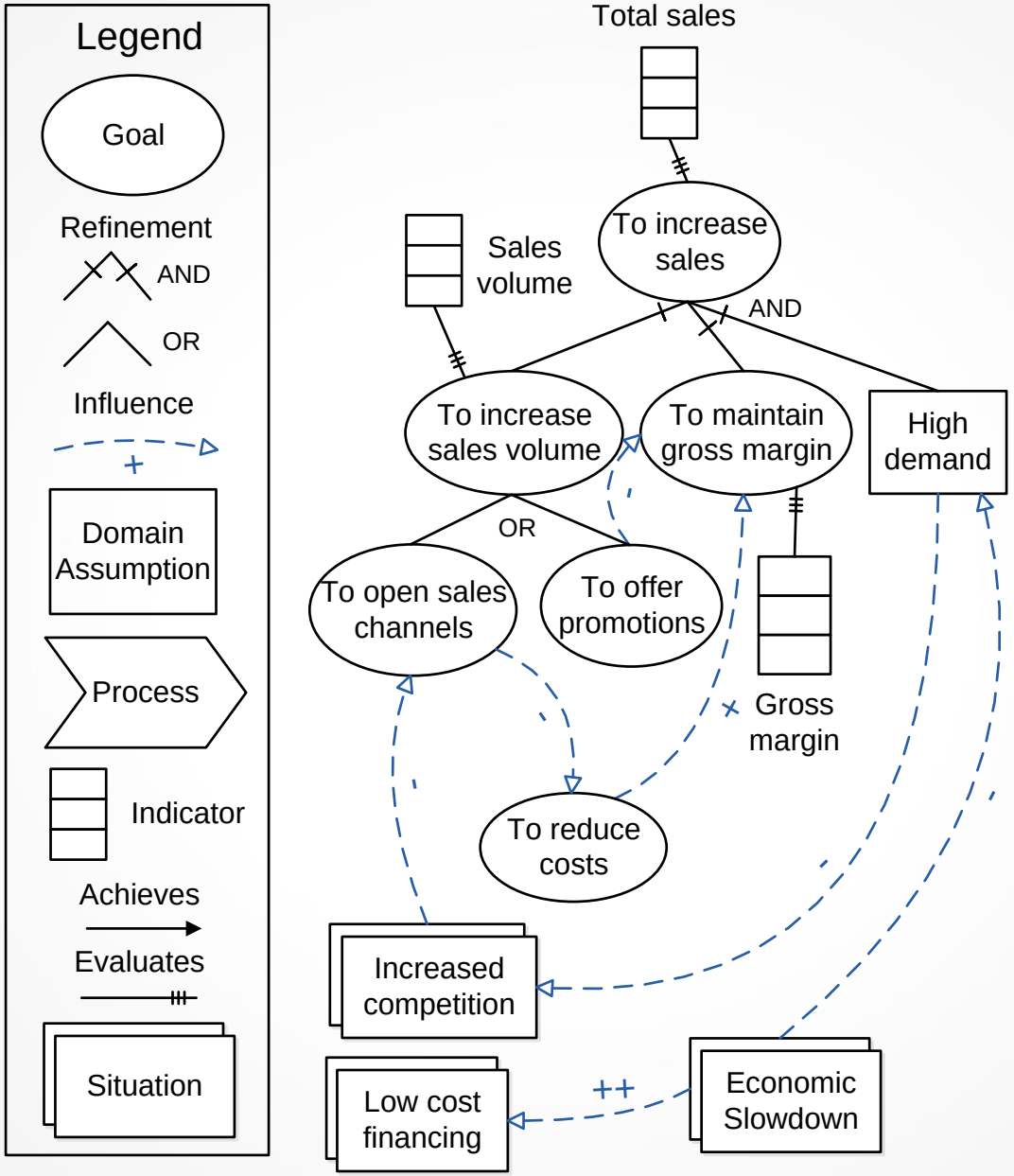
Recap: BIM



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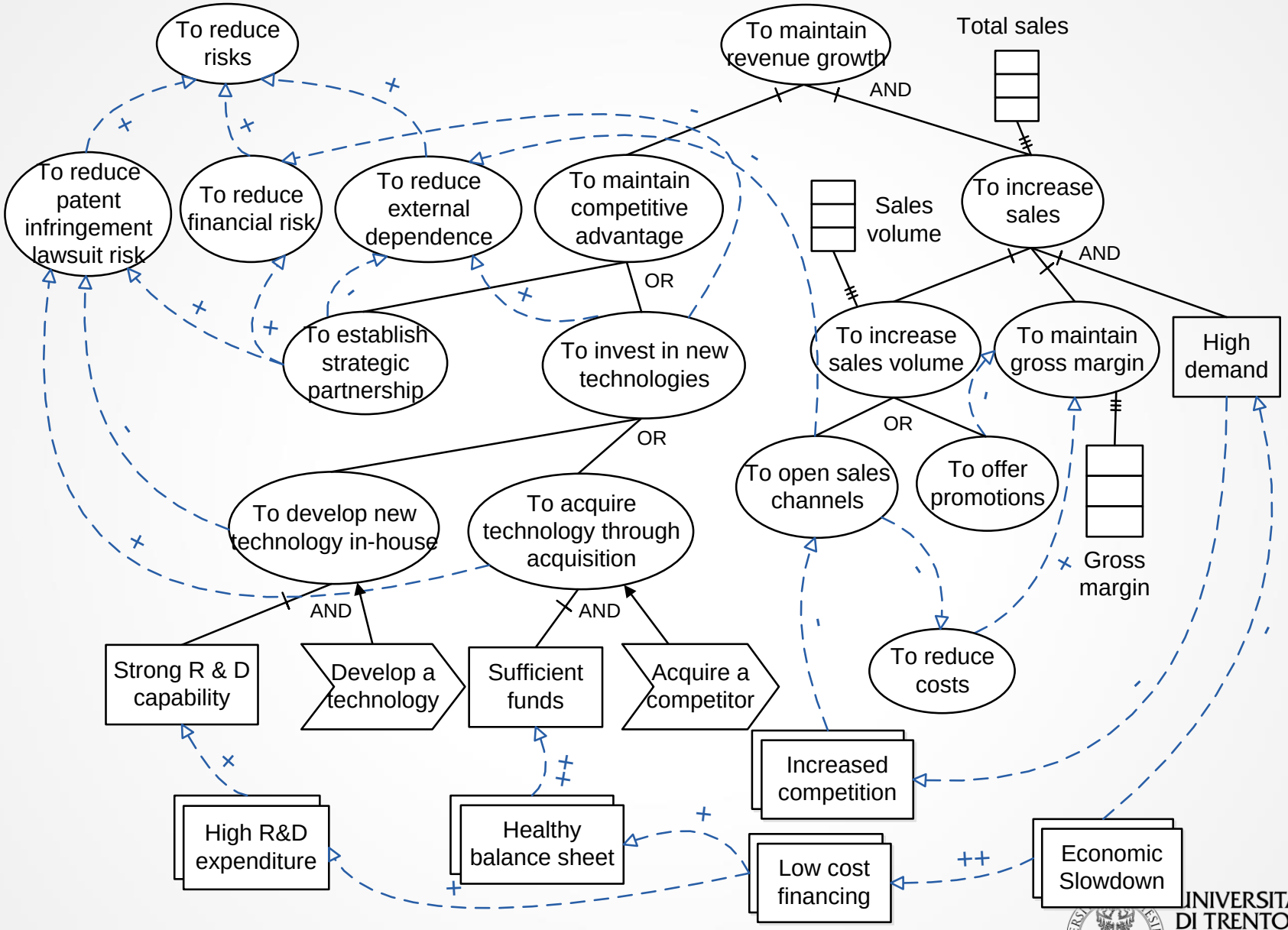
Less Simple Version



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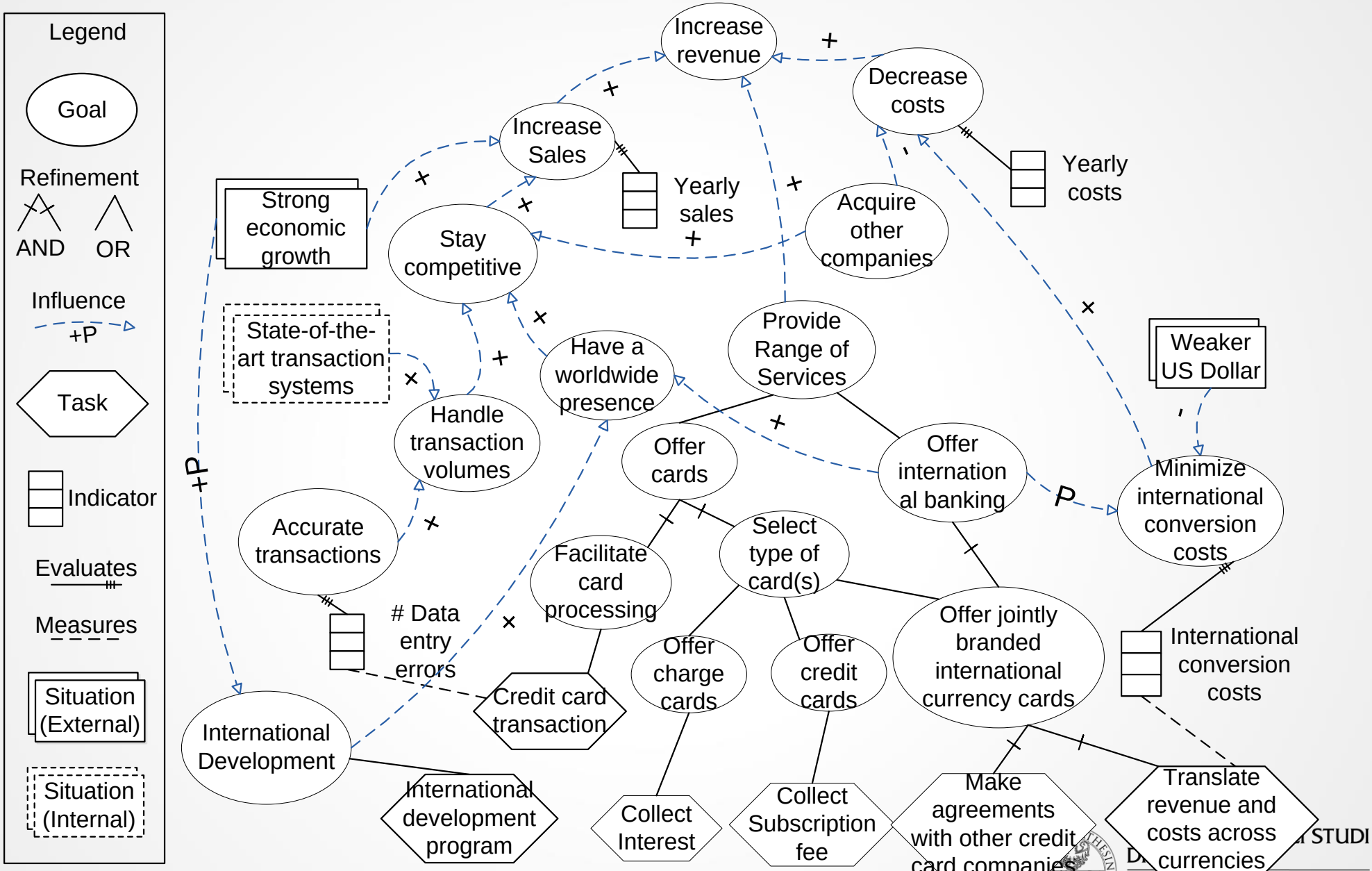
Example: Credit Card Industry Analysis



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

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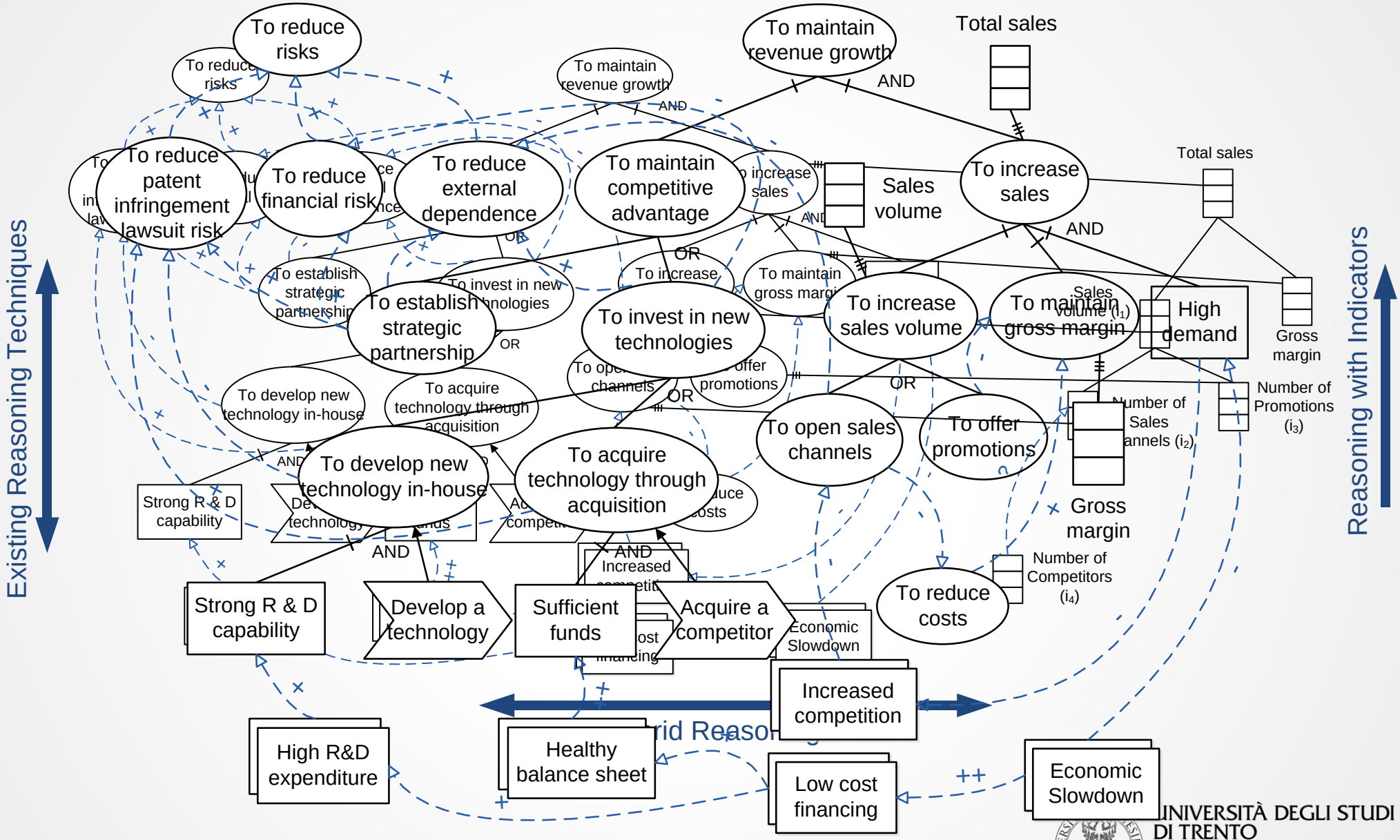
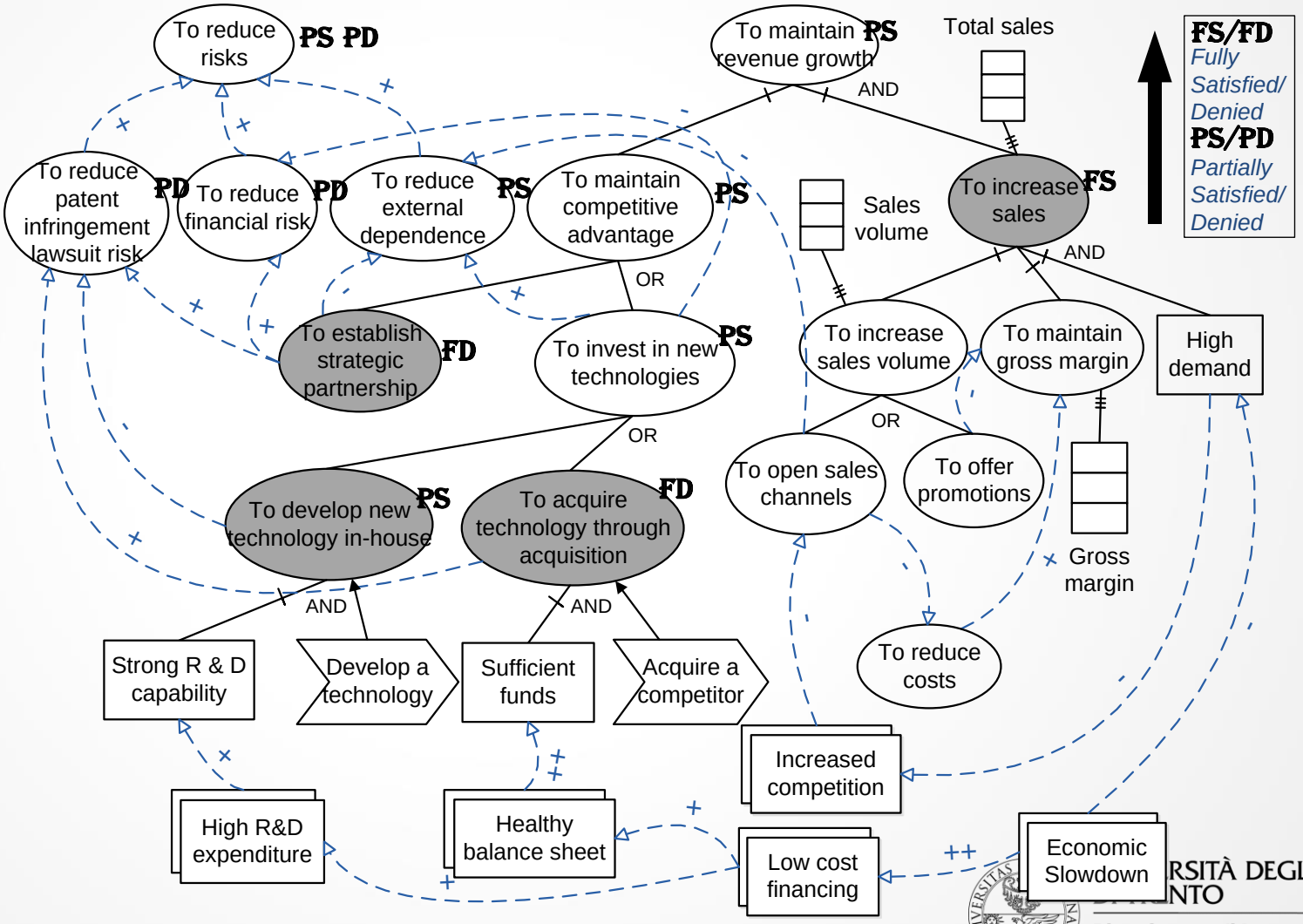
Reasoning Overview



Evaluation of Specific Strategies

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

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

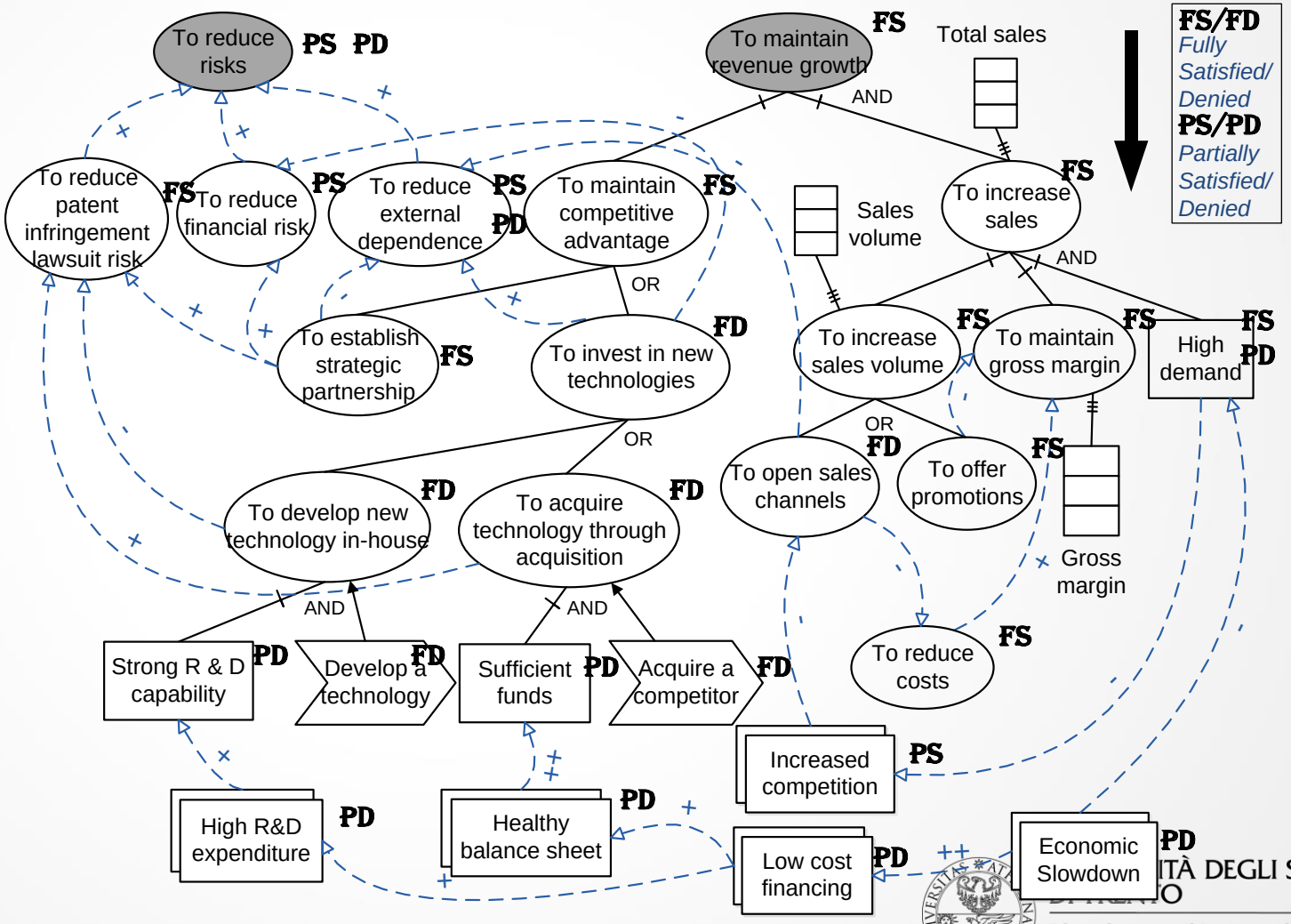


Business Intelligence Model

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



Business Intelligence Model

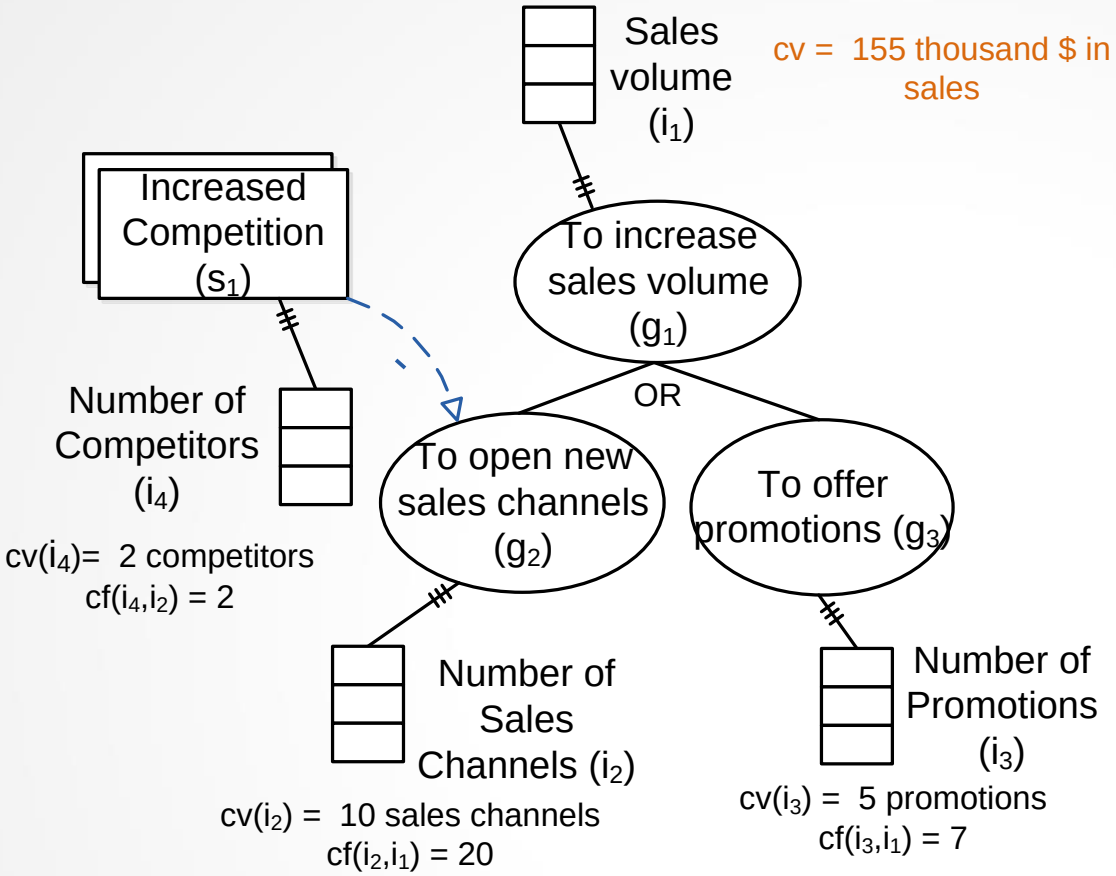
Indicator Reasoning with Varying Levels of Information

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

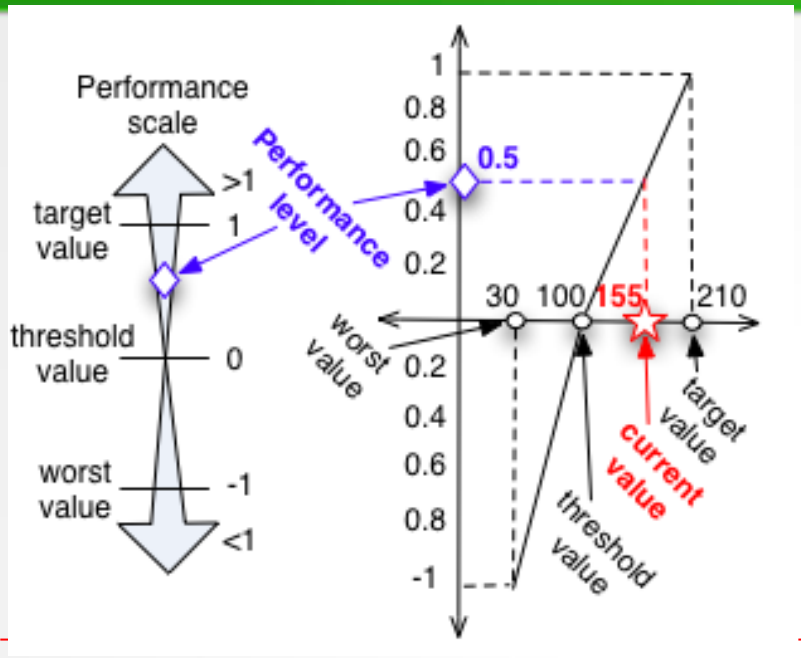
More Accuracy Less

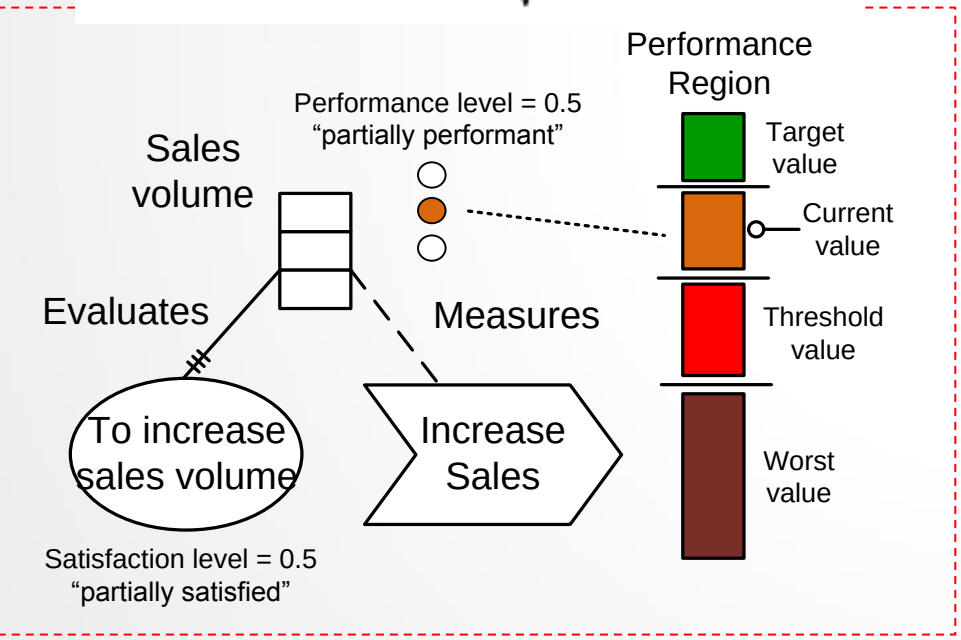
Indicator Reasoning using Business Formulae and Unit Conversion

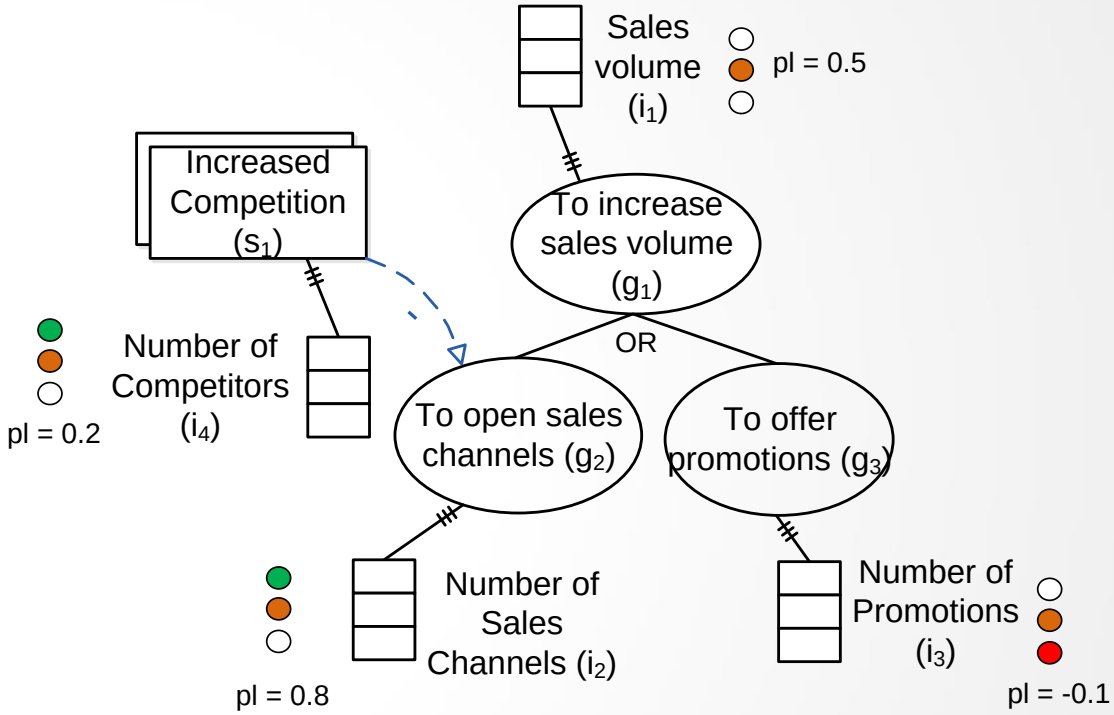


$$(cv(i_2) - cv(i_4)cf(i_4, i_2))\, cf(i_2, i_1) + cv(i_3)\, cf(i_3, i_1) = (20cv(i_2) - 2cv(i_4)) + 7cv(i_3)$$

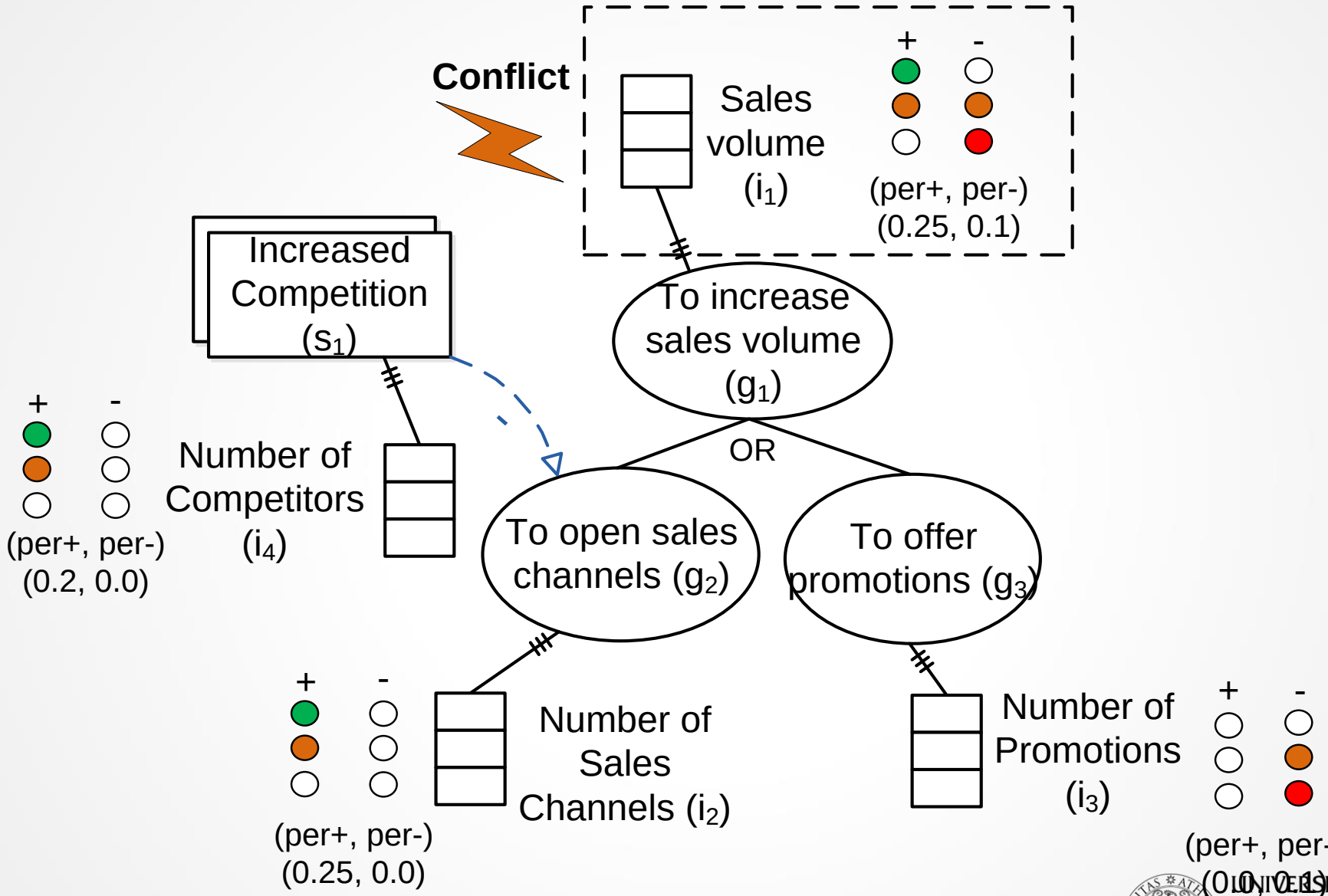
Indicator Reasoning using Business Formulae and Performance Levels





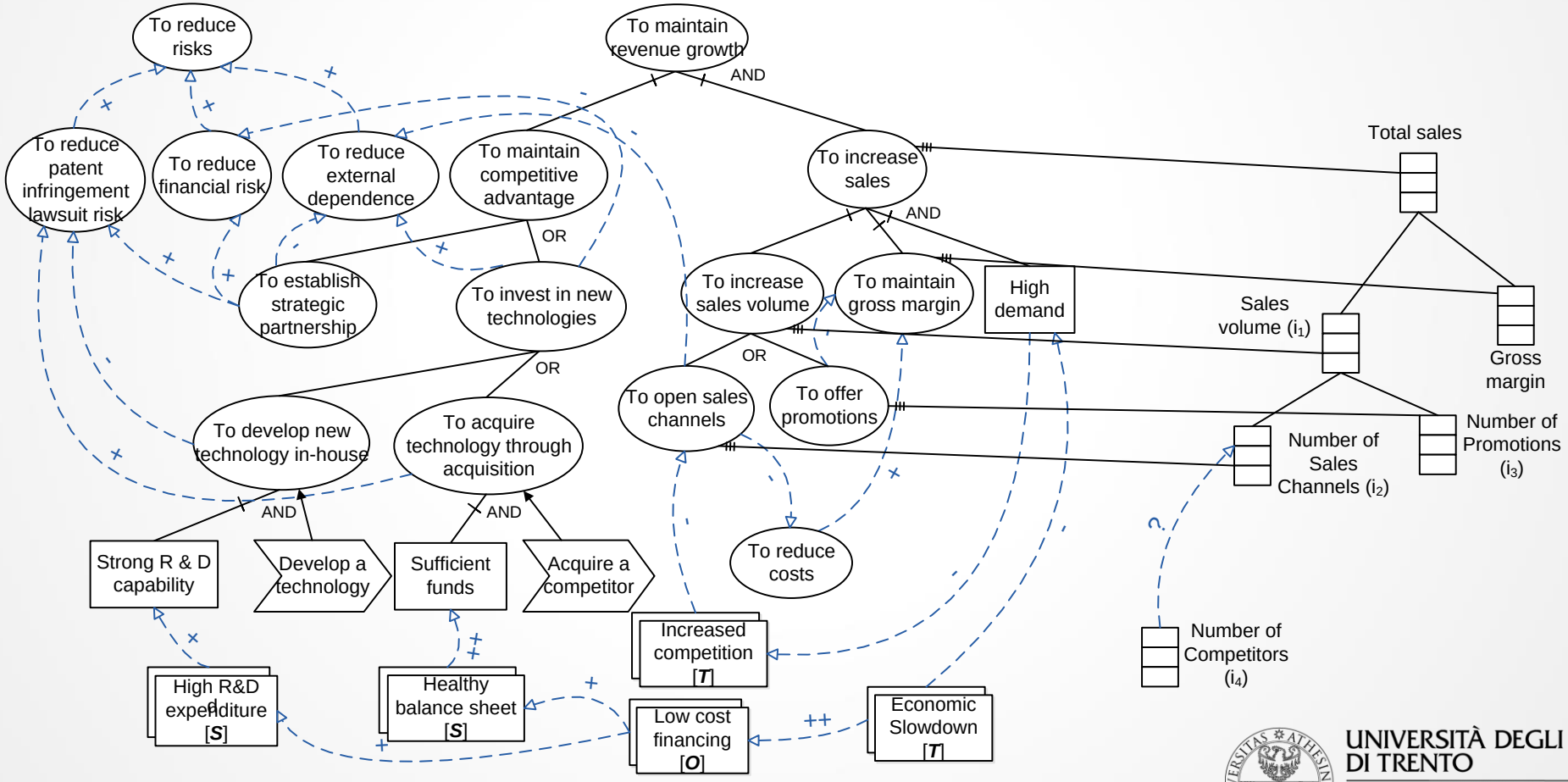


Indicator Reasoning without Business Formulae



Reasoning with Incomplete Indicators

- May not be feasible to have complete indicators
- May not be feasible to have complete business metrics which combine atomic indicators to calculate composite indicators



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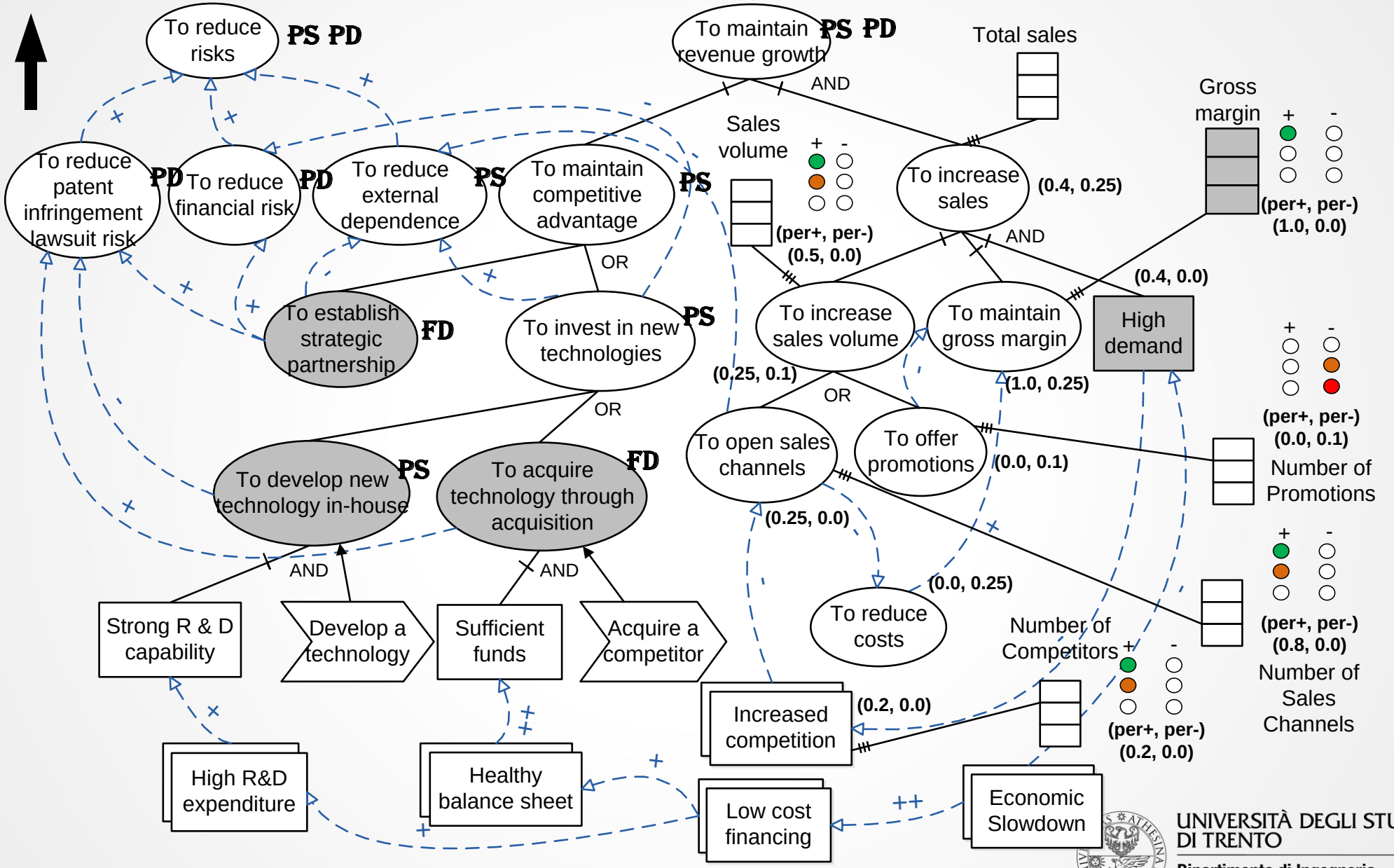
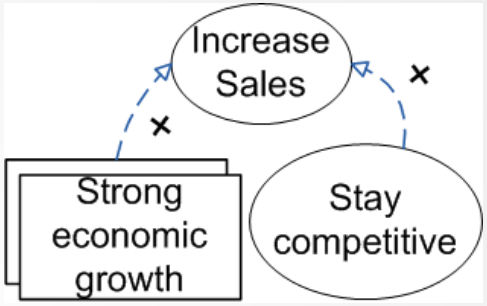
Reasoning with Incomplete Indicators



Business Intelligence Model

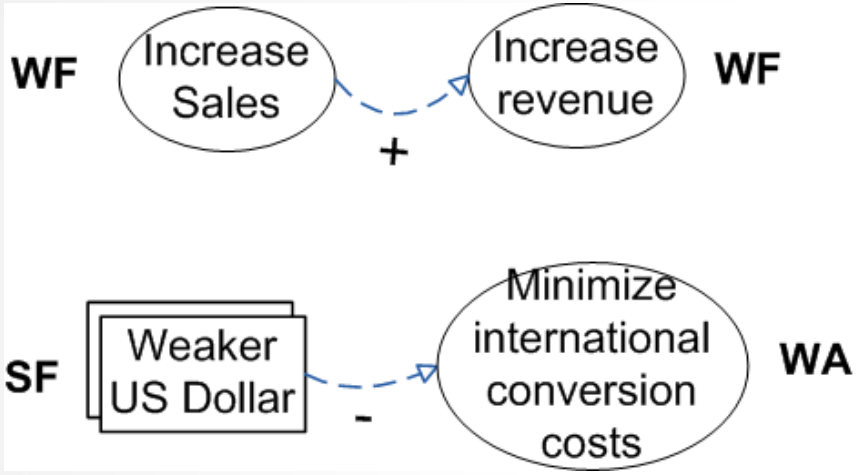
BIM Evidence



- BIM considers multiple sources and degrees of *Evidence*, either for or against
- "Evidence for…?" is answered depending on the specific type of thing:
  - *satisfaction* of goals, *occurrence* of situations, …
- Use a qualitative evidence scale similar to the satisfaction/denial scale used in goal models
  - **S**trong/**W**eak evidence **F**or/**A**gainst a thing, **SF**, **WF**, **WA**, and **SA**

Reasoning with Evidence and Influence

- We use rules for propagating evidence on influence links adapted from Goal Modeling

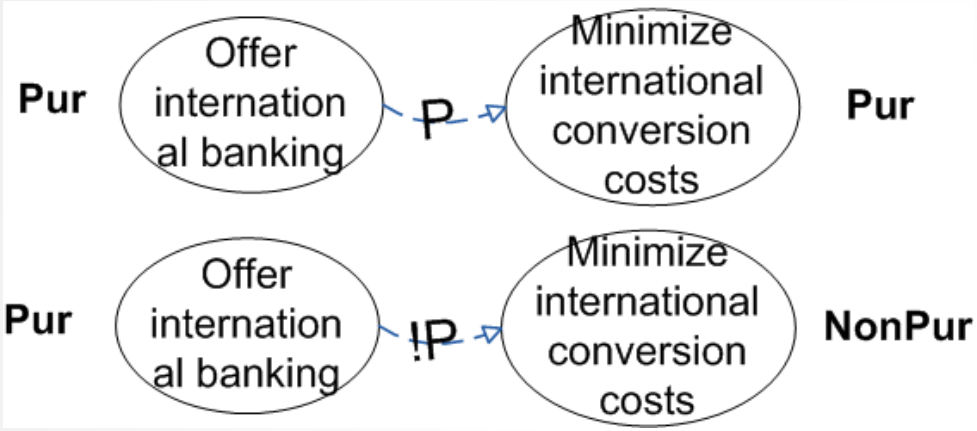


	Link Label Contains			
Source Evidence Set Contains	**++**	**+**	**-**	**--**
SF	SF	WF	WA	SA
WF	WF	WF	WA	WA
WA	WA	WA	WF	WF
SA	SA	WA	WF	SF

SF	Strong For
WF	Weak For
WA	Weak Against
SA	Strong Against

Evidence propagation depending on influence label (destination Evidence value in grey)

Reasoning with Pursuit and Influence



	Link Label Contains	
Source Pursuit Set Contains	P	!P
Pur	Pur	NonPur
NonPur	NonPur	Pur

- Pursuit value propagation depending on influence label (destination Pursuit value in grey)

BIM Tool

- http://www.cs.utoronto.ca/~jm/bim/
- Allows qualitative BIM Reasoning, not quantitative

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Next class...

- More of the same!!
- Wednesday 2 pm (14:00) Tutorial on i* and BIM Reasoning
- OpenOME, jUCMNav, BIM Tool

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