

GrowingLeaf: Supporting Requirements Evolution over Time

Alicia M. Grubb, Gary Song, Marsha Chechik
{amgrubb, gary, chechik}@cs.toronto.edu

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TORONTO

Problem

- Assumptions of early-phase requirements modeling:
 - ➔ all model elements have a value
 - ➔ model values are constant
- In reality intentions and relationships in the environments are not constant.

Example Questions

1. Is it possible to satisfy *Goal-A* and partially satisfy *Goal-B*? and how?
2. How does completing *Task-A* and *Task-B* but not *Task-C* affect the top level goals?
3. How do changes in *Actor-A*'s dependums affect the *Actor-A*'s root-level goals over time?
4. Which possible scenarios always satisfy *Goal-A* even if *Goal-B* becomes denied in the future?
5. Does the satisfaction order of *Goal-C* and *Goal-D* matter?

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2. How does completing *Task-A* and *Task-B* but not *Task-C* affect the top level goals?
3. How do changes in Actor affect the Actor's goals?
4. Which evaluation labels are affected by Goal-A even if Goal-A is not achieved in the future?
5. Does the satisfaction order of *Goal-C* and *Goal-D* matter?

Use Qualitative Evaluation Labels
with Forward Analysis and
Backward Analysis

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Contributions

Provide tooling to:

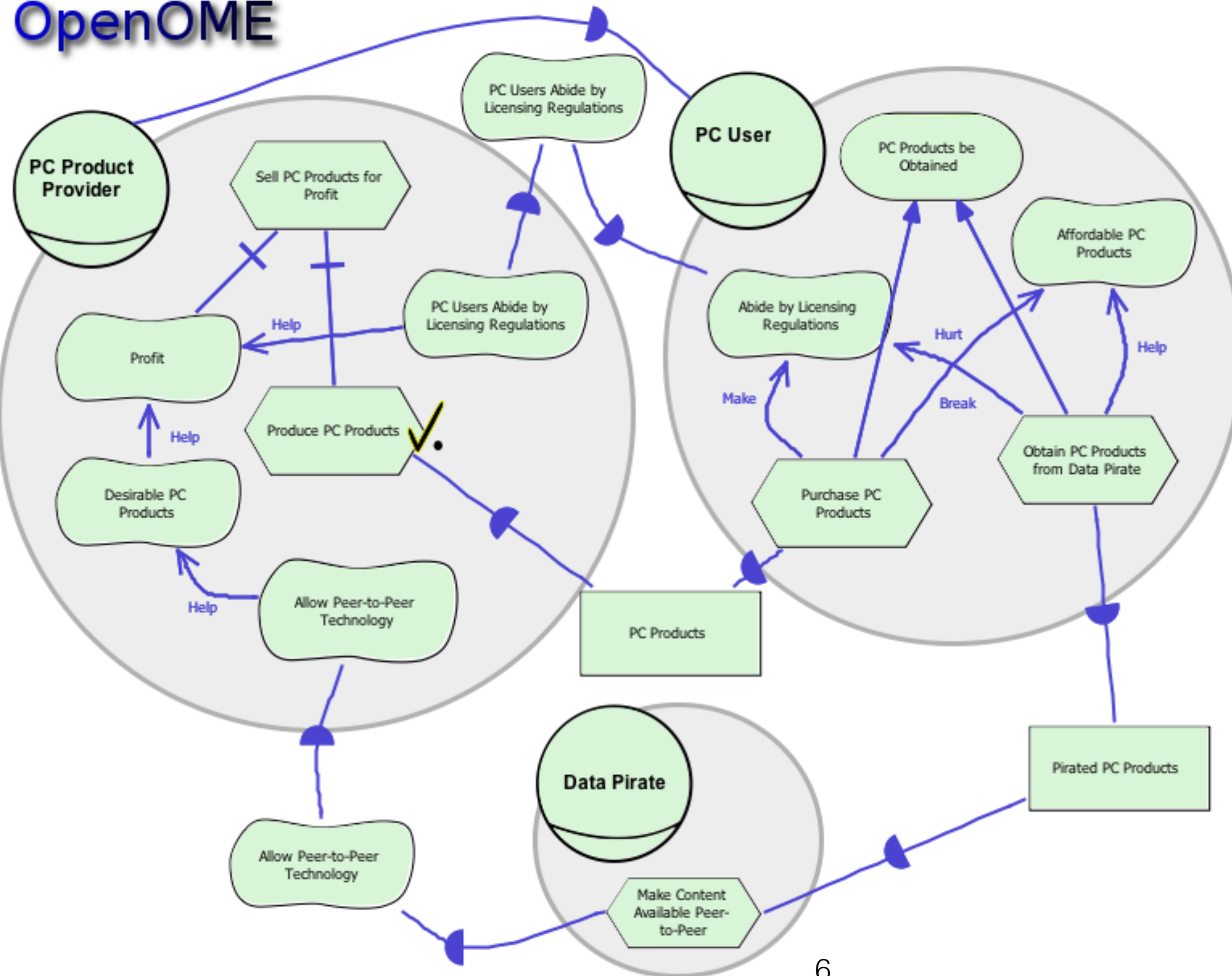
- enrich goal models intentions with dynamically changing evaluation
- analyze the impacts of dynamically changing intentions on decision making

Why another modeling tool?

- Why another modeling tool?

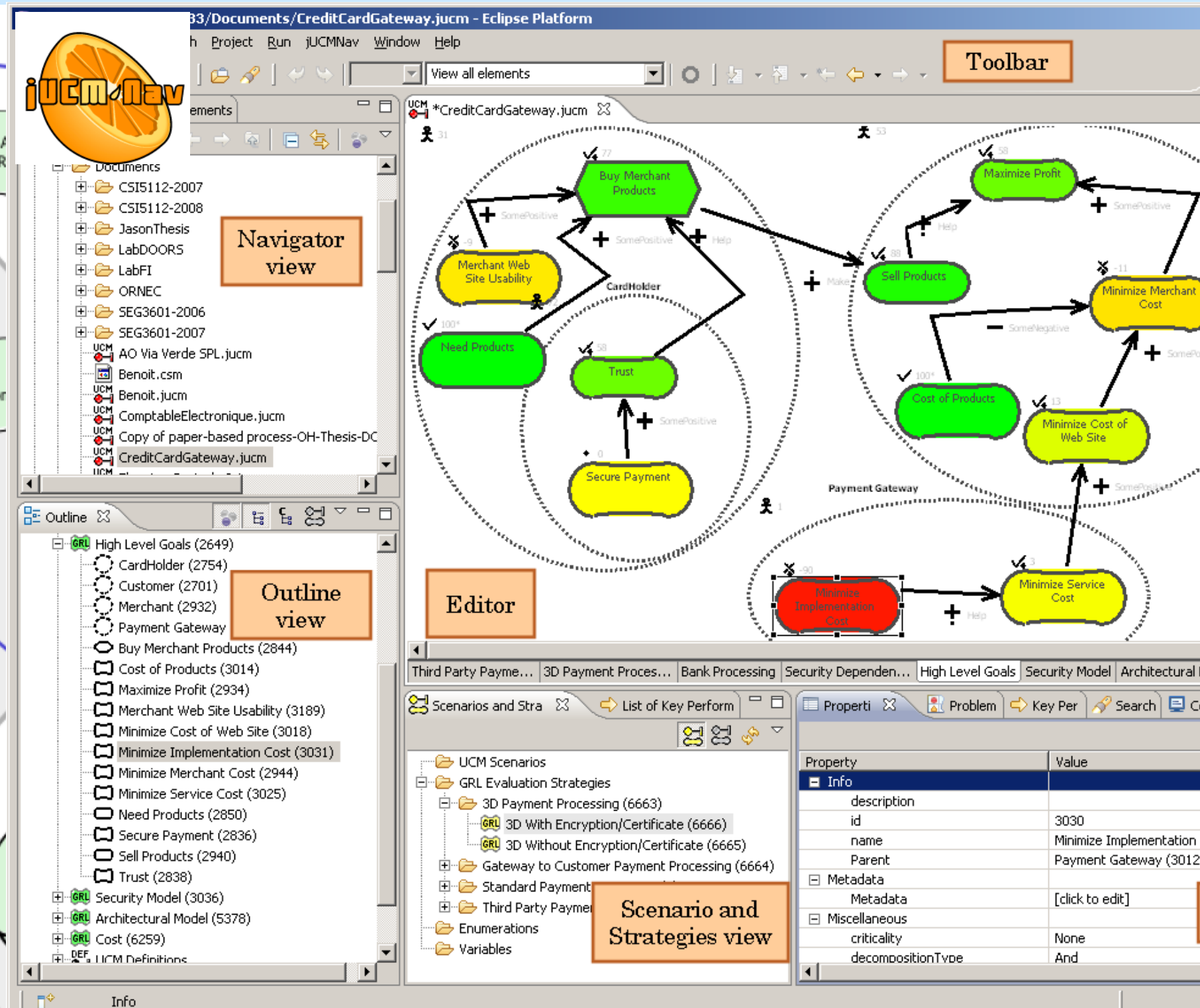
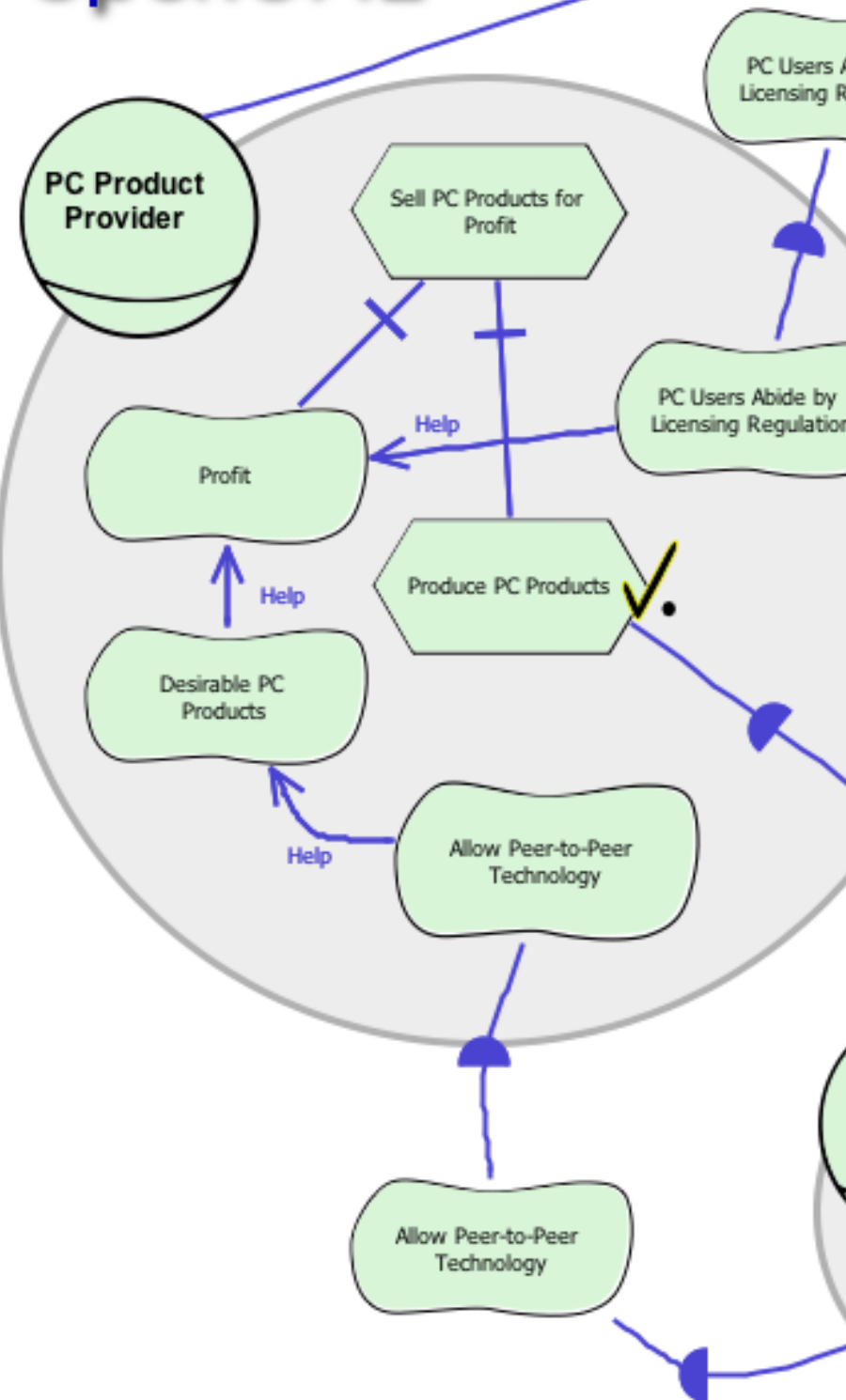
Why another modeling tool?

OpenOME



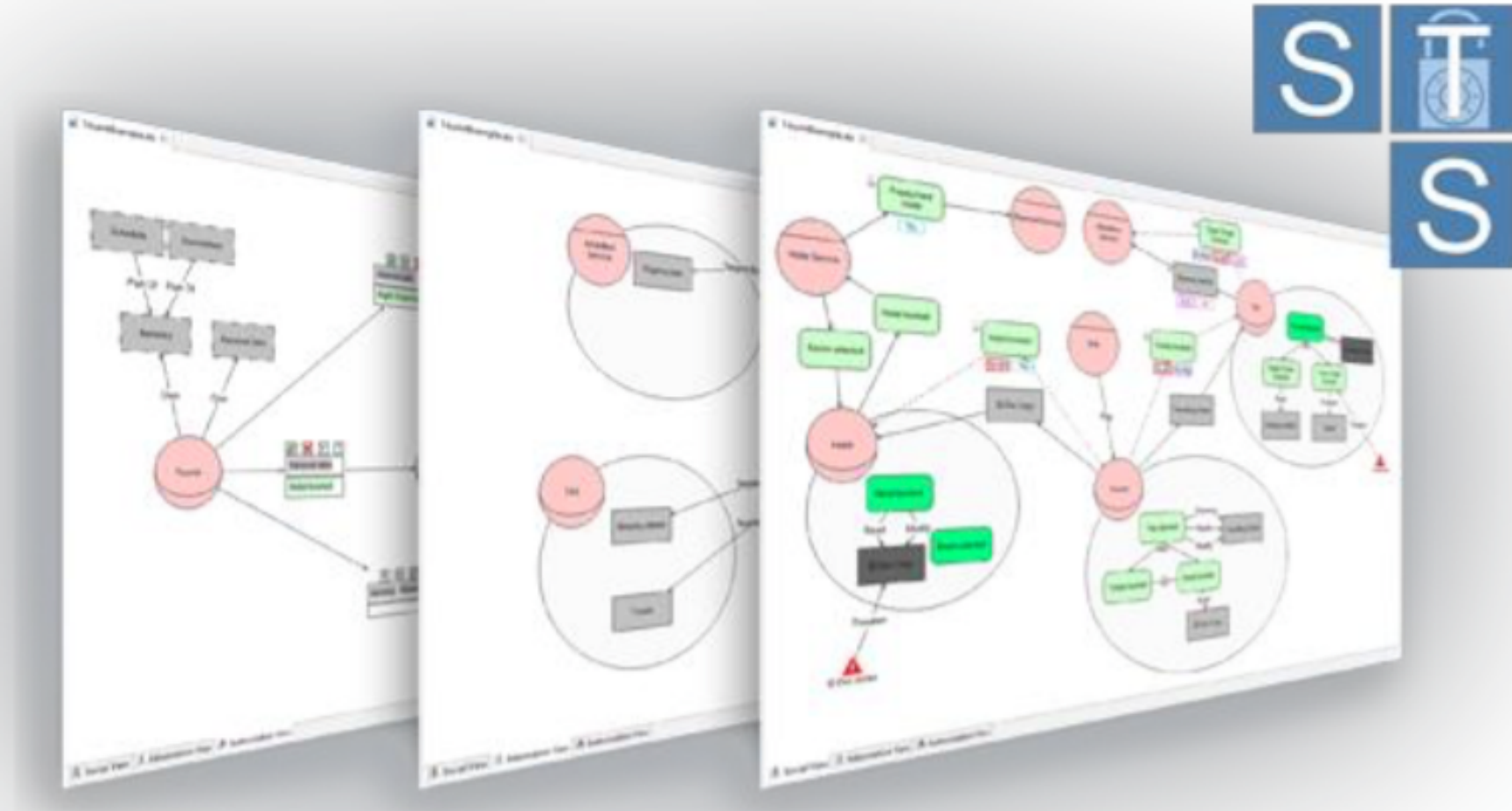
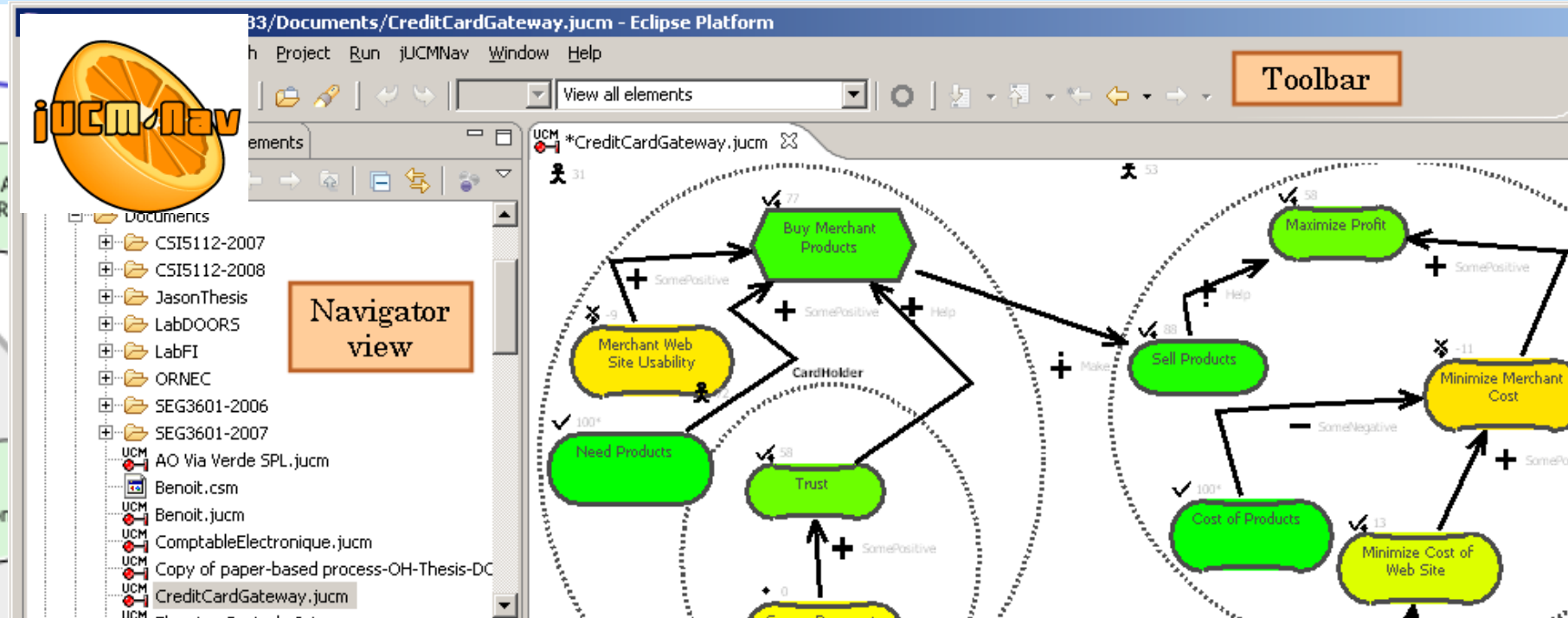
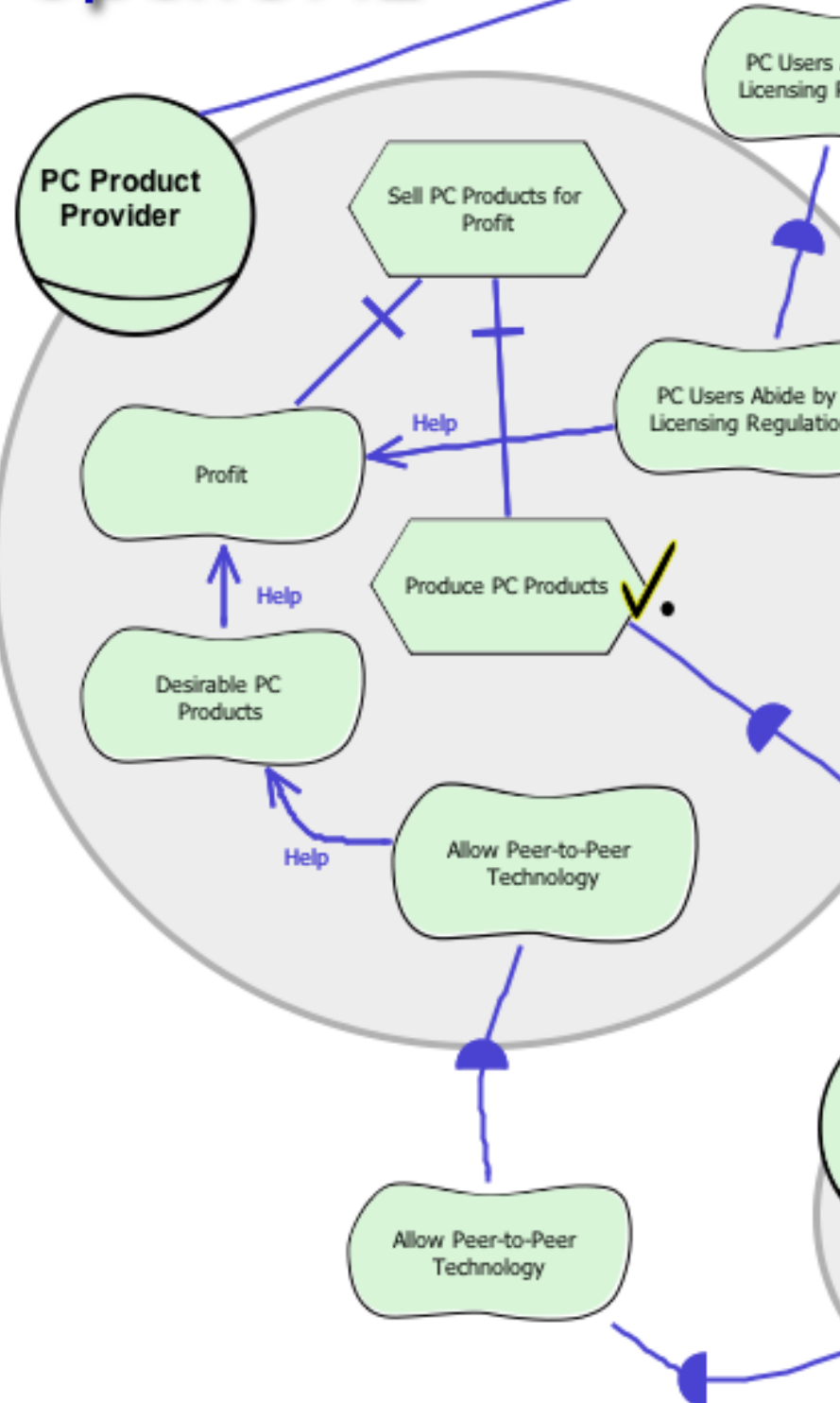
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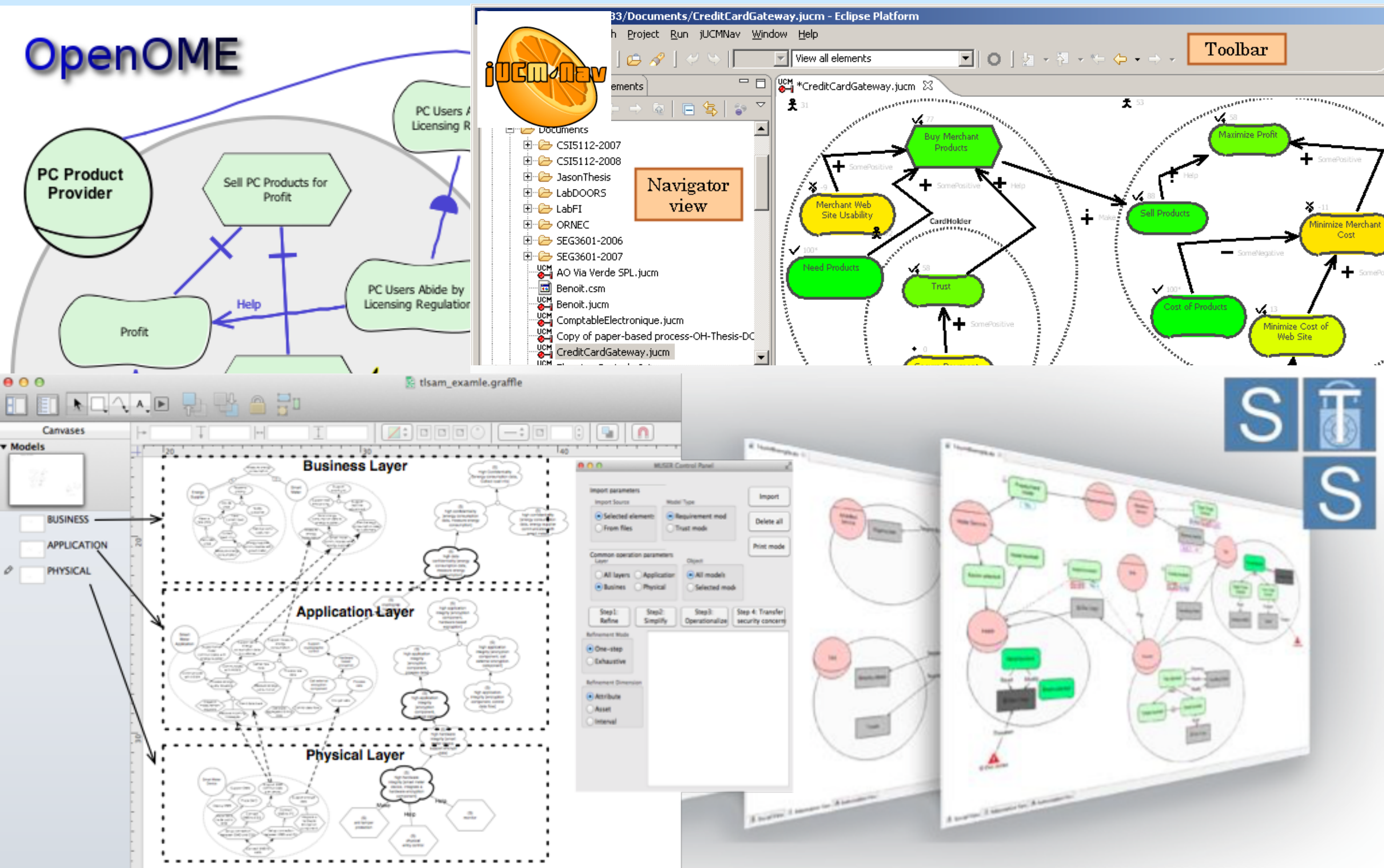


Why another modeling tool?

OpenOME



Why another modeling tool?



Why another modeling tool?

- Surveyed previous tools
 - Extend their iStar meta-model
 - Add icons/labels on top of intentions
- Web-based tool
 - Framework vs. self-built
 - Multi-view vs. multi-tab

Introducing GrowingLeaf

www.cs.utoronto.ca/~amgrubb/leaf-ui/Tool.html

GrowingLeaf Undo Redo Clear Save Load Zoom In Zoom Out Open as SVG Export .leaf Font Size Model Constraints Analysis

Stencil

- Goal
- Task
- Soft Goal
- Resource
- Actor

Modelling Relationships

Node name: Build Green Centre

Initial Satisfaction Value: Denied

Function Type: Denied Satisfied

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www.cs.utoronto.ca/~amgrubb/leaf-ui/Tool.html

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Modelling Constraints

Intension Relationship:

< A A

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Introducing GrowingLeaf

www.cs.utoronto.ca/~amgrubb/leaf-ui/Tool.html

GrowingLeaf Zoom In Zoom Out Open as SVG Export .leaf Font Size **Model**

History Log

Step 1: Leaf Sim

Analysis

Analysis:

Max Sim Steps: 10

Max Epoch Num: 10

Select Analysis:

Forward Analysis

Stochastic Simulation

Leaf Simulate

CSP Analysis

CSP History

Load Analysis

Merge Analyses

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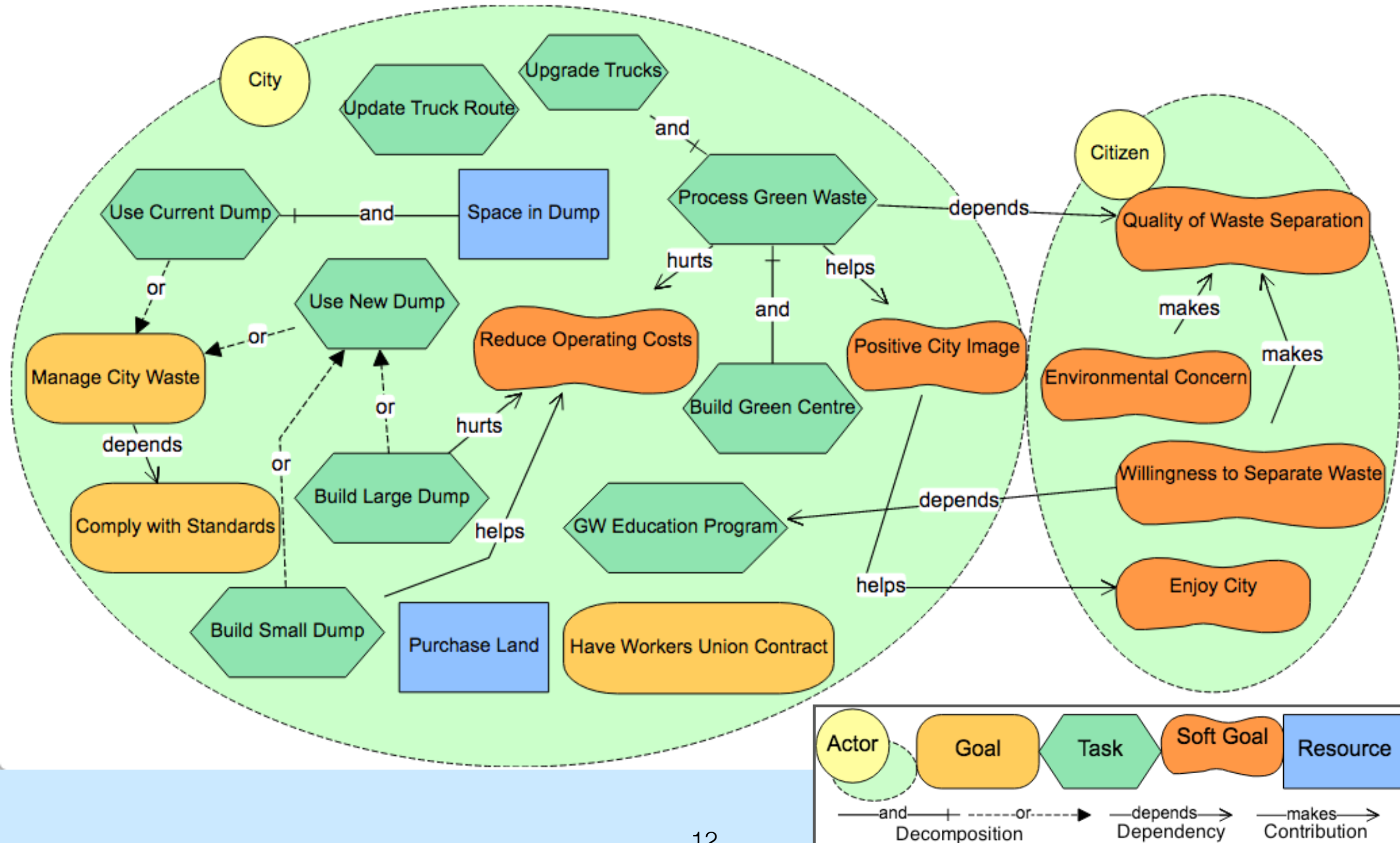
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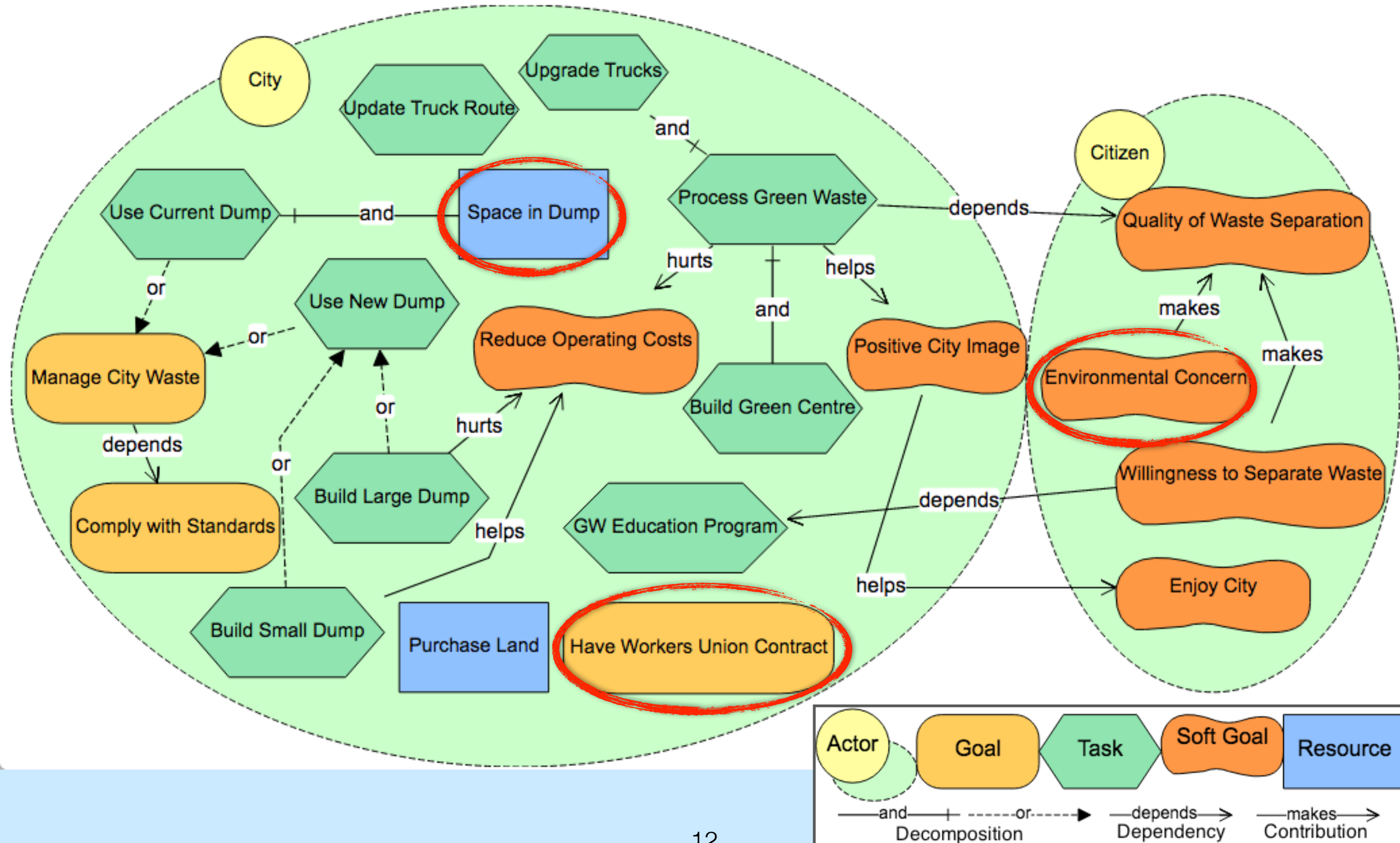
Outline

- Modeling Problem and Tool Justification
- Tool Introduction
- **Dynamic Intentions and Analysis**
- Tool Functionality
- Discussion and Validation
- Status and Future Work

Modeling Dynamic Intentions



Modeling Dynamic Intentions



Modeling Dynamic Intentions

Stochastic (R)

Patterns:



Examples:



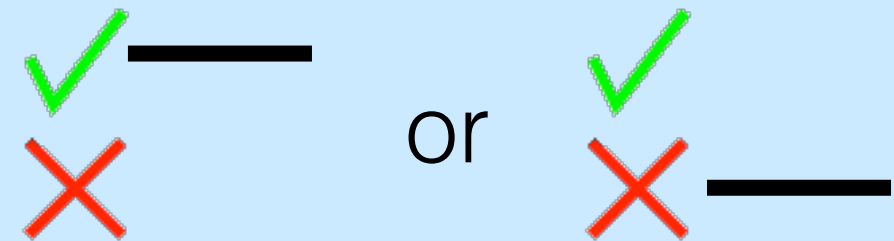
Modeling Dynamic Intentions

Elementary Functions

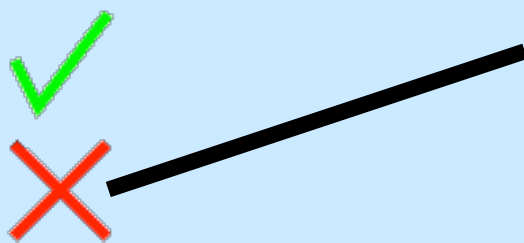
Stochastic (R):



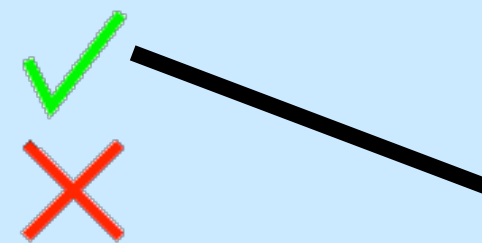
Constant (C):



Increase (I):



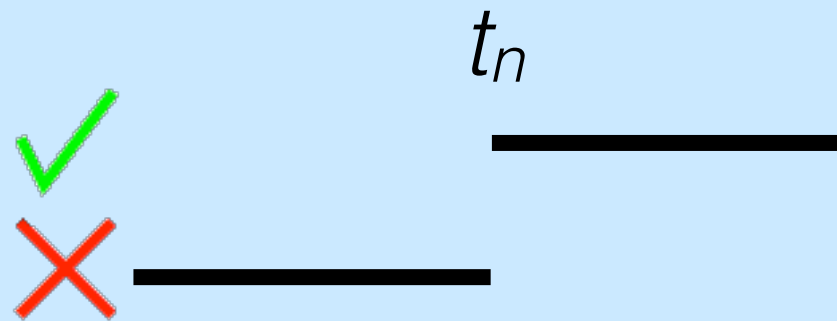
Decrease (D):



Modeling Dynamic Intentions

Denied-Satisfied (DS)

Patterns:



Examples:



Modeling Dynamic Intentions

Denied-Satisfied (DS)

Patterns:



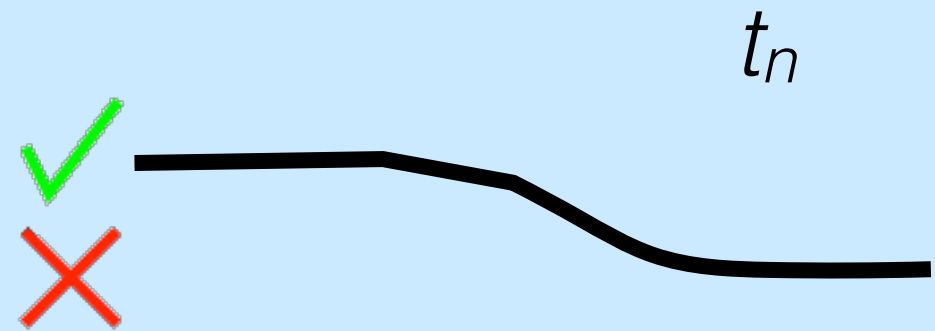
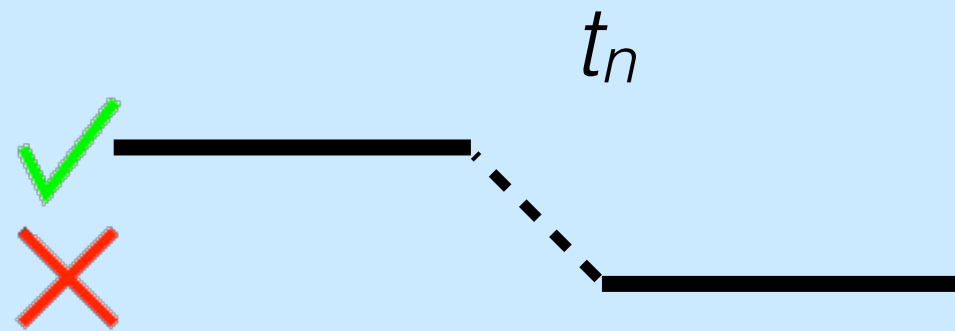
Examples:



Modeling Dynamic Intentions

Monotonic Negative (MN)

Patterns:



Examples:

Space in Dump

Common Compound Functions

Denied-Satisfied
(DS)

the satisfaction evaluation remains *Denied*
until t_i and then remains *Satisfied*

Monotonic Negative
(MN)

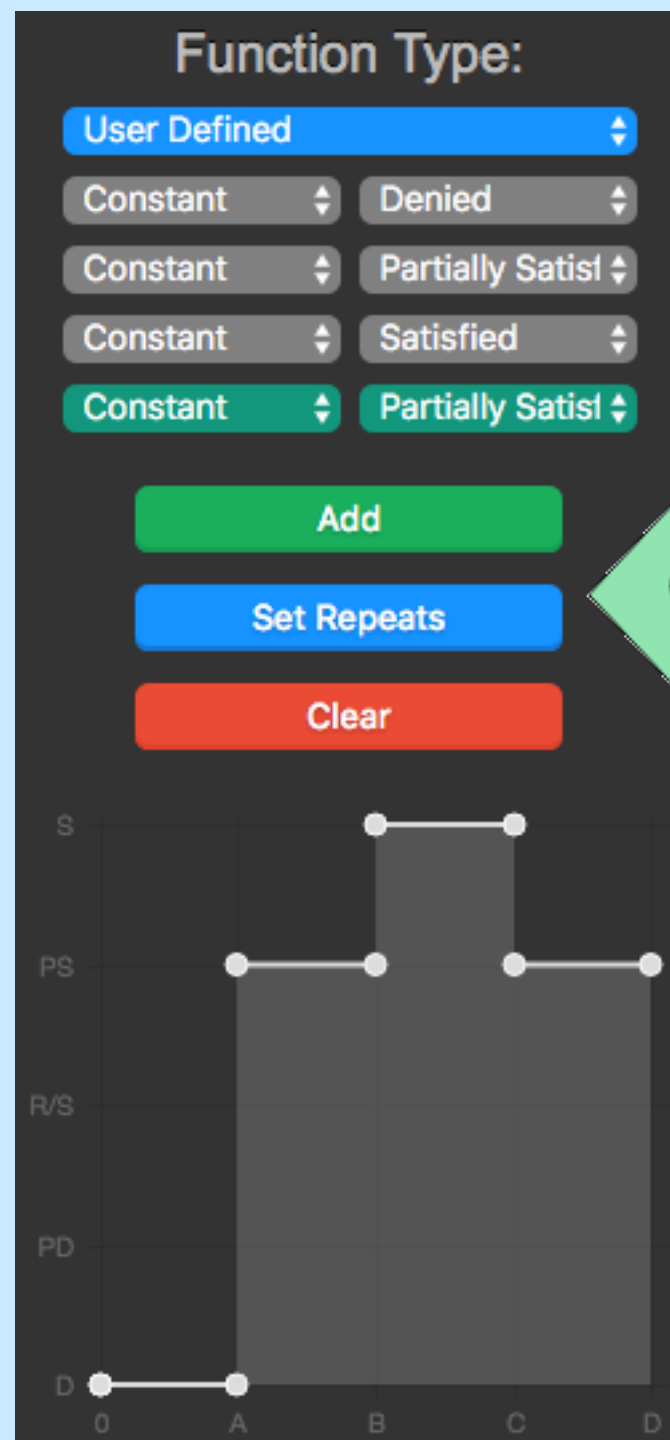
changes in satisfaction evaluation become
“less true” to a *maxValue* at t_i and then
remains constant at *constantValue*

Common Compound Functions

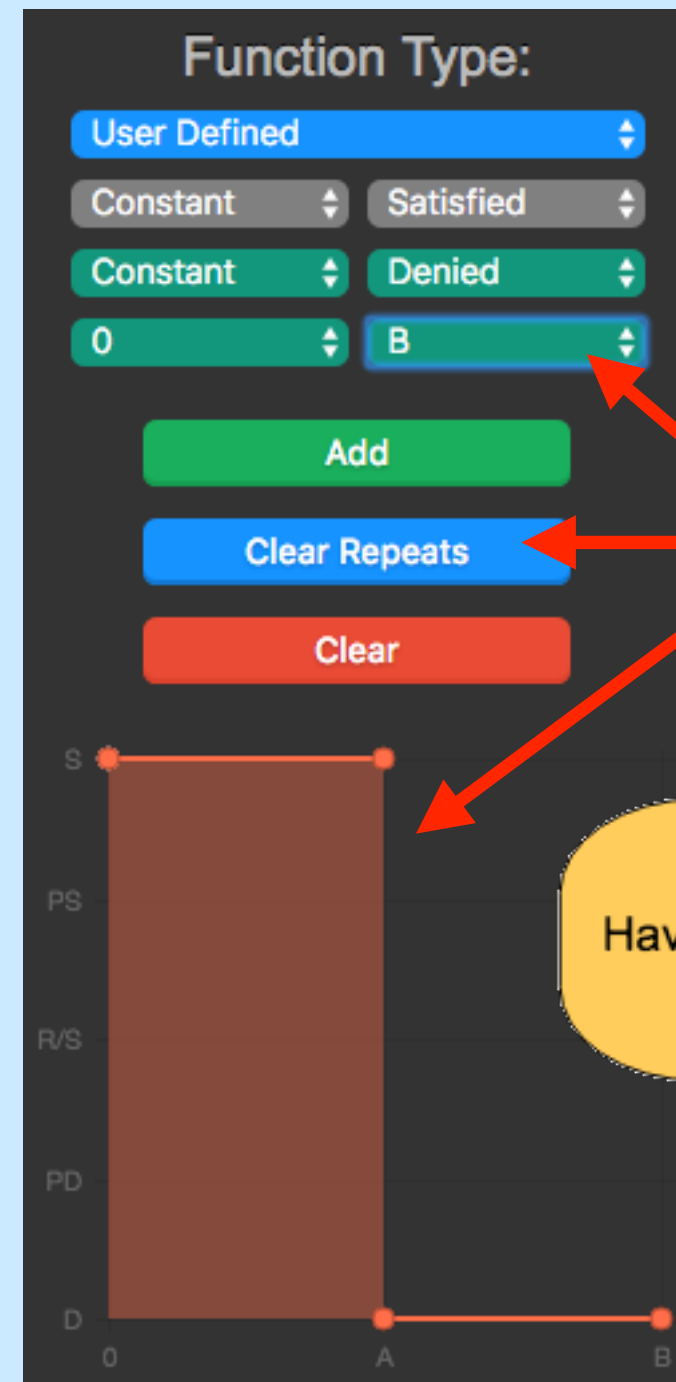
Satisfied-Denied (SD)	the satisfaction evaluation remains <i>Satisfied</i> until t_i and then remains <i>Denied</i>
Denied-Satisfied (DS)	the satisfaction evaluation remains <i>Denied</i> until t_i and then remains <i>Satisfied</i>
Stochastic-Constant (RC)	changes in satisfaction evaluation are stochastic or random until t_i and then remains constant at <i>constantValue</i>
Constant-Stochastic (CR)	the satisfaction evaluation remains constant at <i>constantValue</i> until t_i and then changes in evaluation are stochastic or random
Monotonic Positive (MP)	changes in satisfaction evaluation become “more true” to a <i>maxValue</i> at t_i and then remains constant at <i>constantValue</i>
Monotonic Negative (MN)	changes in satisfaction evaluation become “less true” to a <i>maxValue</i> at t_i and then remains constant at <i>constantValue</i>

Modeling Dynamic Intentions

User Defined (UD)



GW Education Program



Repeating Function

Have Workers Union Contract

Analysis Strategies

(Strategy 1: Leaf Simulation) create a **random path** given initial states in the model

(Strategy 2: CSP Analysis) create a path given **desired properties** of the **intermediate state** (with optional properties over the initial or final state)

(Strategy 3: CSP History) create a path which is **different than the previously seen path** over the same constraints

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GrowingLeaf - Modeling Demo

GrowingLeaf

UndoRedoClearSaveLoadZoom InZoom OutOpen as SVGExport .leafFont SizeModel ConstraintsAnalysis

Stencil

Goal

Task

Soft Goal

Resource

Actor

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Modelling Relationships

GrowingLeaf - Modeling Demo

GrowingLeaf

UndoRedoClearSaveLoadZoom InZoom OutOpen as SVGExport .leafFont SizeModel ConstraintsAnalysis

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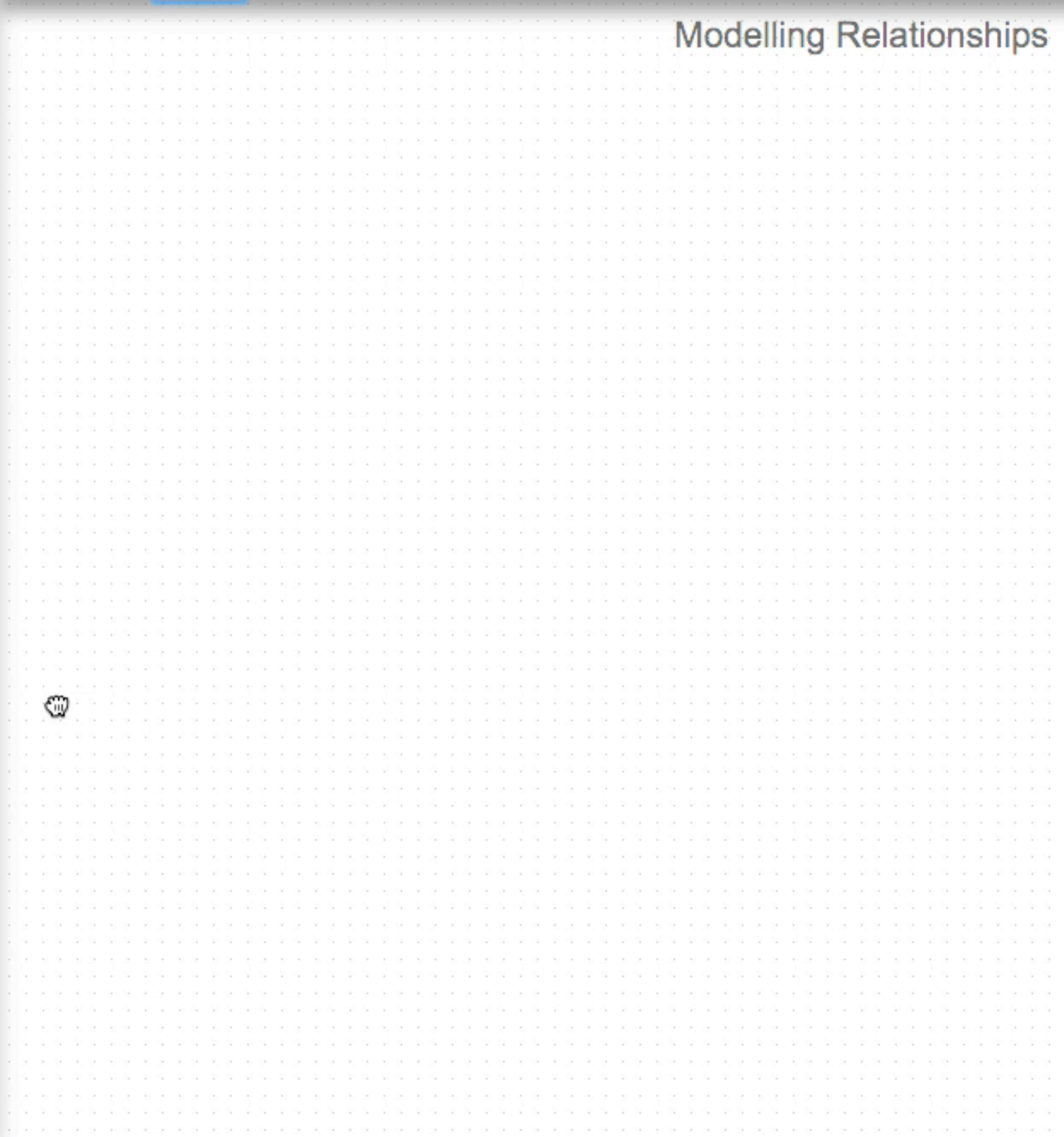


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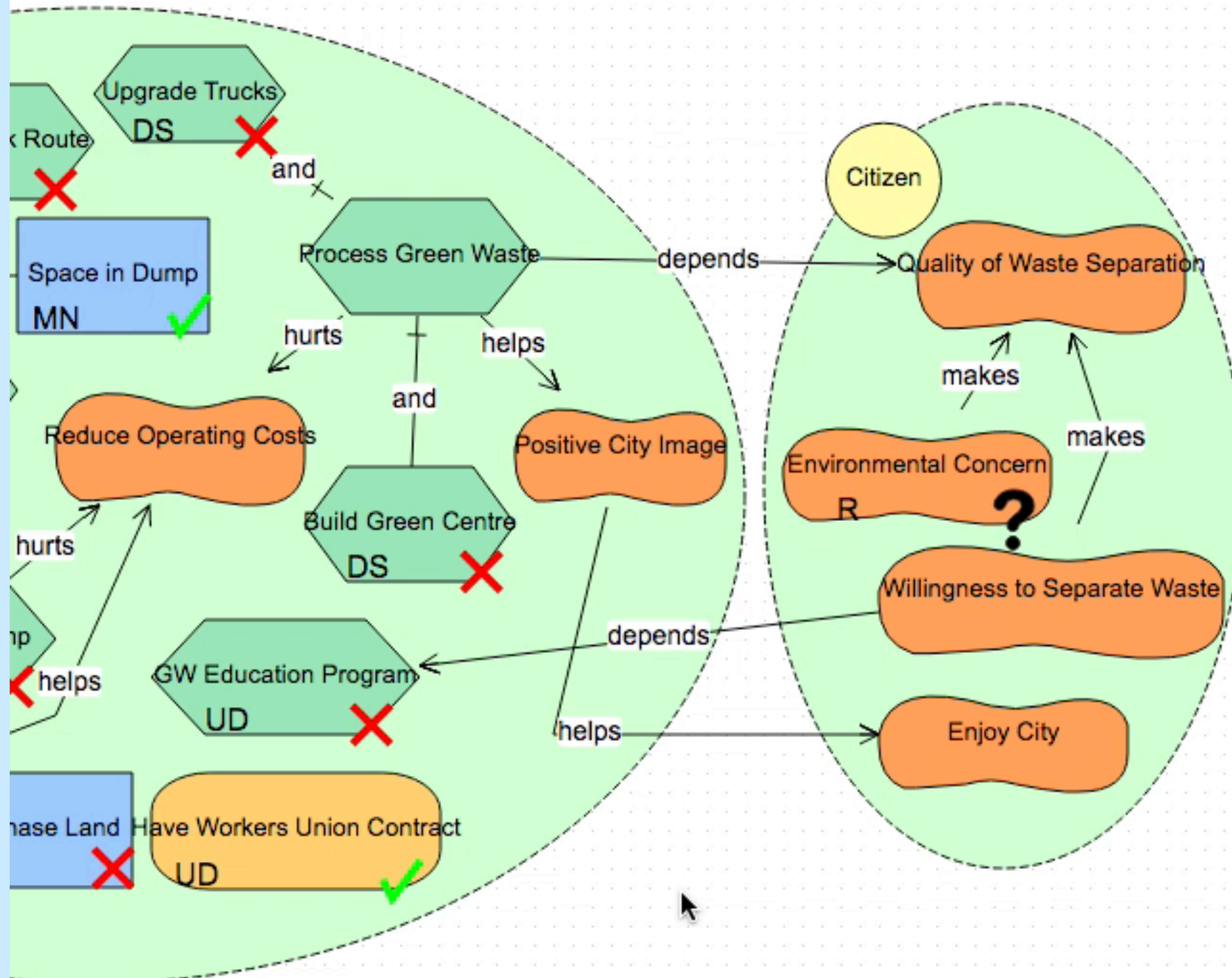
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Modelling Relationships



Modelling Relationships



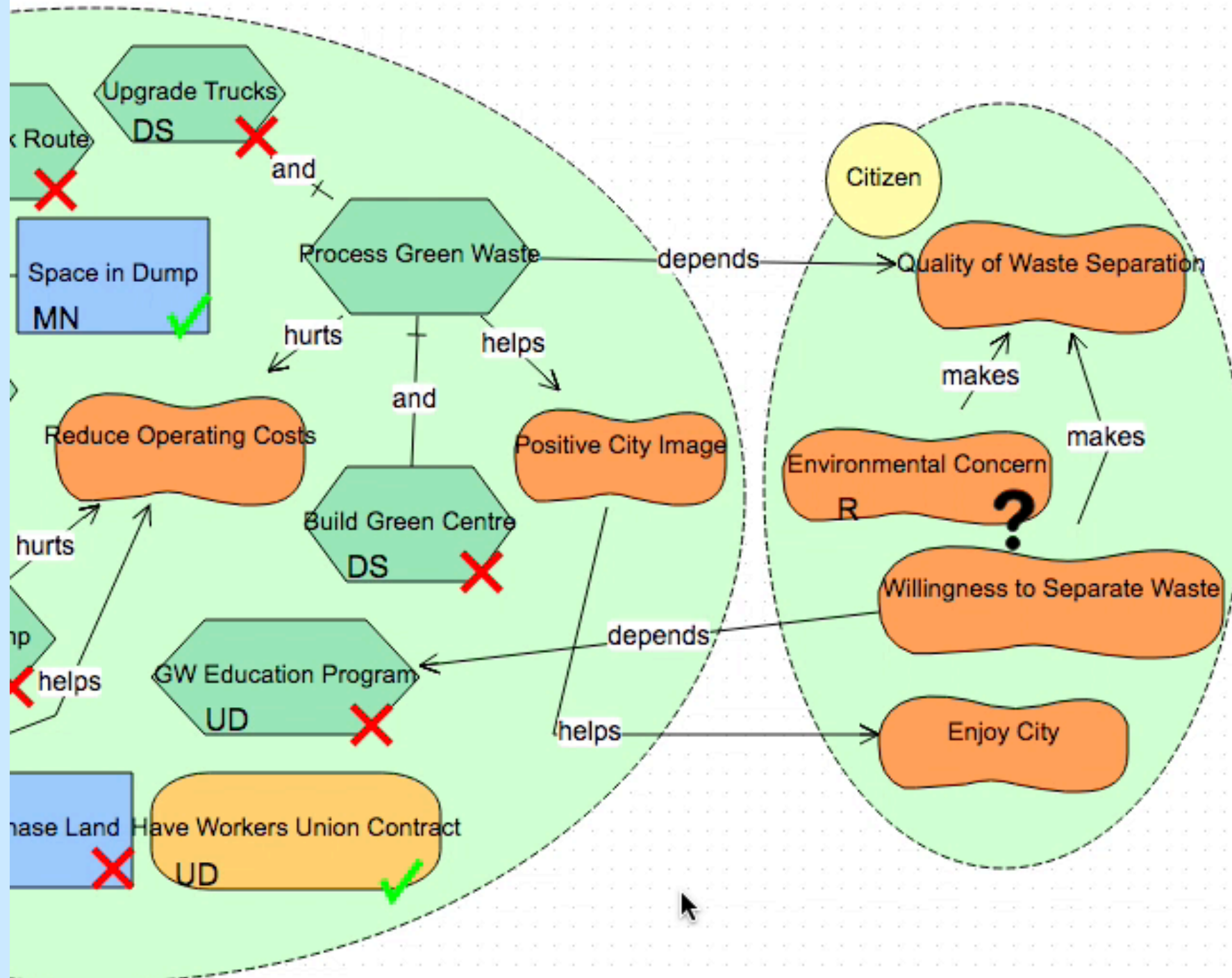
Node name:

Positive City Image

Initial Satisfaction Value:

None

Modelling Relationships



Node name:

Positive City Image

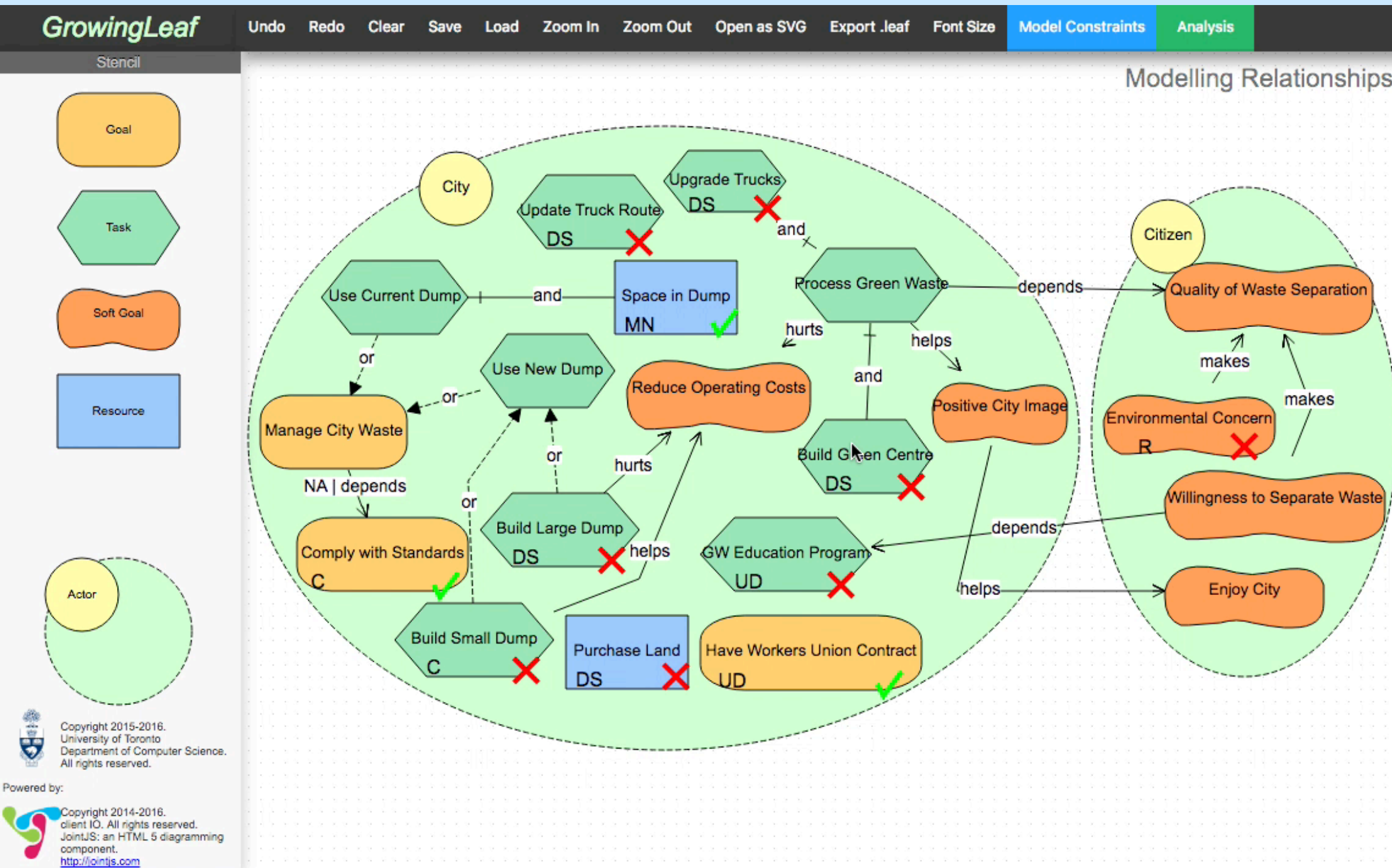
Initial Satisfaction Value:

None

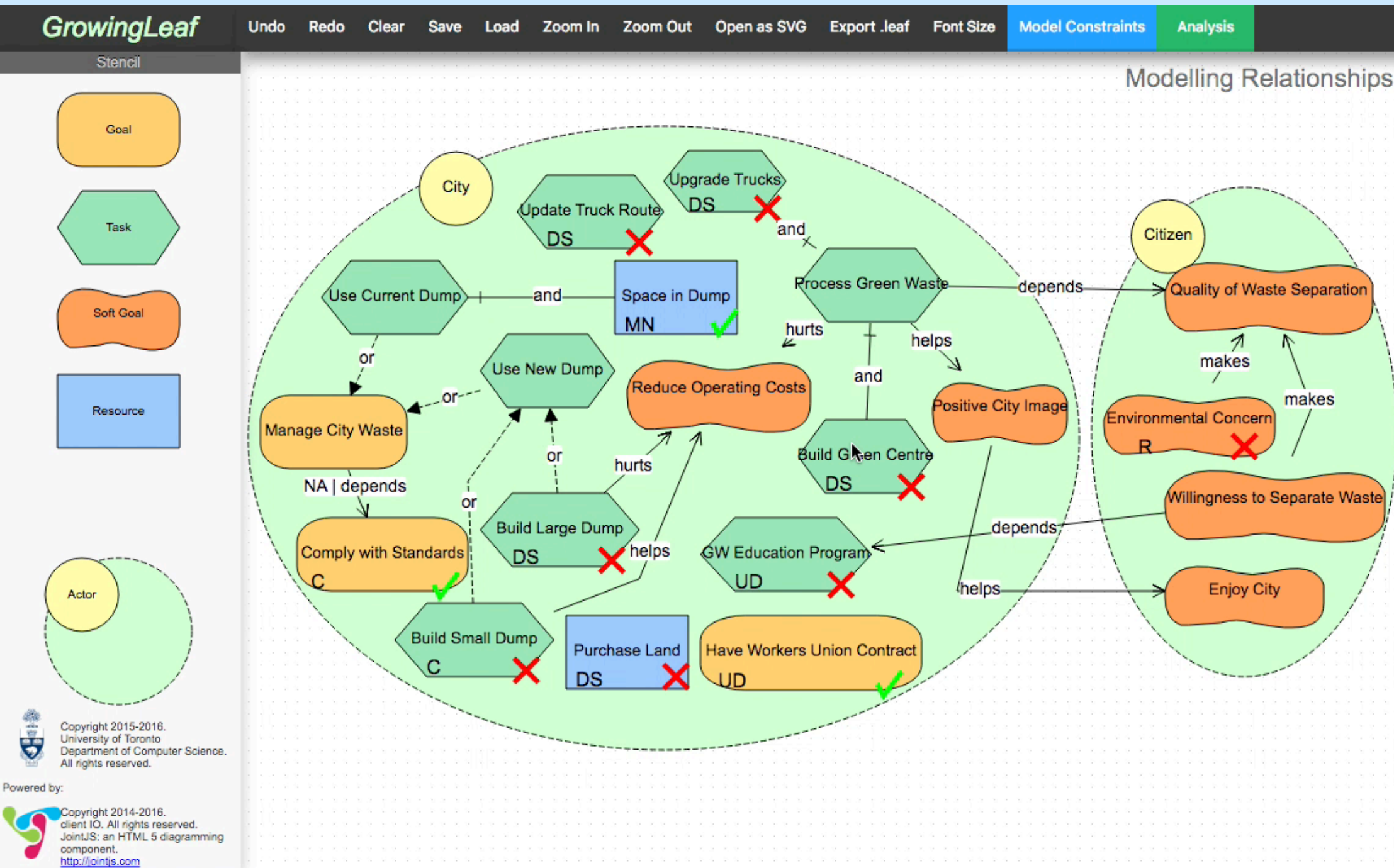
GrowingLeaf - Modeling Demo Summary

- Drag and drop interface
- Naming and adding elements
- Loading, saving, exporting, and zooming models
- Resizing label fonts
- Changing initial satisfaction values
- Changing dynamic function types
- Creating User Defined functions

GrowingLeaf - Analysis Demo



GrowingLeaf - Analysis Demo

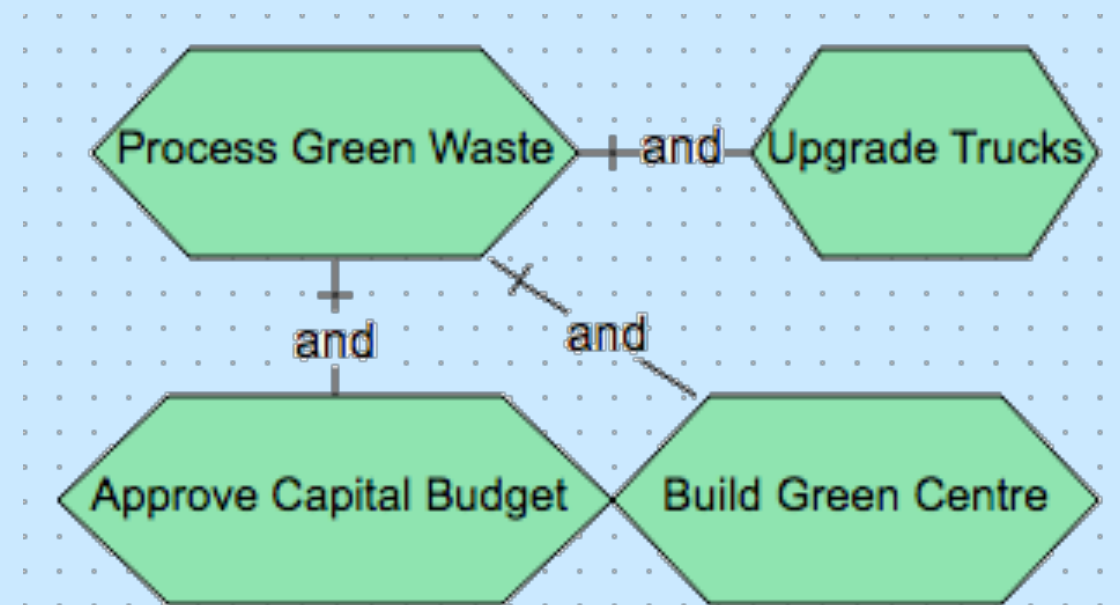


GrowingLeaf - Analysis Demo Summary

- How to run analysis
- Adjust simulation length
- Types of analysis
- Scrolling through analysis results

Improving Analysis with Constraints

- Undesirable results due to EB ordering
- Add constraints over EB order
 - Adding model links is inappropriate
 - Test relationship before updating the model
- Used on rare occasions



GrowingLeaf - Model Constraints Demo

GrowingLeaf

Undo

Redo

Clear

Save

Load

Zoom In

Zoom Out

Open as SVG

Export .leaf

Font Size

Model Constraints

Analysis

Stencil



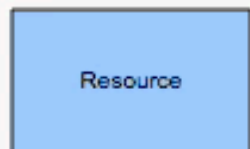
Goal



Task



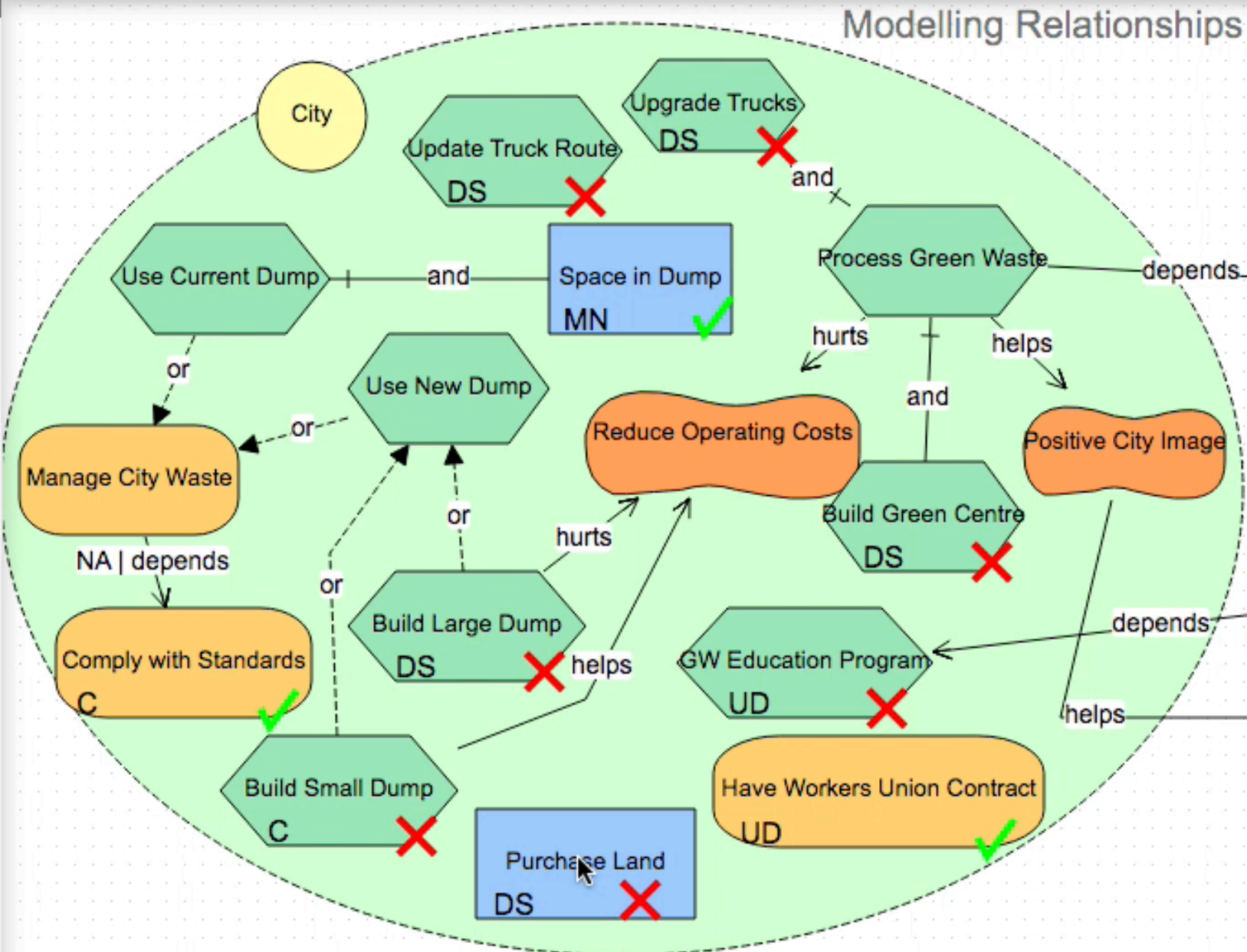
Soft Goal



Resource



Actor



Node name:

Comply with Standards

Initial Satisfaction Value:

Satisfied

Function Type:

Constant



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GrowingLeaf - Model Constraints Demo

GrowingLeaf

Undo

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Model Constraints

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Stencil



Goal



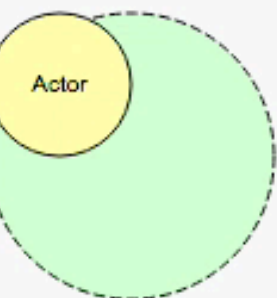
Task



Soft Goal



Resource



Actor



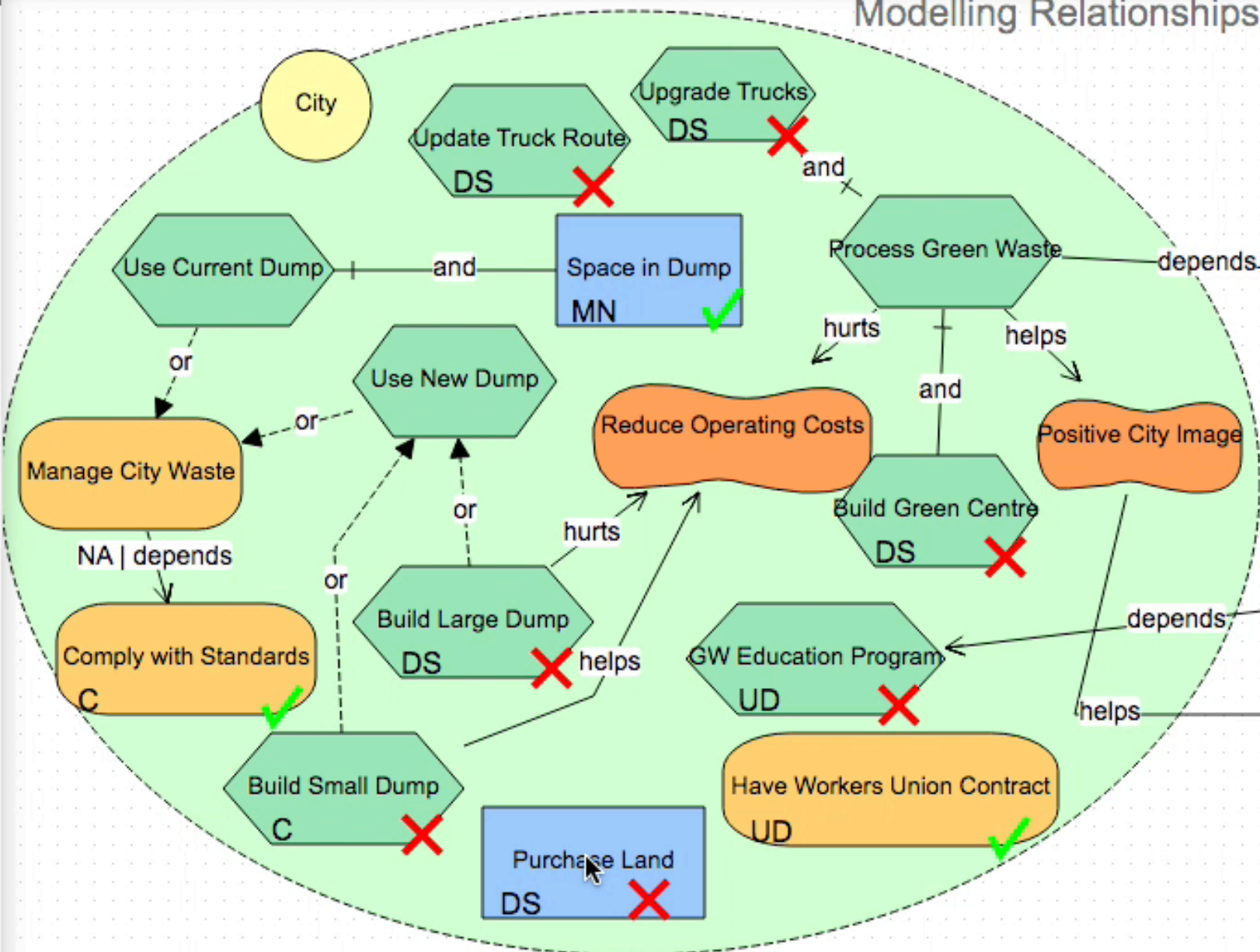
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Modelling Relationships



Node name:

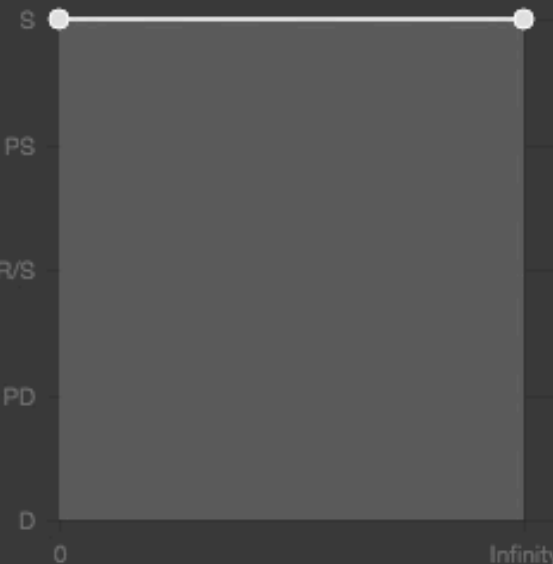
Comply with Standards

Initial Satisfaction Value:

Satisfied

Function Type:

Constant



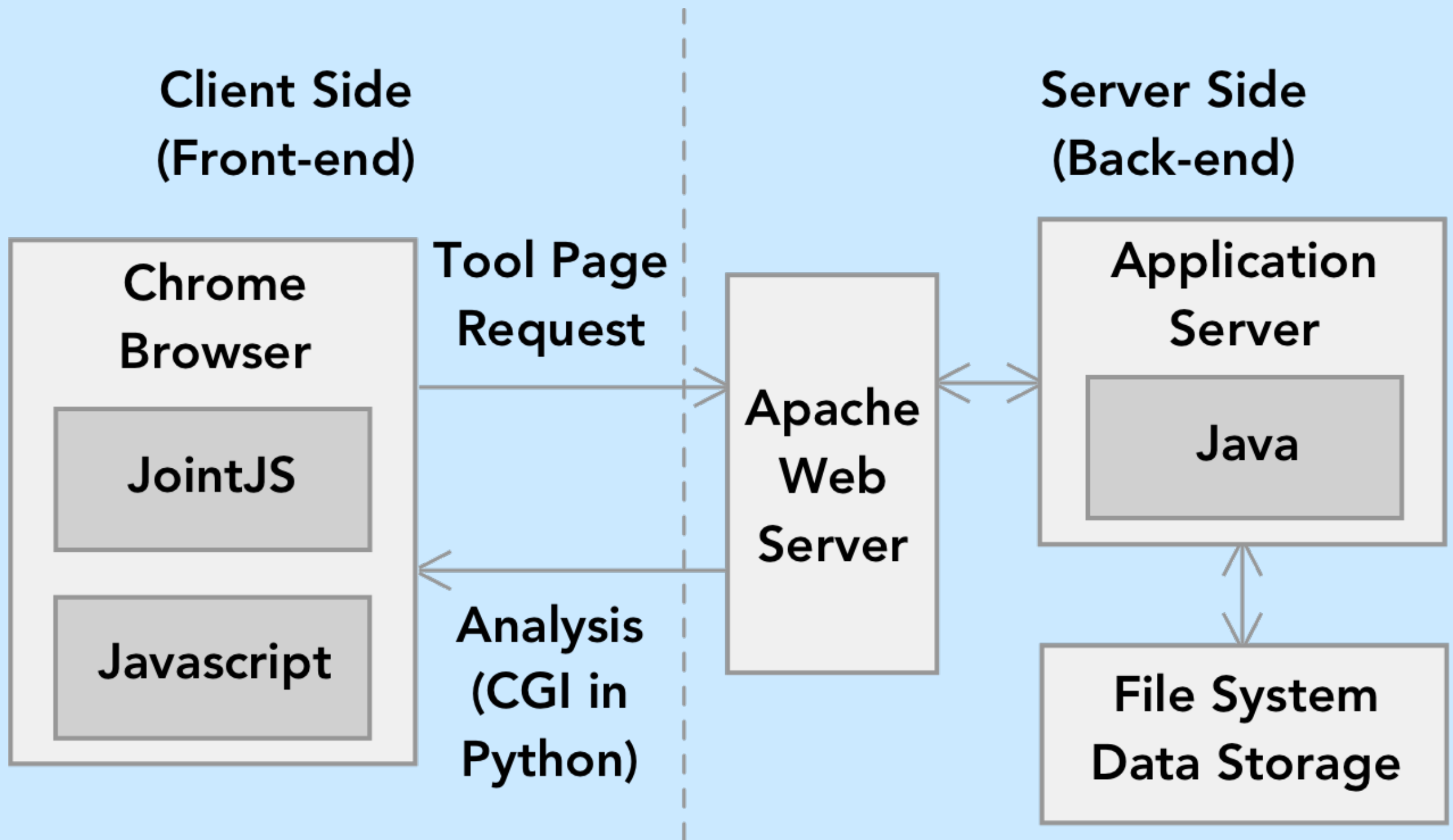
GrowingLeaf - Constraints Demo Summary

- Adding constraints between EBs

Outline

- Modeling Problem and Tool Justification
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- **Discussion and Validation**
- Status and Future Work

Architecture



Design Decisions

- Browser versions and updates
- JointJS data model and constraints

Usability

- Two rounds user testing
- Found issues with
 - resizing
 - 'enter' key
 - 'backspace'/'delete' key
 - selecting analysis techniques
- Further user studies are ongoing
- Built several models and examples

Examples and Case Studies

- City transportation planning
- Network maintenance
- Software supply chains
- Technical debt
- Compliance
- Sustainability

Further case studies are ongoing....

Ongoing Validation

- Evaluate usability / effectiveness with controlled experiment
- Prototype study at this week at iStar and RE
- Please Participate!!

<http://www.cs.toronto.edu/~amgrubb/restudy.htm>

Where do I get the tool?

<http://www.cs.toronto.edu/~amgrubb/growing-leaf>

Where do I get the tool?

<http://www.g-leaf.org>

GrowingLeaf

Click [here](#) to be redirected to a live version of the tool.

Modelling Relationships

Node name: Buy Bread

Initial Satisfaction Value: Satisfied

Function Type: Montonic Negative, Denied

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[g-leaf](http://www.g-leaf.org)

GrowingLeaf: is an iStar modeling and analysis tool focused on understanding model evolution and how the evaluations of intentional elements change over time. GrowingLeaf was developed as an extension to [Leaf \(beta\)](#).

Where do I get the tool?

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<http://www.growingleaf.org>

g-leaf

GrowingLeaf: is an iStar modeling and analysis tool focused on understanding model evolution and how the evaluations of intentional elements change over time. GrowingLeaf was developed as an extension to Leaf (beta).

Where do I get the tool?

The screenshot shows the GrowingLeaf web application in a browser. The address bar displays www.cs.toronto.edu/~amgrubb/leaf-ui/Tool.html. The application has a dark top bar with the 'GrowingLeaf' logo and a menu of tools: Undo, Redo, Clear, Save, Load, Zoom In, Zoom Out, Open as SVG, Export .leaf, Font Size, Model Constraints (highlighted in blue), and Analysis (highlighted in green). On the left, a 'Stencil' panel lists four diagram elements: Goal (yellow rounded rectangle), Task (green hexagon), Soft Goal (orange rounded rectangle), and Resource (blue rectangle). Below these is an 'Actor' element represented by a yellow circle overlapping a larger green circle. The main workspace, titled 'Modelling Relationships', is a large grid of dots. The bottom left corner contains copyright information for the University of Toronto (2015-2016) and client IO (2014-2016), along with the JointJS logo and website link.

← → ↻ ⓘ www.cs.toronto.edu/~amgrubb/leaf-ui/Tool.html ☆ ⋮

GrowingLeaf Undo Redo Clear Save Load Zoom In Zoom Out Open as SVG Export .leaf Font Size **Model Constraints** Analysis

Stencil

- Goal
- Task
- Soft Goal
- Resource

Actor

Modelling Relationships

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<http://jointjs.com>

Where do I get the tool?

The screenshot shows the GrowingLeaf web application running in a Google Chrome browser. The address bar displays the URL www.cs.toronto.edu/~amgrubb/leaf-ui/Tool.html. The application's interface includes a top navigation bar with the 'GrowingLeaf' logo and several menu items: 'Undo', 'Redo', 'Clear', 'Save', 'Load', 'Zoom In', 'Zoom Out', 'Open as SVG', 'Export .leaf', 'Font Size', 'Model Constraints' (highlighted in blue), and 'Analysis' (highlighted in green). On the left side, there is a 'Stencil' panel containing four diagram elements: 'Goal' (yellow rounded rectangle), 'Task' (green hexagon), 'Soft Goal' (orange rounded rectangle), and 'Resource' (blue rectangle). Below these is a larger diagram element labeled 'Actor' consisting of a yellow circle overlapping a green circle. The main workspace, titled 'Modelling Relationships', is a large grid with a dotted pattern. The text 'Use Google Chrome' is overlaid in the center of the workspace. At the bottom left, there is a copyright notice for the University of Toronto and a 'Powered by:' section mentioning 'client IO' and 'JointJS: an HTML 5 diagramming component' with a link to <http://jointjs.com>.

Use Google Chrome

Where do I get the tool?

<http://www.cs.toronto.edu/~amgrubb/growing-leaf>

Join the development team.

Future Work

- Update tool to use iStar 2.0 Language Guide
- External industrial case study
- Improve server connection (security)
- Multiple users to simultaneously edit
- Development for other browsers

Questions?

GrowingLeaf: Supporting Requirements Evolution over Time

GrowingLeaf

<http://www.cs.toronto.edu/~amgrubb/growing-leaf>

Tool Study at RE'16:

<http://www.cs.toronto.edu/~amgrubb/restudy.htm>