

MSDL

Modelling, Simulation and Design Lab

Hans Vangheluwe



McGill

School of Computer Science

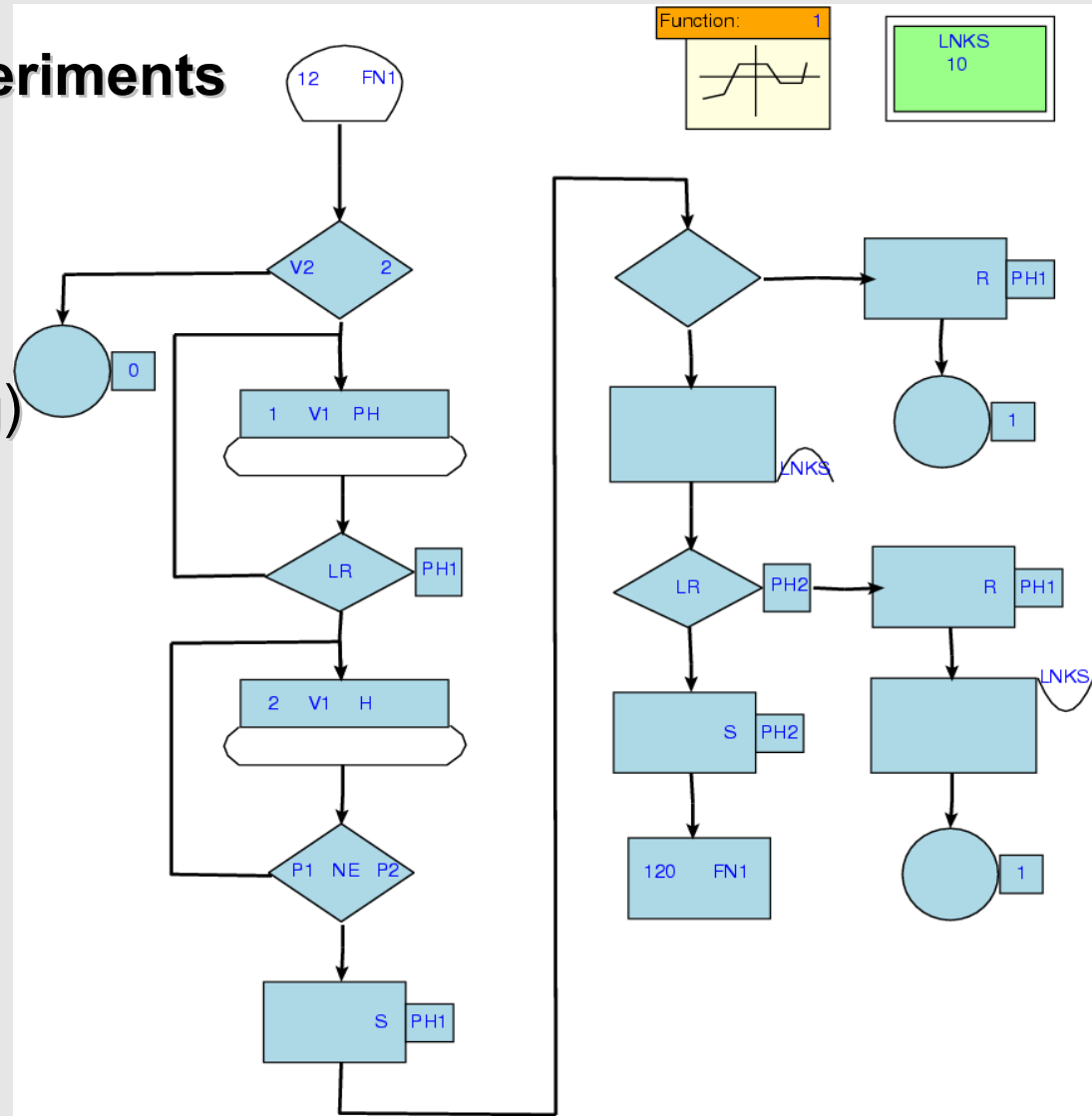
OO Design; Modelling and Simulation; Modelling and Simulation Based Design

Learning all the time ...

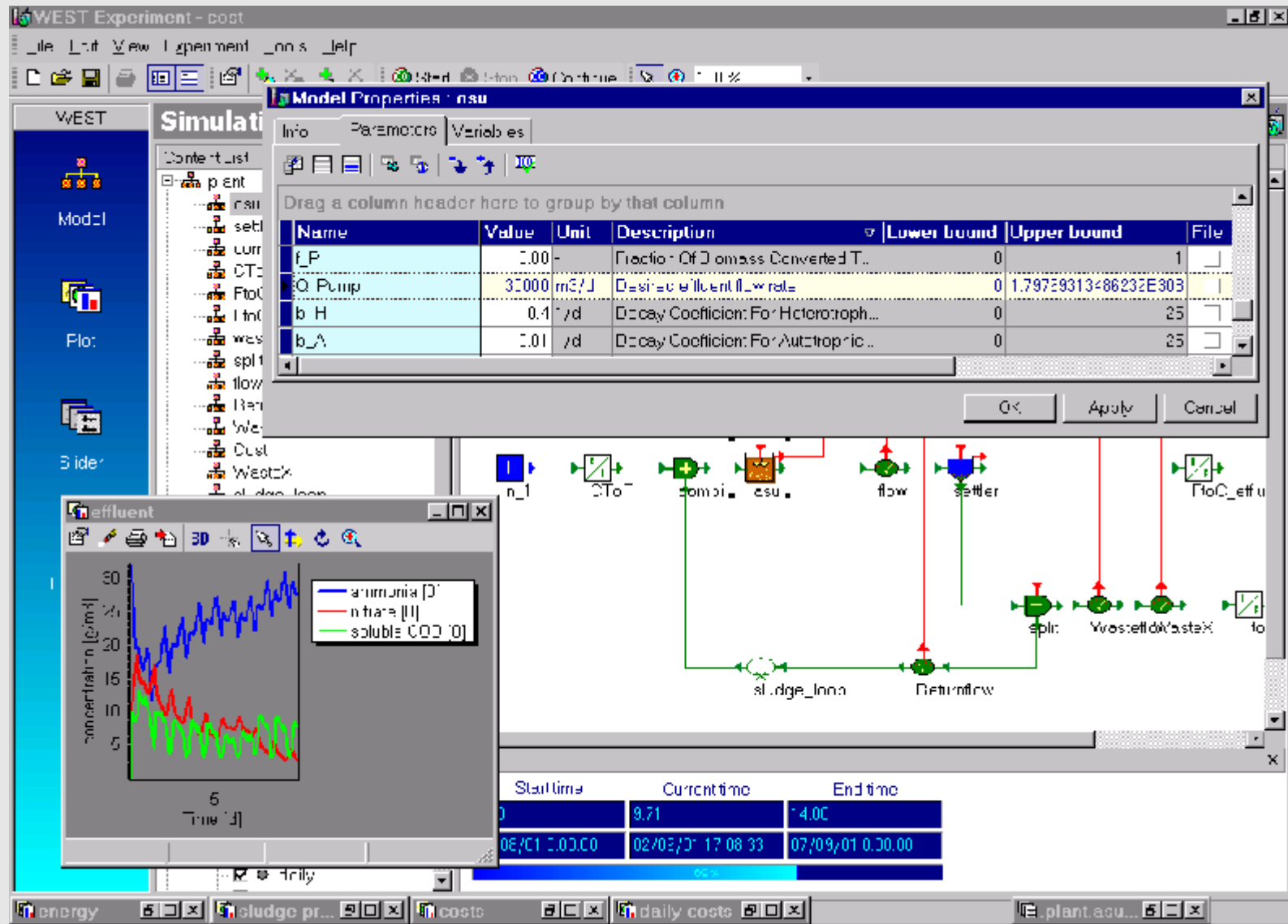
- **Theoretical Physics (Ghent, Belgium)**
quantum field theory (models of models, unify)
- **Pedagogy (Ghent, Belgium)**
- **Computer Science (Ghent, Belgium)**
compilers (prolog interpreter)
visiting Laurie Hendren
at McGill (optimizing compilers – gcc 1.37)
- **Doctor of Science (Ghent, Belgium)**
math-CS-biology-chemistry-physics
multi-formalism modelling, FTG, ...

Designing Modelling Languages/Simulators

- **CSSL** simulators
- **Real-time simulators, fixed point code**
(AD10, ADI RTS)
- **Distributed simulators and experiments**
(Time Warp)
- **Discrete-event simulators**
DEVS
Hierarchical GPSS
- **MSL-USER** (non-causal modelling)



Building WWTP DSM&E environment the hard way



DSM, model transformation, experiment management, optimization, model storage, distributed simulation&experimentation, ...

Simulation in Europe

ESPRIT Basic Research Working Group 8467 (co-founder)
Industry – Academia: future of M&S, key problems

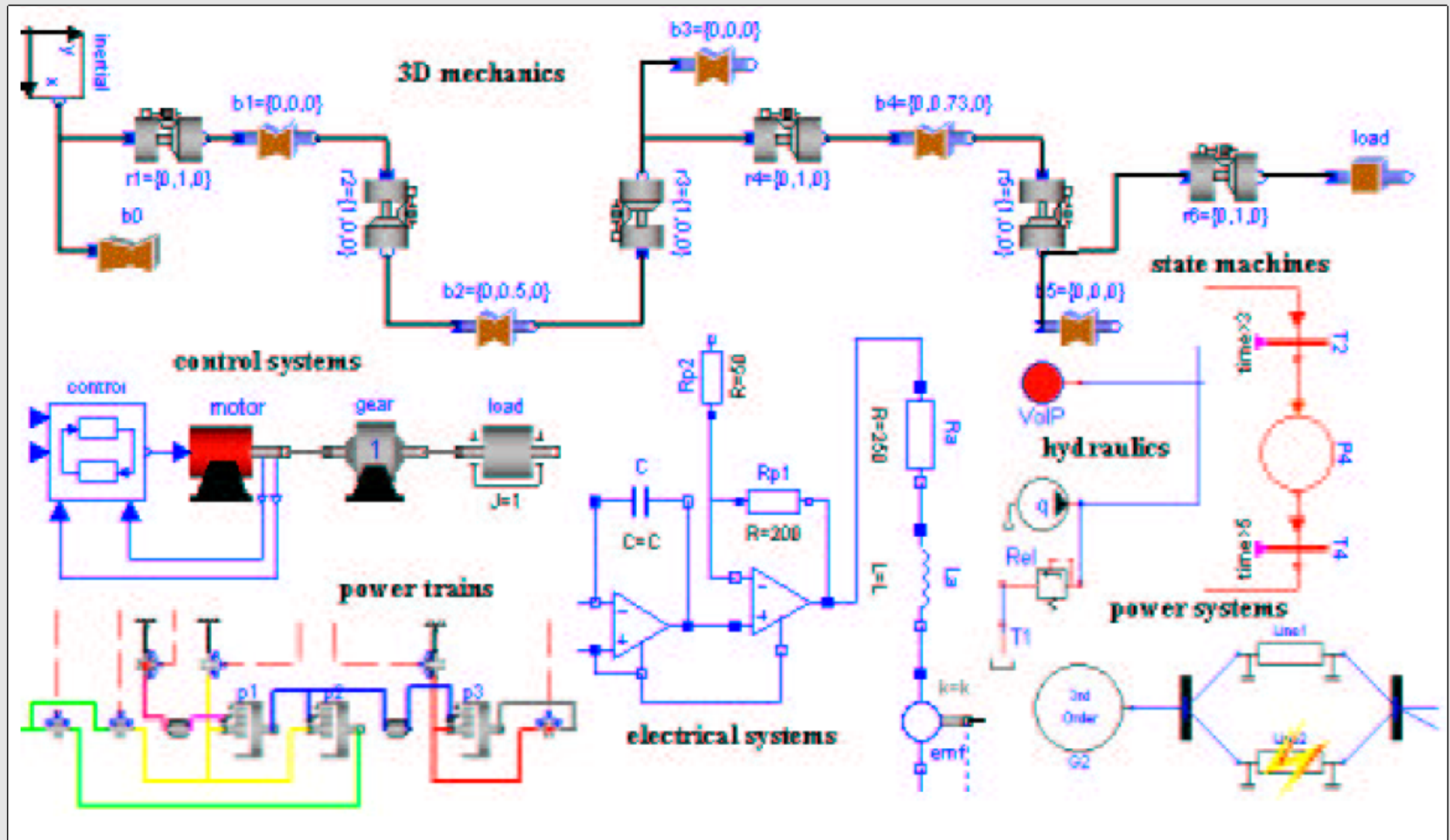
- 1) multi-paradigm modelling**
- 2) non-causal modelling of physical systems**
- 3) meta-modelling (STEP/EXPRESS)**
- 4) usability by end-user (GUI, DSM, traceability, ...)**

(SiE report)



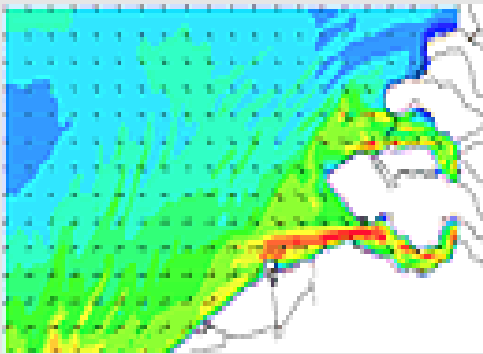
SiE

Modelica (www.modelica.org)



SiE spin-off, co-founder, muModelica compiler

Belgian Navy and MUMM



Concurrent Engineering Research Center (DARPA)



(software) process modelling

At different **levels of abstraction**:

- “management” level (planning)
- “operational” level (orchestrating)

Using **most appropriate formalisms**:

- Forrester System Dynamics
- Process Interaction
- DEVS
- Statecharts

Continuity between
abstraction levels, formalisms !

Modelling, Simulation and Design Lab

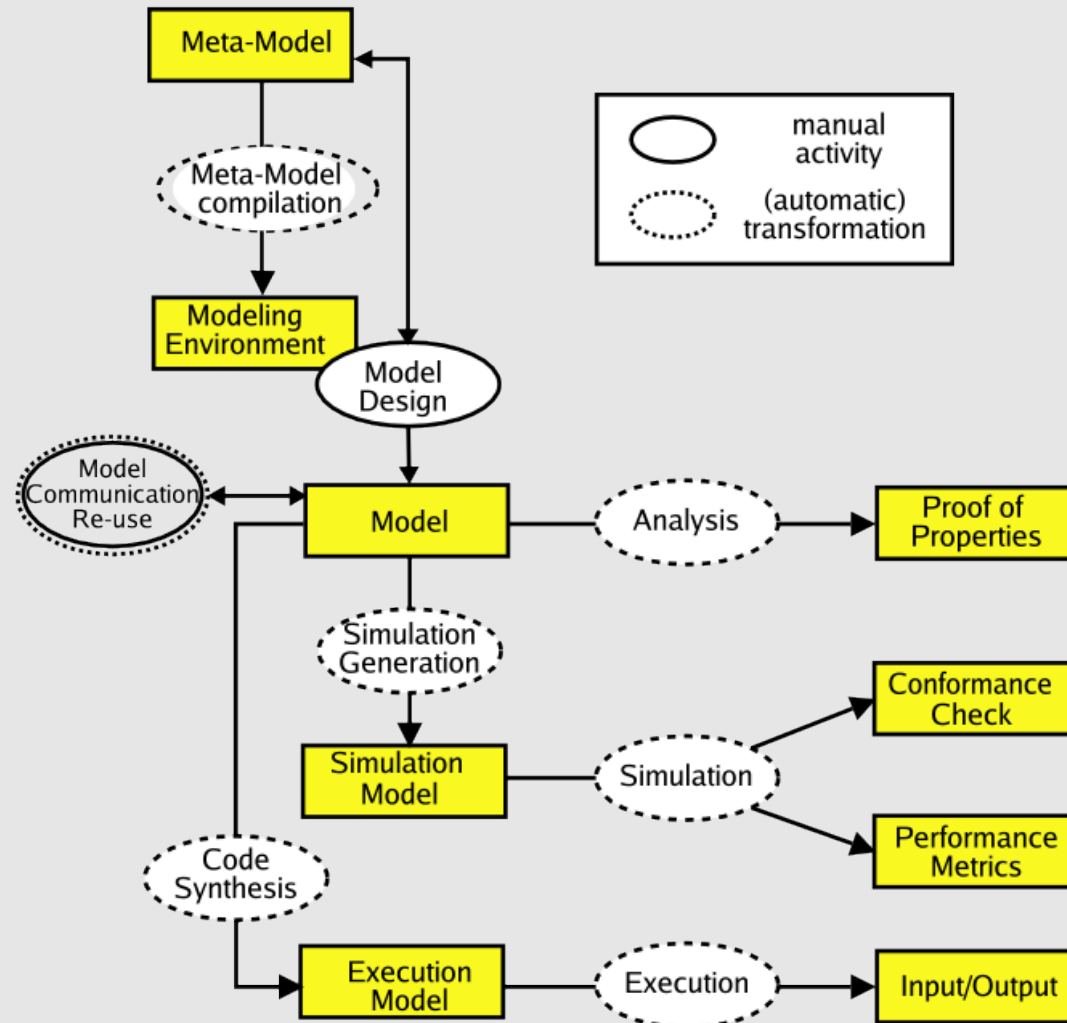


- started in 2001
- Modelling and Simulation
applied to Software Engineering applied to ...
- fundamental research => prototypes => deployment

Modelling, Simulation and Design Lab

- **applications** of domain-specific modelling (and simulation)
 - software design
 - environment
 - traffic
- domain-specific **visual modelling**
 - specification of reactive behaviour
 - link concrete and abstract syntax
- **meta-modelling** and **model transformation ((T)GG)**
- **theory/foundations:**
 - new formalisms, multi-formalism modelling
 - formalism transformation

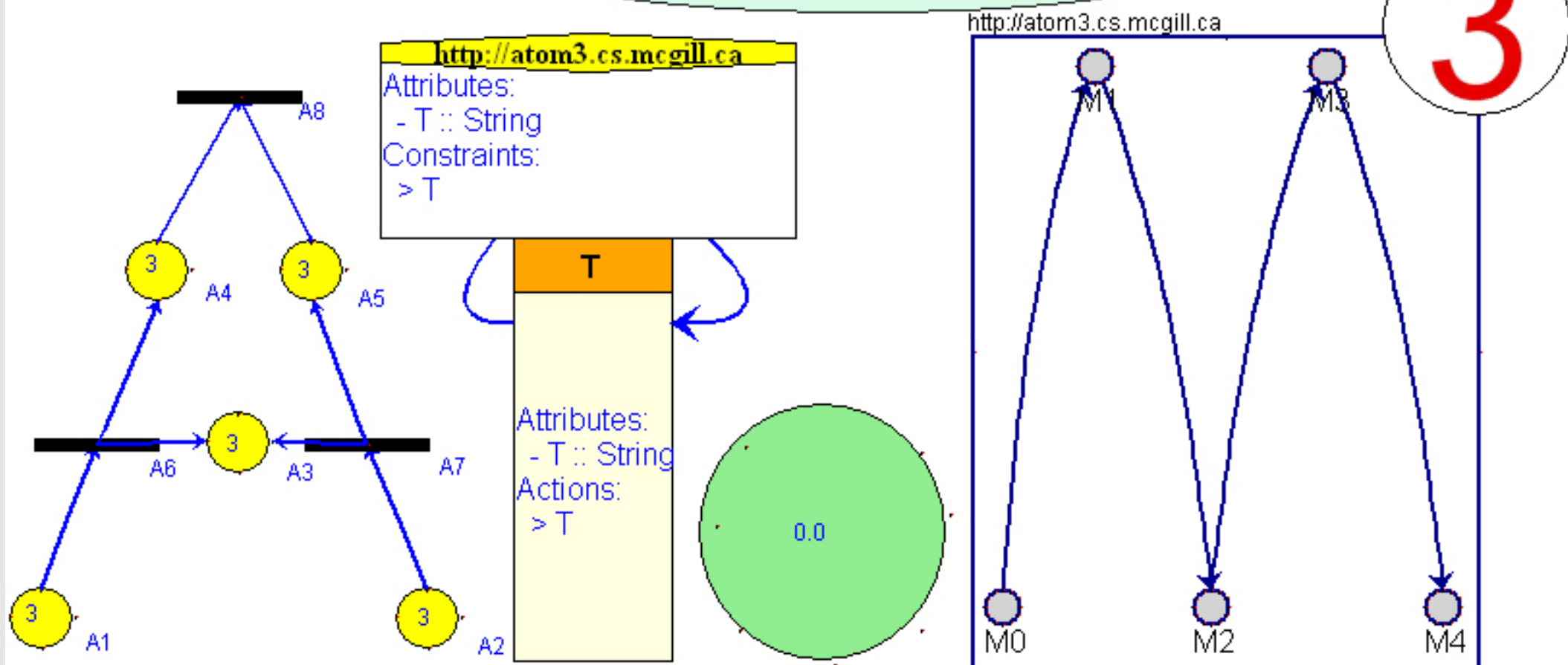
Modelling and Simulation Based Design



Our CAMPaM tool ...

A Tool for Multi-formalism and Meta-Modeling

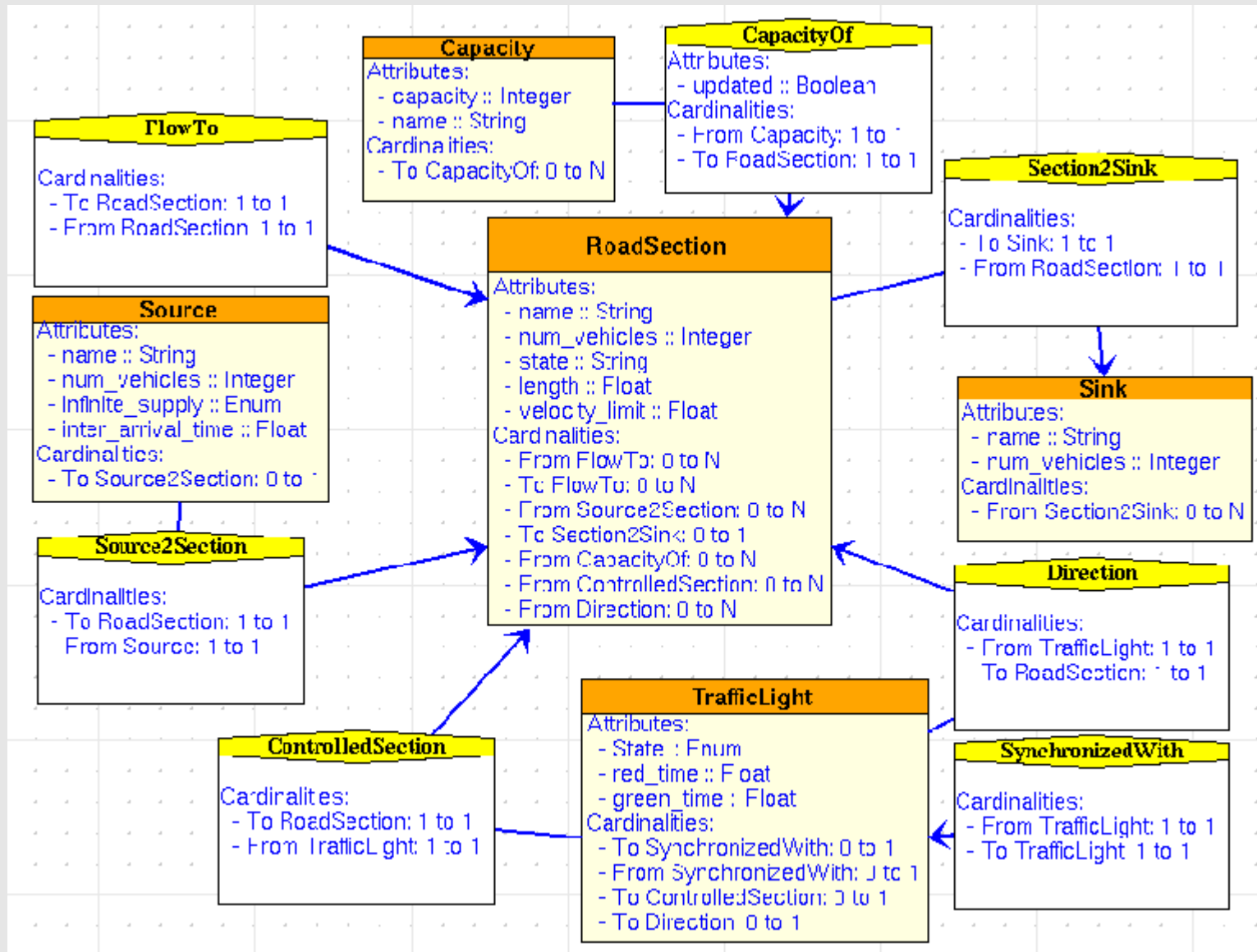
Even our logos are modeled!



Visit MSDL at <http://msdl.cs.mcgill.ca>

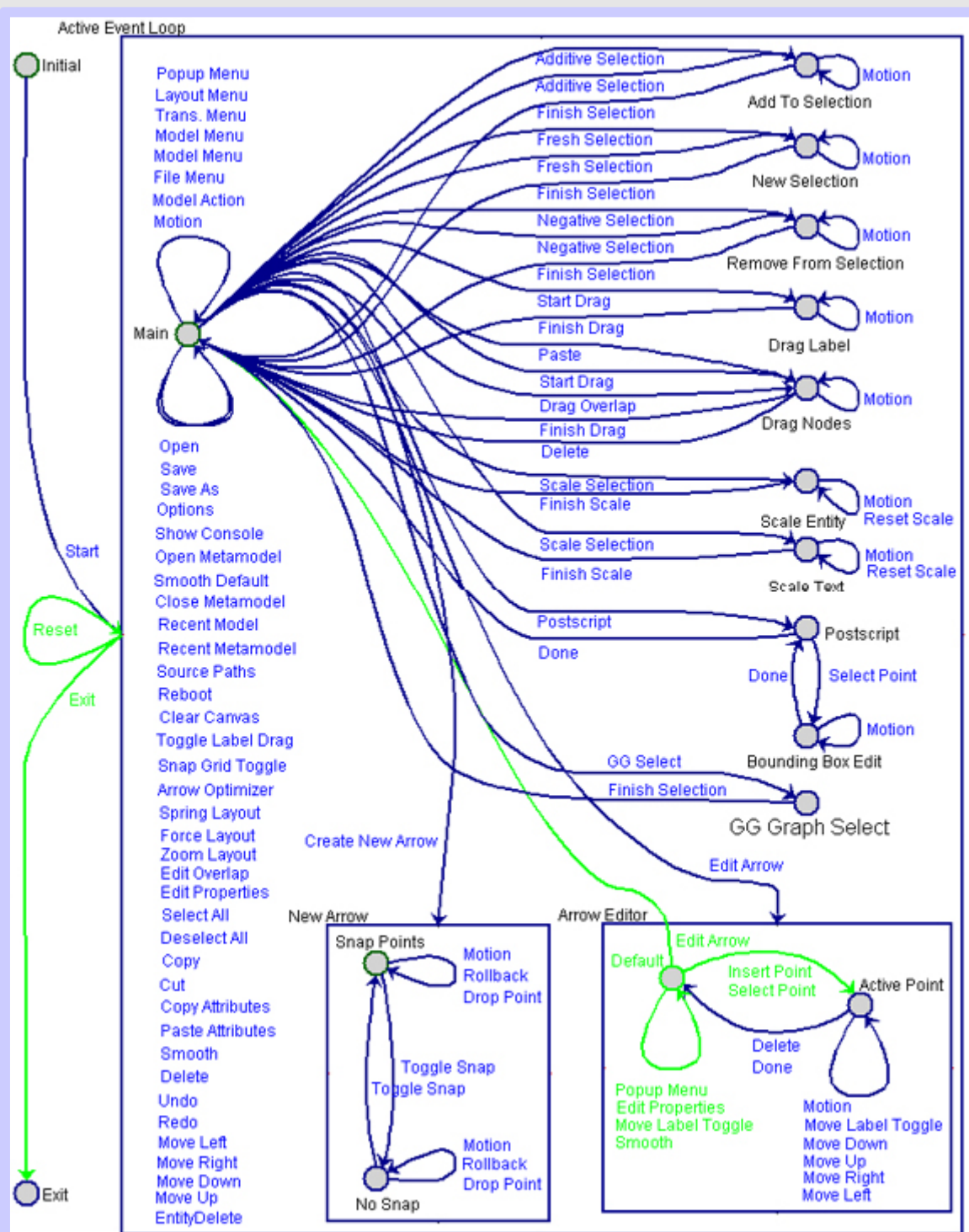


Meta-modelling Traffic



Dchart modelling of reactive behaviour of a visual modelling environment

... has spawned a whole new thread of research on the modelling, analysis and synthesis of advanced user interfaces ...



synthesized Traffic-specific modelling environment

74 AToM3 v0.3 using: EntityRelationshipV3 + TransformationToolbar + Traffic

The interface features a toolbar with the following sections:

- EntityRelationshipV3:** Entity, rel, EDIT, GEN, ?
- TransformationToolbar:** EDIT, LOAD, SAVE, GEN, EXEC, DOG, ?
- Traffic:** R, So, Si, C, CO, T2PN

The main workspace displays a diagram with the following entities and connections:

- cars:** A horizontal line with an arrow pointing right, labeled 'cars' with a '2' in a red circle.
- turn2_CAP:** A point at the top left, labeled 'turn2_CAP' with a '1' in a red circle.
- top_CAP:** A point at the top right, labeled 'top_CAP' with a '1' in a red circle.
- bot_N2S:** A point in the middle, labeled 'bot_N2S' with a '0' in a red circle.
- bot_W2E:** A point at the bottom left, labeled 'bot_W2E' with a '0' in a red circle.
- bot_CAP:** A point at the bottom right, labeled 'bot_CAP' with a '1' in a red circle.

Connections include a vertical line from 'turn2_CAP' to 'bot_N2S', a horizontal line from 'turn2_CAP' to 'top_CAP', a diagonal line from 'top_CAP' to 'bot_CAP', and a horizontal line from 'bot_W2E' to 'bot_CAP'.

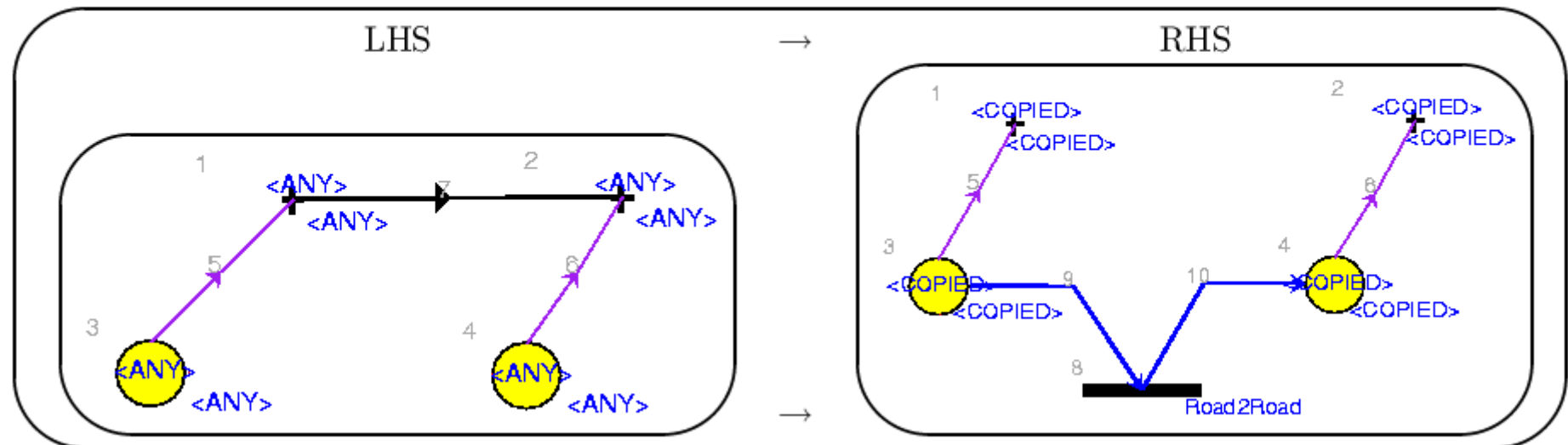
AToM³

Action (IDLEMODE)	Ctrl-Right-Click
Select All	Ctrl-A
Paste	Ctrl-V
Undo	Ctrl-Z
Redo	Ctrl-Y
File Menu	F
Model Menu	M
Transformation Menu	T
Layout Menu	L
Export Menu	
Open Recent Model	F6
Open Recent Meta-Model	F7
Source Paths	F8
Spline arrows by default	F9
Exit AToM3	Alt-X

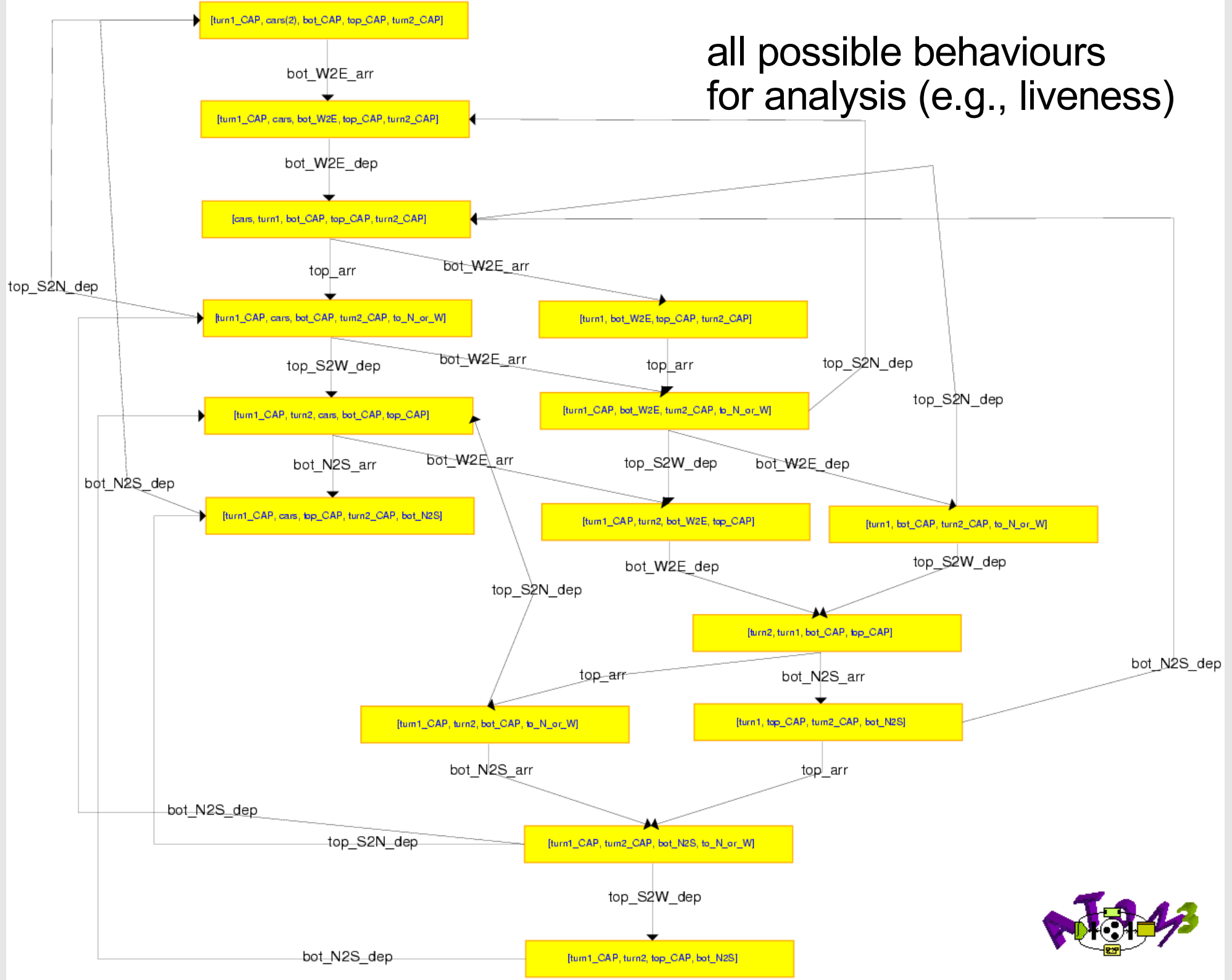
Explicitly model model transformation (using GG)



Rule 2 (Order 2): FlowTo2PNTransition



all possible behaviours
for analysis (e.g., liveness)



=====

=

= Conservation Analysis Results: =

=

=====

$$1.0 \times [\text{turn1_CAP}] + 1.0 \times [\text{turn1}] = 1.0$$

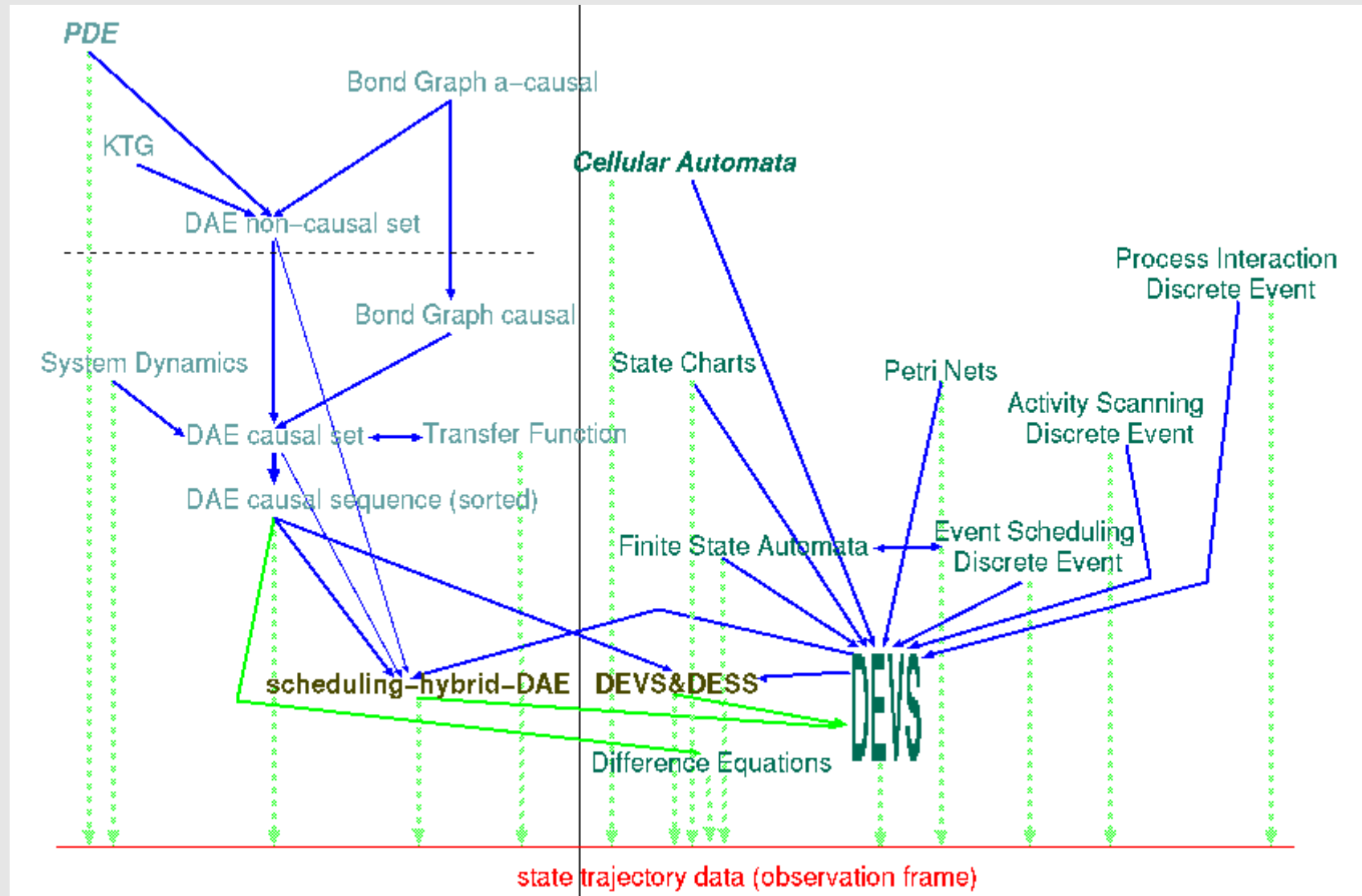
$$1.0 \times [\text{cars}] + 1.0 \times [\text{bot_W2E}] + 1.0 \times [\text{turn1}] + \\ 1.0 \times [\text{to_N_or_W}] + 1.0 \times [\text{turn2}] + 1.0 \times [\text{bot_N2S}] = 2.0$$

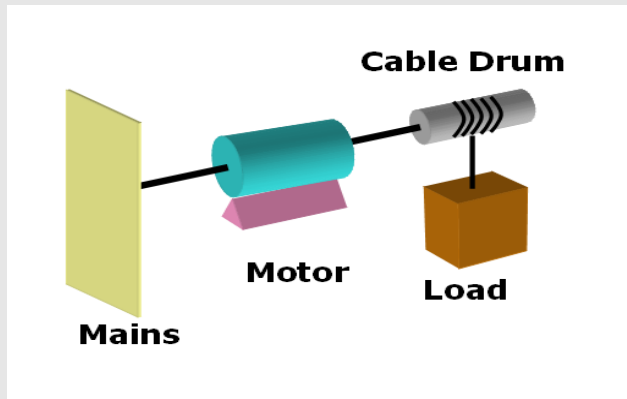
$$1.0 \times [\text{top_CAP}] + 1.0 \times [\text{to_N_or_W}] = 1.0$$

$$1.0 \times [\text{turn2_CAP}] + 1.0 \times [\text{turn2}] = 1.0$$

$$1.0 \times [\text{bot_CAP}] + 1.0 \times [\text{bot_W2E}] + 1.0 \times [\text{bot_N2S}] = 1.0$$

Formalism Transformation Graph





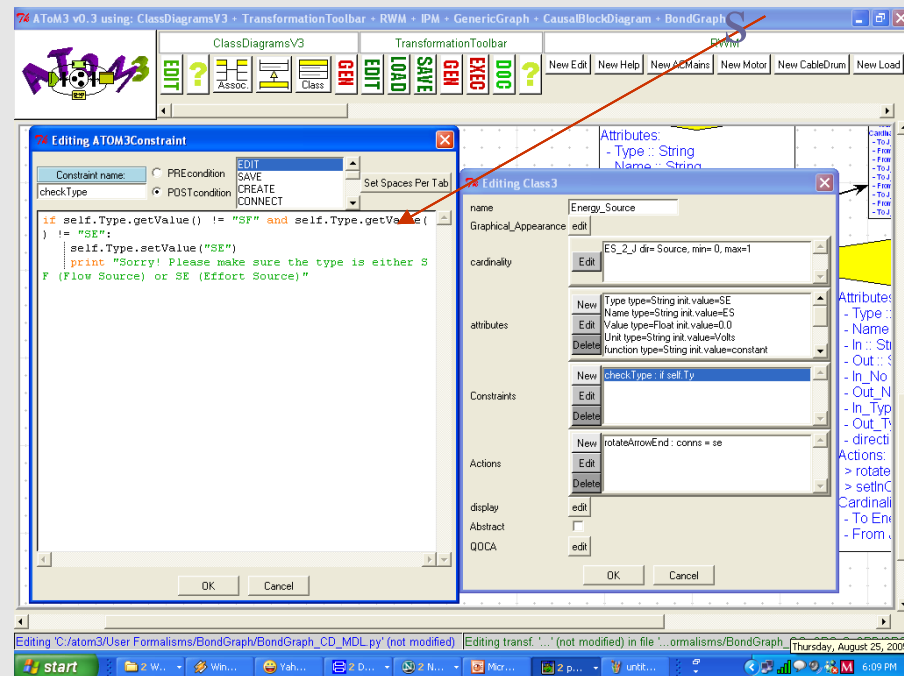
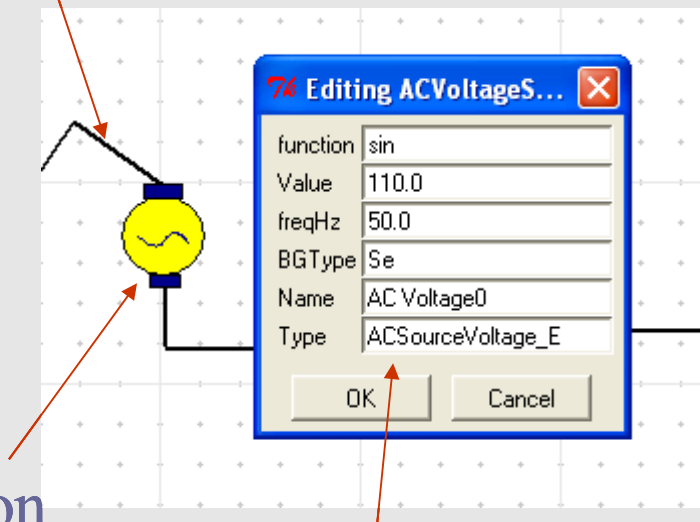
- modelling of **physical systems**
- domain-specific **design-space exploration** based on genetic algorithms

Constraint

Edge

Icon

Attributes



Software Engineering

e.g., Dsheet: the Designed Spreadsheet

DSheet <observing subject 1> 0.85

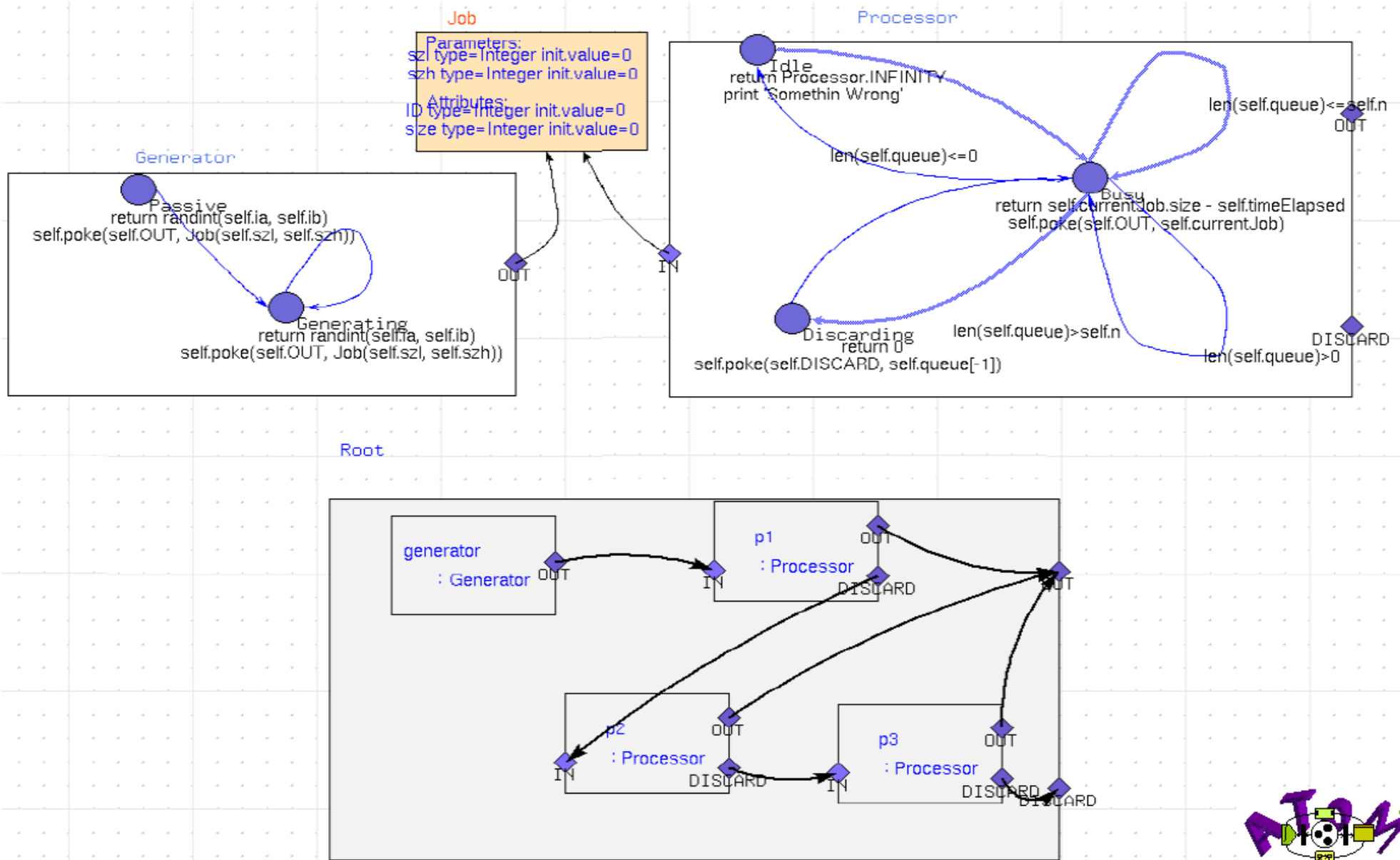
File Edit

=avg(B5:B9) B12 01:04

	A	B	C	D	E	F	G	H	I
1	weight	10.0	15.0	25.0	50.0	100.0			
2	max	9.0	14.0	23.0	46.0	92.0			
3									
4		ass1	ass2	midterm	final	grade	letter		
5	marc	6.0	12.0	20.0	38.0	76.0	B+		
6	marie	7.0	11.0	23.0	38.0	79.0	B+		
7	hans	8.0	12.0	23.0	43.0	86.0	A		
8	steve	9.0	14.0	23.0	46.0	92.0	A		
9	anna	3.0	10.0	16.0	38.0	67.0	B-		
10									
11									
12	Average	6.6	11.8	21.0	40.6	80.0			
13	Median	7.0	12.0	23.0	38.0	79.0			
14	Min	3.0	10.0	16.0	38.0	67.0			
15	Max	9.0	14.0	23.0	46.0	92.0			
16									
17									
18									
19									
20									
21									



DEVS: visual modelling, standardize



DEV(S): simulation, standardize



Interests

- **Collect/Structure Requirements for CAMPaM**
- Continue to work on **framework** to “**model** everything”
At the most appropriate **level of abstraction**
In the most appropriate **formalism**
- **Transformations as first-class models**
-> higher order transformations
- **Model evolution, consistency (using TGGs) of multi-view models**
syntax **and** semantics
- **Scale up -> need modularity (in all its forms)**

Workshop Success Metrics

- Maximize $\sum p^{\text{participants successMetric}(p)}$
- Learn
- Convergence of ideas
- Publish CAMPaM report
- Plan publication of results