COMP 522A: Modelling and Simulation

- . . . for *analysis* and *design* of *complex* systems
- . . . to study *structure* and *behaviour*
- . . . for different *application domains*:
  computer networks, traffic, software engineering, biology, physics, chemistry, management, . . .
- . . . implemented using Computer Science !

Overview

1. What is Modelling and Simulation ?
2. Which topics does COMP 522 cover ?
3. What are the pre-requisites ?
4. How is evaluation done ?
5. What are the assignments about ?
6. Where do I get the material covered in CS522 ?

What is Modelling and Simulation ?

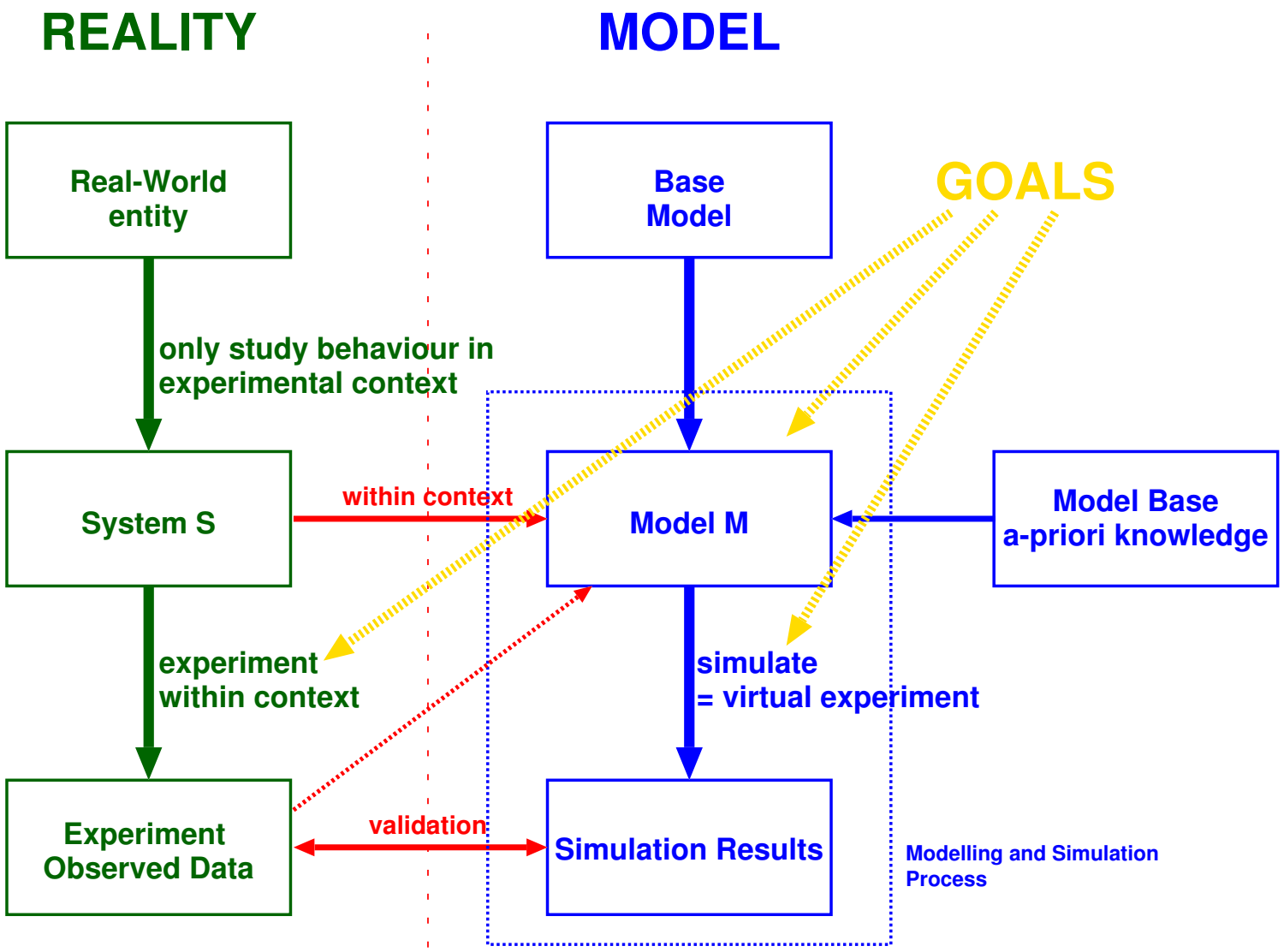
- Modelling: represent/re-use/exchange *knowledge* about system *structure* and *behaviour*
- Simulation: to *accurately* and *efficiently emulate* real behaviour
- Why ?
  - cost, danger, . . .
  - what-if ?
  - optimization (do it right the first time) !

Modelling and Simulation . . .

- . . . is Systems Theory, Control Theory
- . . . is Numerical Analysis, Computer Algebra
- . . . is Computer Science, Artificial Intelligence
- . . . is Operations Research
- . . . is Application Domain: Mechanical Engineering, . . .

. . . or more GENERIC ?

USC (Prof. Swartout): VR Training


REALITY
MODEL
Real-World entity
Base Model
GOALS
only study behaviour in experimental context
System S
within context
Model M
Model Base a-priori knowledge
experiment within context
simulate = virtual experiment
Experiment Observed Data
validation
Simulation Results
Modelling and Simulation Process

Which topics does the course cover ?

1. The Modelling and Simulation Process: Block Diagram example.
2. Hierarchy of System Specification, Systems Theory.
3. Classification of Models, Formalisms (model + simulator).
4. Untimed Discrete Event Formalisms:
   (a) (non)Deterministic State Automata.
   (b) Adding Concurrency and Synchronisation: Petri Nets (cfr. specifying network protocols).
   (c) Adding Hierarchy and Orthogonality: Statecharts (cfr. UML, specifying reactive software).
5. Timed Discrete Event Formalisms:
   (a) Timed Automata.

(b) Event Scheduling.

(c) Activity Scanning (AI).

(d) Three Phase Approach.

(e) Process Interaction (GPSS).

(f) DEVS as a rigourous basis for hierarchical modelling.

6. Deterministic Simulation of Stochastic Processes:

   (a) Pseudo Random Number Generation.

   (b) Gathering Statistics (performance metrics).

7. Continuous-time Formalisms:

   (a) Ordinary Differential Equations & Algebraic Equations.

   (b) Differential Algebraic Equations.

   (c) CSSLs: sorting and algebraic loop detection.

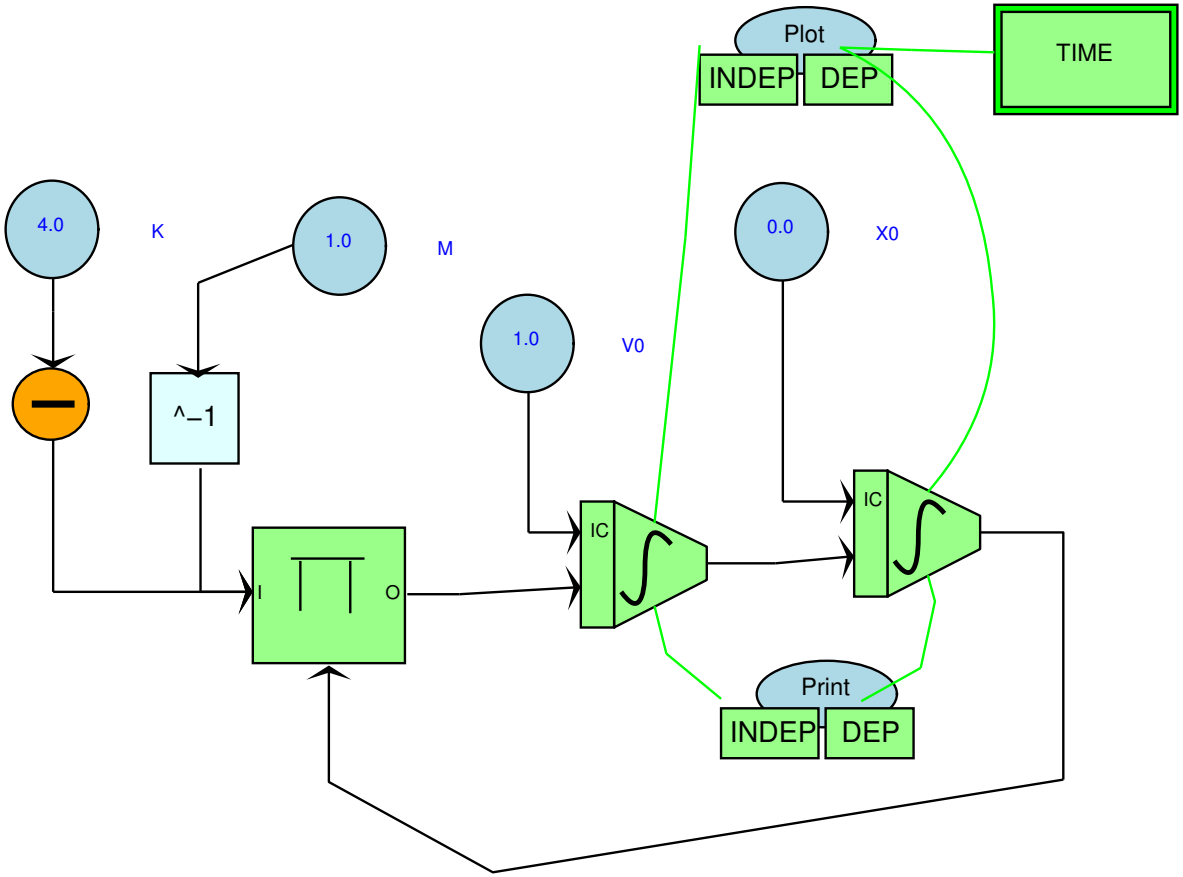
   (d) Forrester System Dynamics, Population Dynamics.

   (e) Hybrid (continuous-discrete) modelling and simulation.

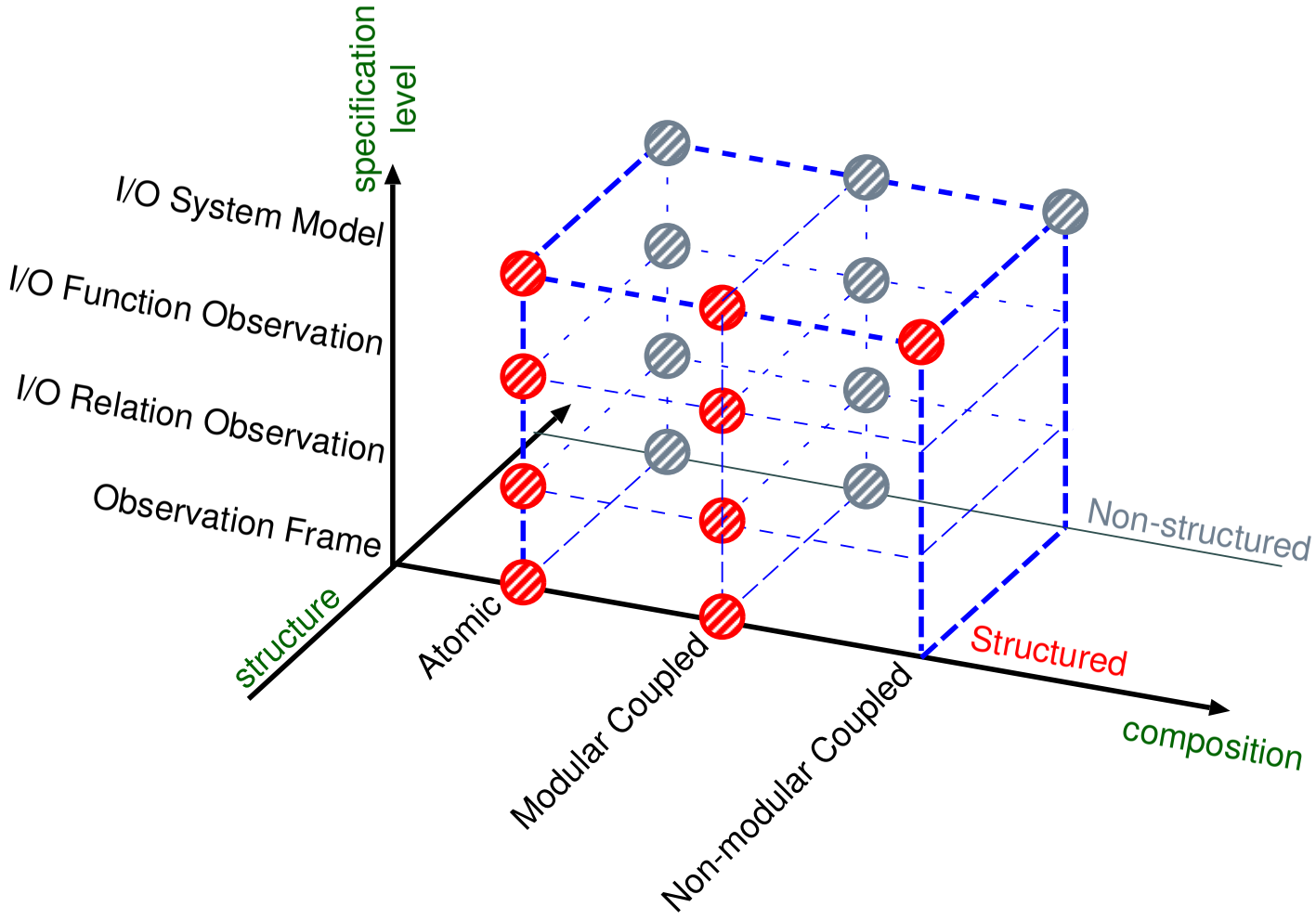
(f) Object-oriented Physical Systems Modelling: Non-causal modelling, Modelica.

Assignments/project: Object-oriented Design, Rapid Application Development with Python.

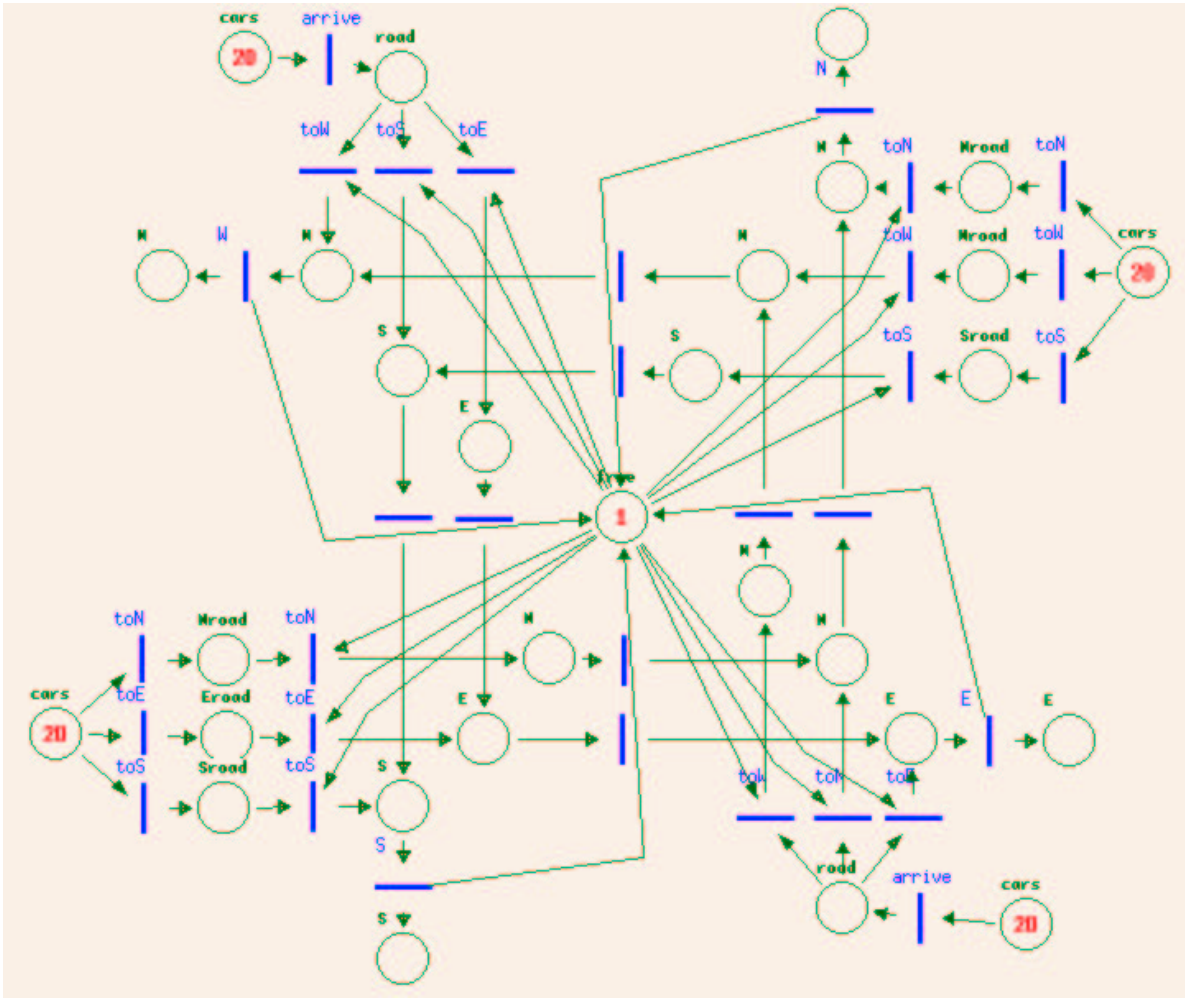
Causal Block Diagrams (cfr. Matlab/Simulink)



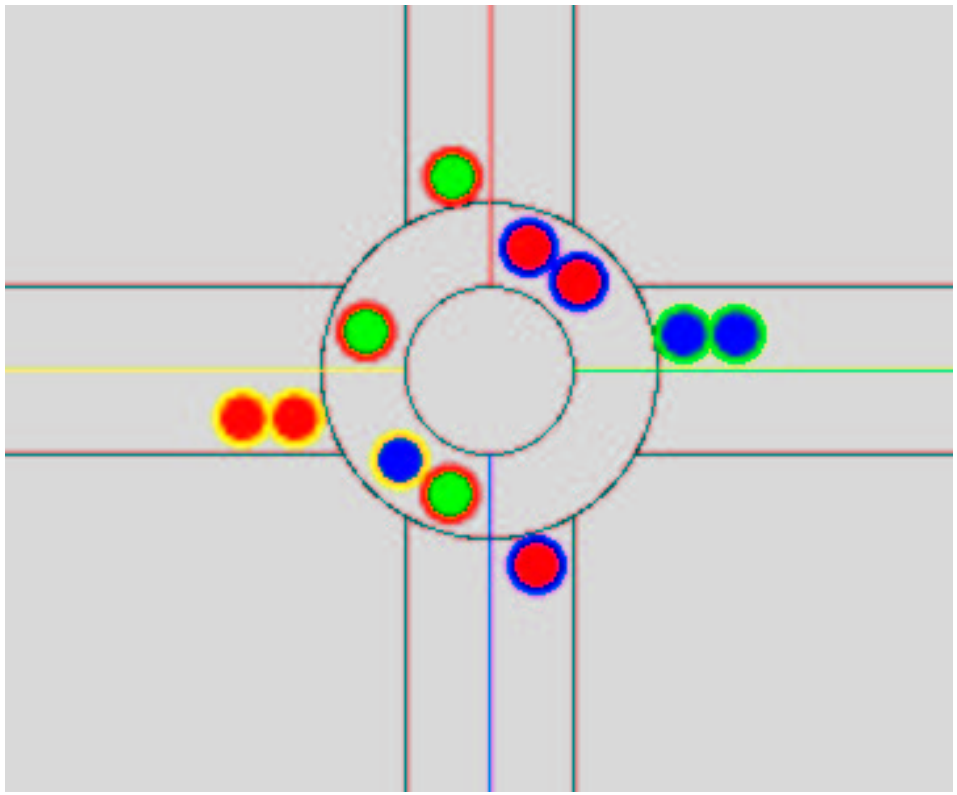
System Specification Hierarchy



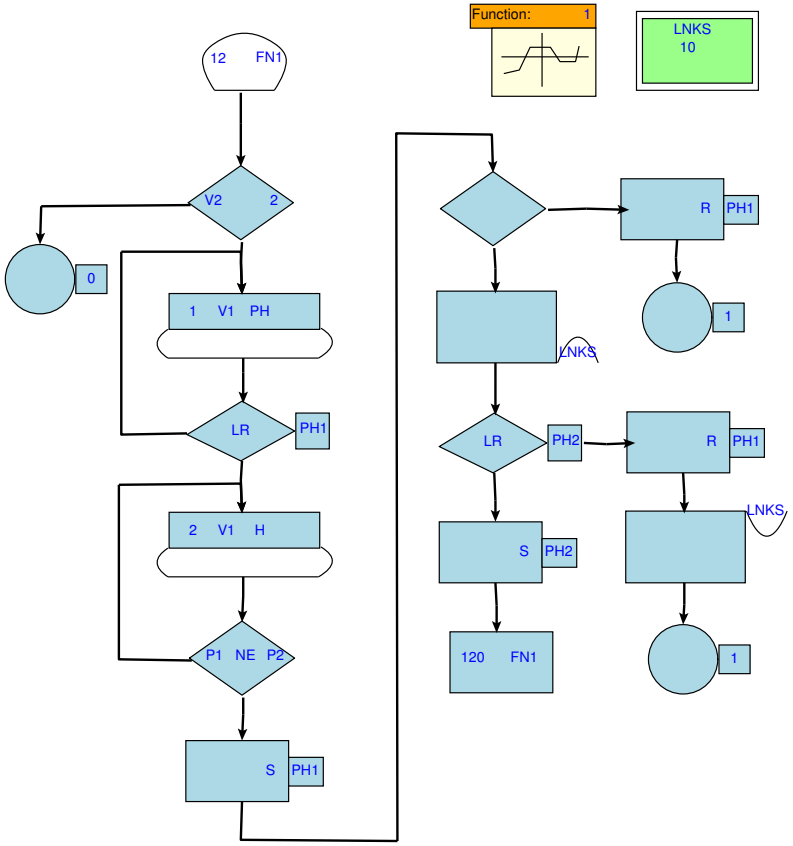
Petri Net model of intersection



DEVS model/animation of intersection



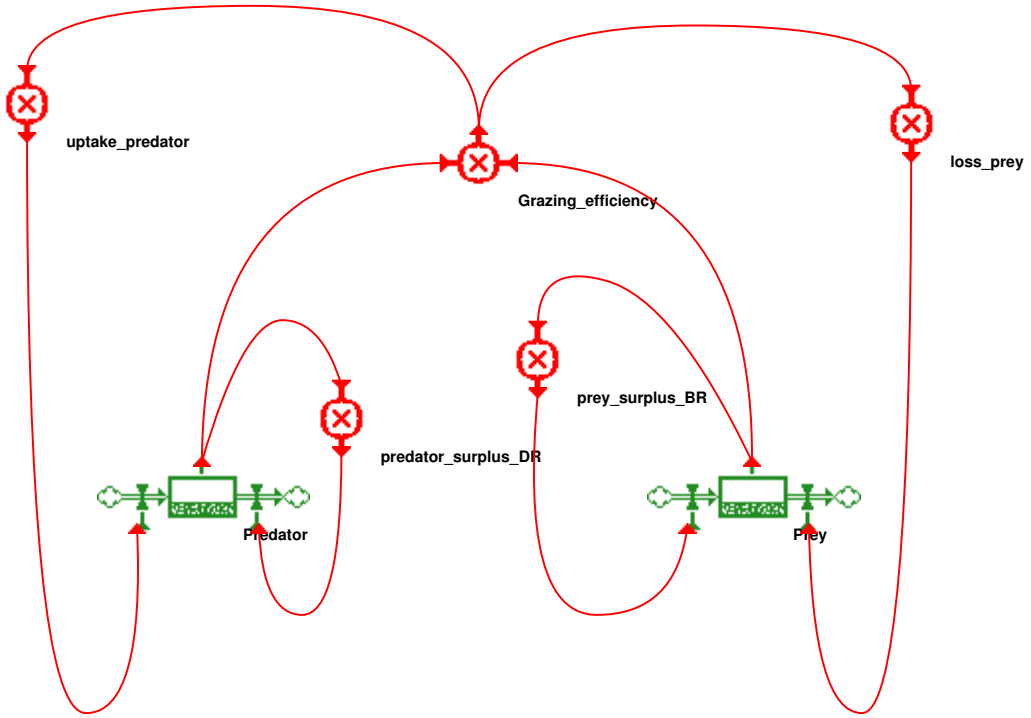
GPSS model of Telephone Exchange



Process Interaction DEV: GPSS

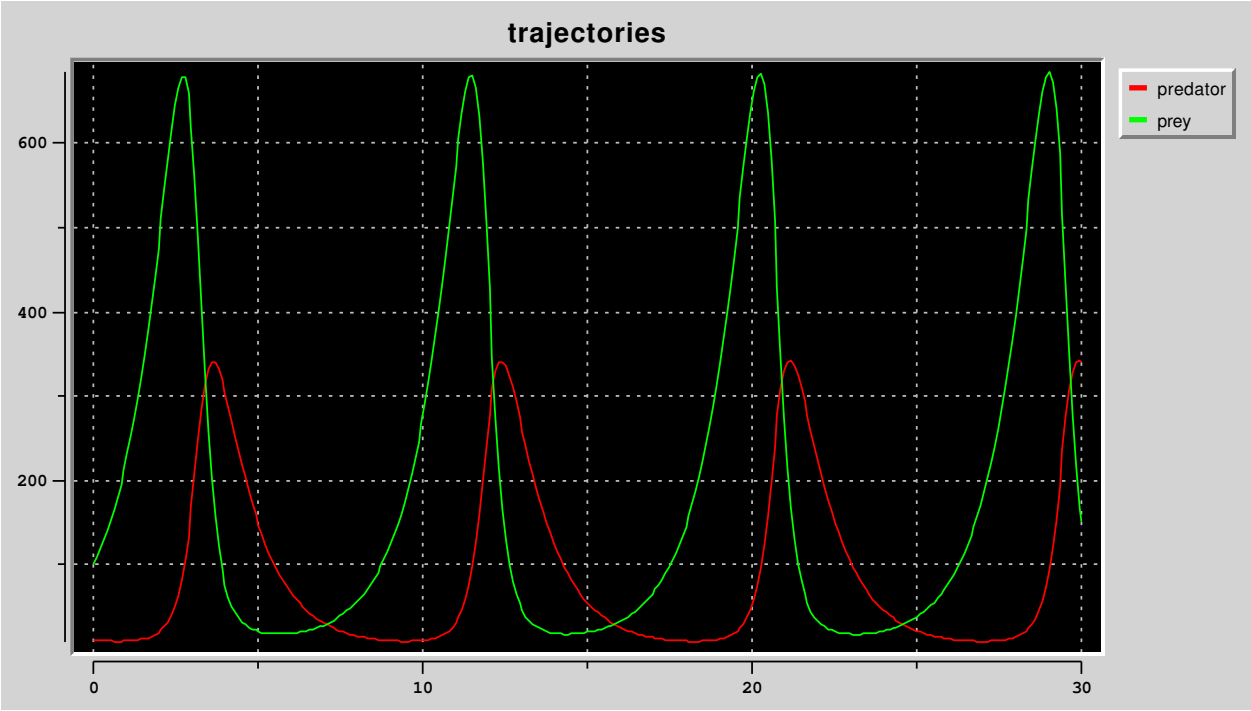
```
       SIMULATE

*
*      GPSS/H Block Section (the model)
*


*
*      MANUFACTURING SHOP - MODEL 1
*      Time unit = 1 minute
*
       GENERATE    5          Create parts
       ADVANCE     4,3        Inspect
       TRANSFER    .1,ACC,REJ Select rejects
ACC    TERMINATE   1          Accepted parts
REJ    TERMINATE   1          Rejected parts

*
*      GPSS/H Control Statements (the experiment(s))
*
       START       1000       Run 1000 parts

       END
```

Population Dynamics, System Dynamics



2–species predator–prey system

Trajectory



What are the pre-requisites ?

- COMP 251 (data structures and algorithms),
- COMP 302 (programming languages and paradigms),
- COMP 350 (numerical computing).

. . . or equivalent (see me).

How is evaluation done ?

- 70% on 6 assignments.
- 30% on the project.

Together, assignments and project cover the entire course.

Hence, there is no final exam.

Assignment/project rules of the game ?

- Completely in HTML form: requirements, design, code, discussion.
- Submit via WebCT.
- All coding in Python (where appropriate).
- In groups of max. 3 people (alone is feasible).
- Original work, some presented in class.
- Respect deadlines (or do more work to compensate).
- Alternate subjects may be proposed.

Need help ?

- Send mail to cs522@cs.mcgill.ca
- Come and see me Monday 16:00 - 18:00 in MC328
- See the TA (Jean-Sébastien Bolduc) in MC202
- Assignments/projects are never fully specified ! Give feedback !

What are the assignments about ?

1. A Causal Block Diagram simulation tool.
2. Petri Net model for a network protocol.
3. Statechart model for a GUI.
4. GPSS (process interaction).
5. A DEVS model of a traffic system.
6. Forrester System Dynamics.

What are the project subjects ?

Will be announced soon. Choose ASAP !

Suggestions are welcome !

- Model/simulate a particular application (*e.g.,* traffic, biology)
- Build a modelling/simulation/animation tool for a particular formalism

Where do I get the material covered in CS522 ?

- Class presentations/notes online in PDF format.
- Some handouts.
- Links and references for those interested.