

# Teaching System Modeling, Simulation and Validation

Jörg Desel  
Katholische Universität Eichstätt  
Germany

## OUTLINE (1)

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### Teaching **System** Modeling, Simulation and Validation

#### **What kind of systems?**

- any kind of systems
- distributed systems
- discrete events
- time associated to conditions / events

## OUTLINE (2)

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### Teaching System **Modeling**, Simulation and Validation

#### **What kind of models?**

- any models of distributed systems
- Petri nets (with time and cost annotations)

## OUTLINE (3)

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Teaching System Modeling, **Simulation** and Validation

### What kind of simulation?

- generation of runs of the model
- visualization and inspection of the generated runs
- analysis of the generated runs and visualization of the results

## OUTLINE (4)

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### Teaching System Modeling, Simulation and **Validation**

#### **What is validation?**

- does the model represent the system correctly?
- does the system match the requirements?
- do the specifications match the requirements?

## OUTLINE (5)

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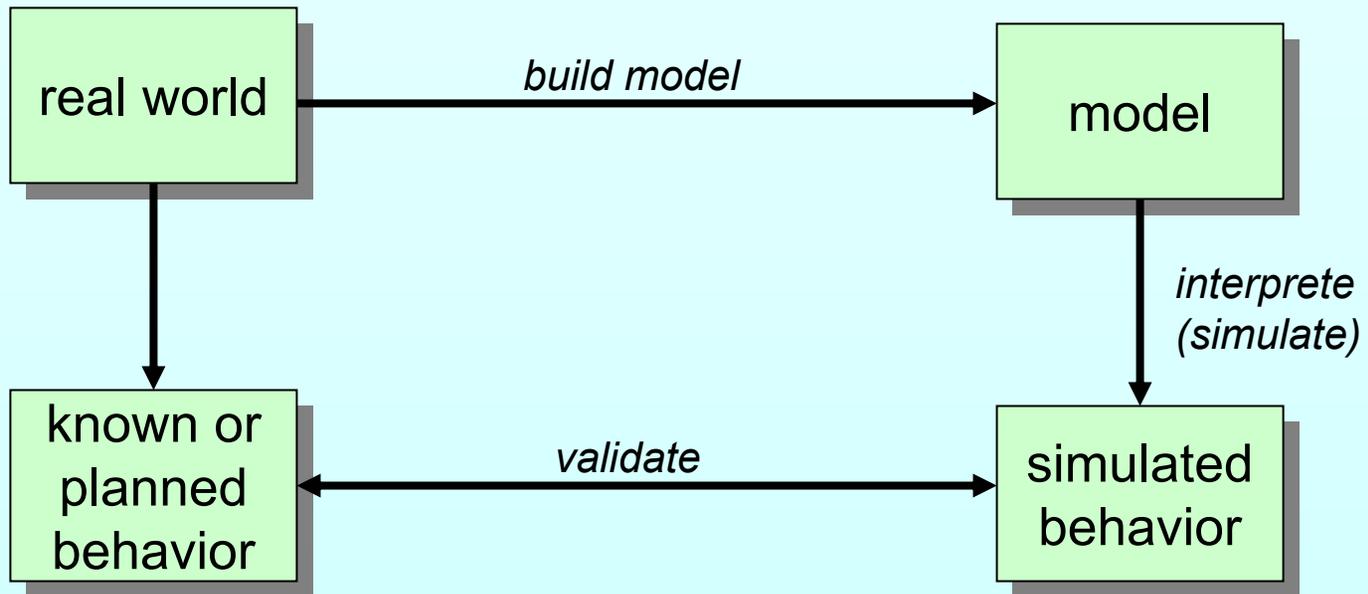
### **Teaching** System Modeling, Simulation and Validation

#### **About teaching**

- **explain the use of modeling, simulation and validation in university courses (computer science, graduate level)**
- **using tools for simulating case studies**
- **experiences with virtual courses**

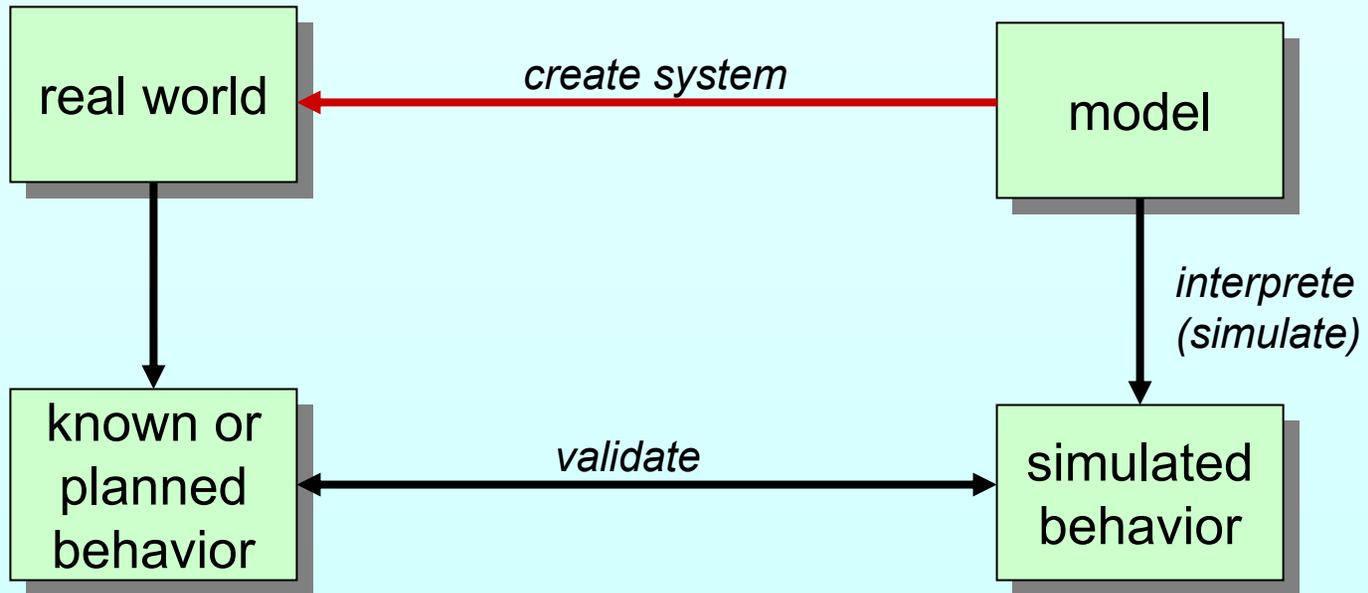
# SIMULATION FOR MODEL VALIDATION (1)

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## SIMULATION FOR MODEL VALIDATION (2)

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# MODELING / SIMULATION / VALIDATION CURRICULUM (1)

**modeling / simulation / validation is a process  
incorporating machines and humans**

- **modeling belongs to system design**
- **cooperation with the user**
- **analysis w.r.t. user-defined criteria**
- **experts need social and communication skills**

## MODELING / SIMULATION / VALIDATION CURRICULUM (2)

### **Simulation has diverse objectives**

- **validation of models with respect to the system**
- **validation of systems with respect to requirements**
- **qualitative properties of systems (deadlocks, ...)**
- **quantitative properties of systems (cost / time)**

## MODELING / SIMULATION / VALIDATION CURRICULUM (3)

### **Systems can run automatically or interactively**

- **models can provide interaction, too**
- **simulation considers roles of the modeler and the user**
- **what can be input and output to a simulation tool?**
- **what should good user interfaces look like?**

**Good exercise: Develop concepts for a simulation tool**

# MODELING / SIMULATION / VALIDATION CURRICULUM (4)

## **Simulation tools differ w.r.t. various criteria**

- **different features support different aspects**
- **quality criteria for simulation tools**
  - **depending on users / application domain**
  - **functionality**
  - **efficiency**
- **how do simulation tools work?**
  - **algorithms**
  - **mathematics**
  - **modeling languages**

## MODELING / SIMULATION / VALIDATION CURRICULUM (5)

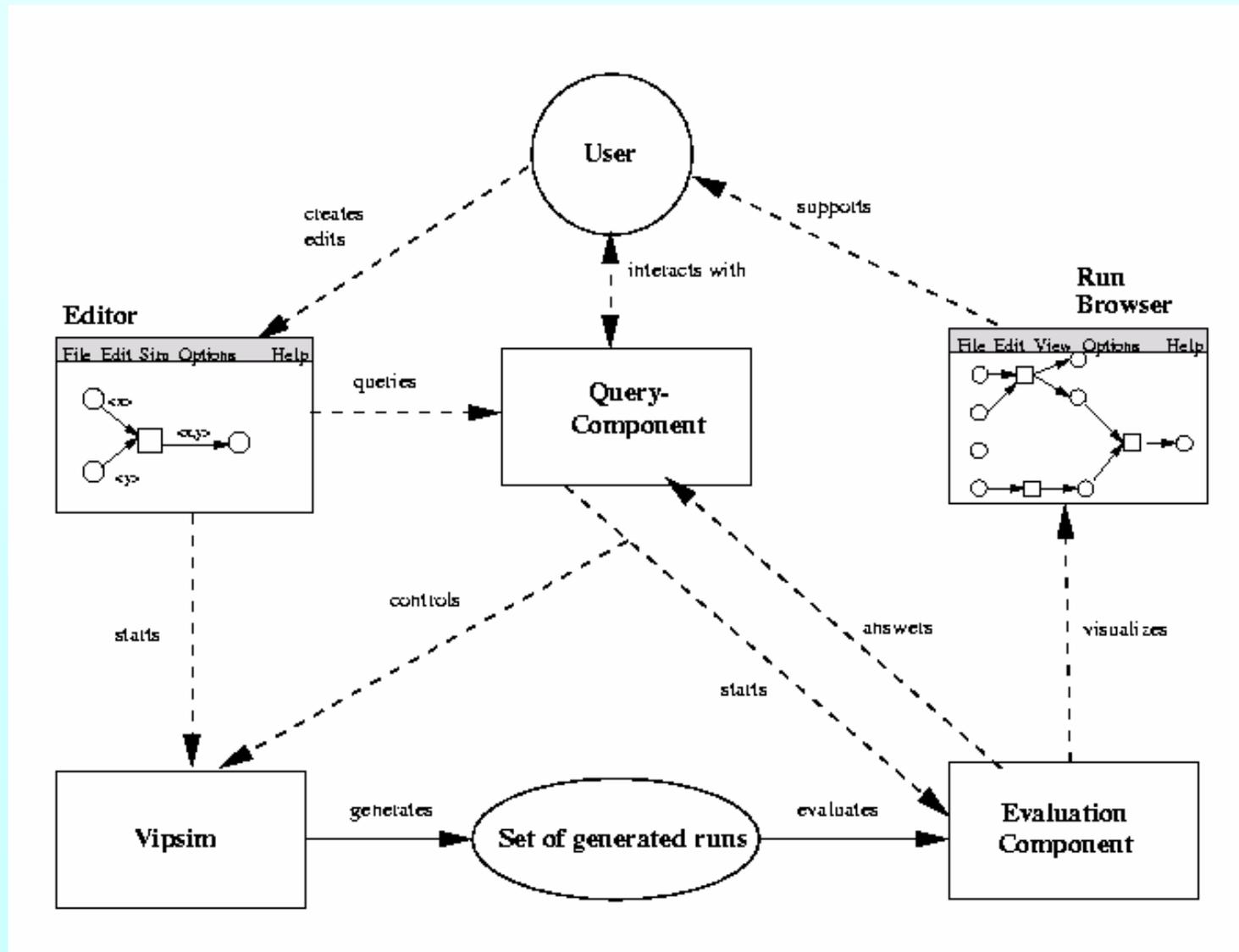
### **Simulation can be integrated in software architectures**

- **example:**  
**look-ahead simulation to detect undesirable states**
- **component based system design**
- **interfaces**

# MODELING / SIMULATION / VALIDATION CURRICULUM (6)

## **Simulation is based on content**

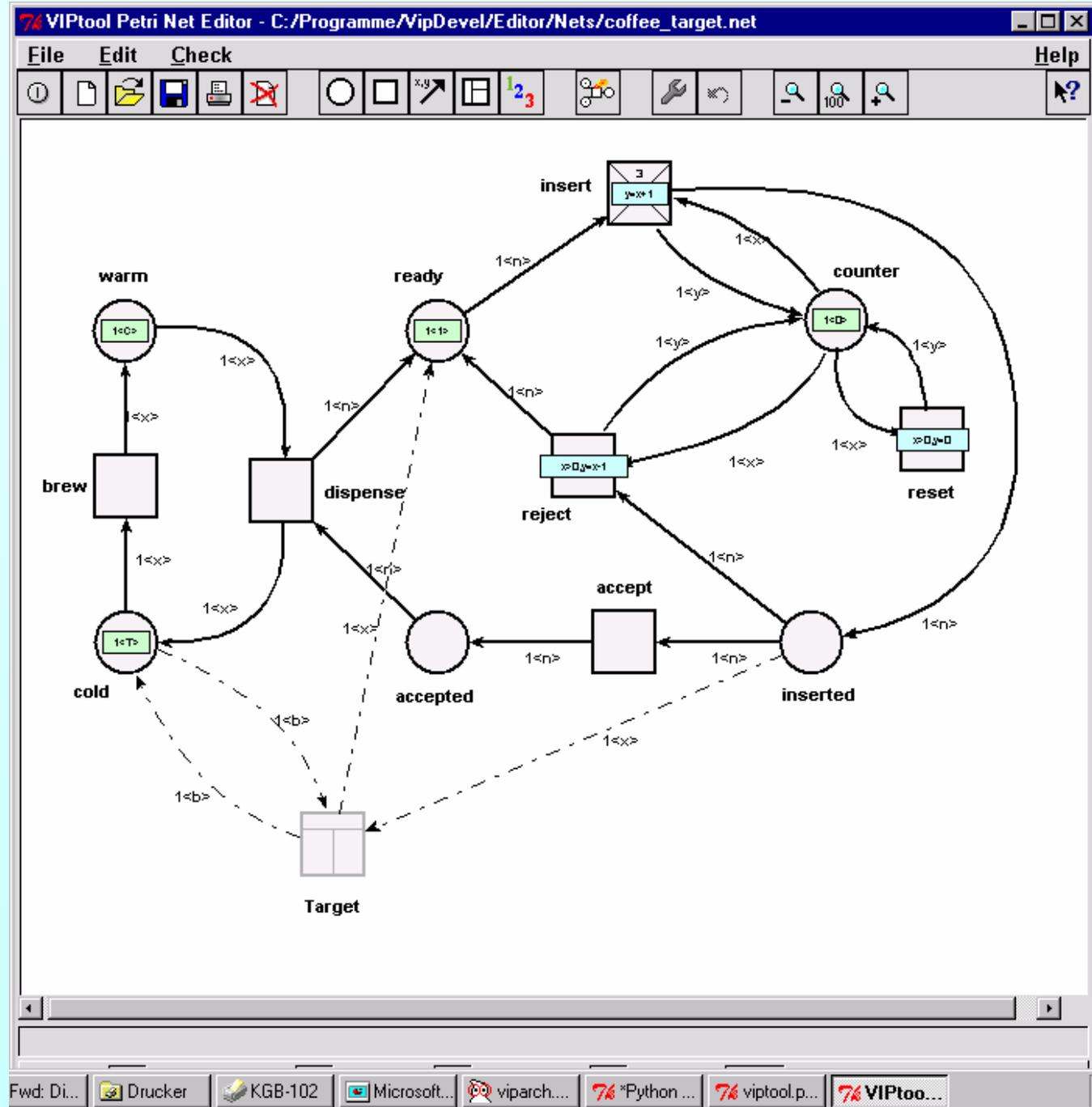
- **concrete application domains**
  - **distributed algorithms (fairness)**
  - **data base transactions (concurrency control)**
  - **operation systems (deadlock-freeness)**
  - **workflows (termination)**
- **at least one area has to be understood**



# VIPTOOL

## Petri net simulation tool

KU Eichstätt



# VIPTOOL

## Petri net simulation tool

## KU Eichstätt

The screenshot displays the VIPTool Petri Net Editor interface. The main window shows a Petri net diagram with the following components:

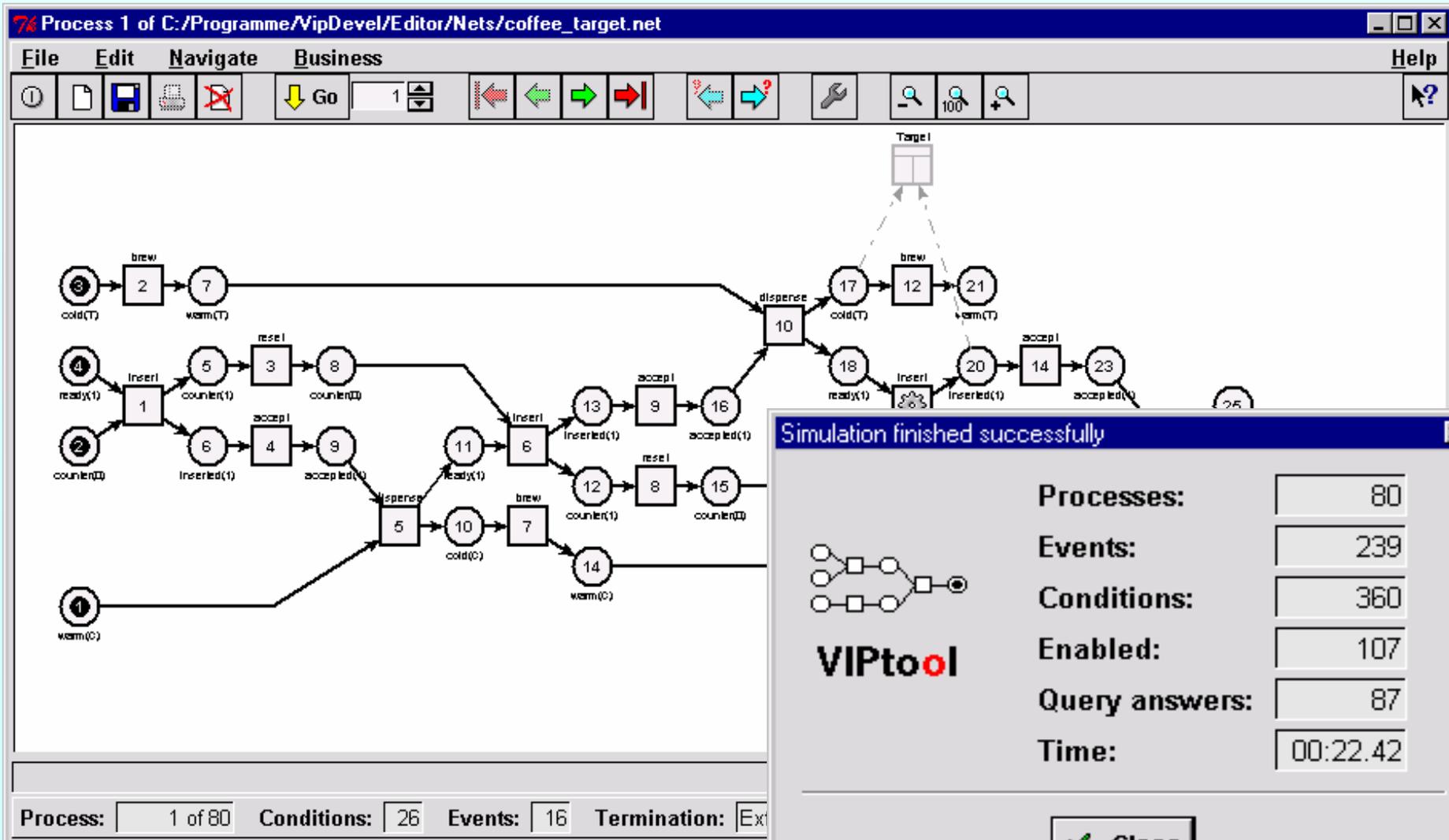
- Places:** warm (1<O>), ready (1<I>), counter (1<D>), cold (1<T>).
- Transitions:** brew, insert.
- Transitions:** 3 (y>x+1).

The simulation dialog box, titled "Simulation of net C:/Programme/VipDevel/Editor/Nets/coffee\_target.net", contains the following settings:

- # Processes:**  No limit  Limit to: 10
- Process length:**  No limit  Limit to: 20
- External events:**  Disabled  Enabled
- Query evaluator:**  Disabled  Enabled
- Cutoff events:**  Disabled  Enabled
- Termination:**  Query match  Deadlock
- User interaction:**  Automatic  Dialog

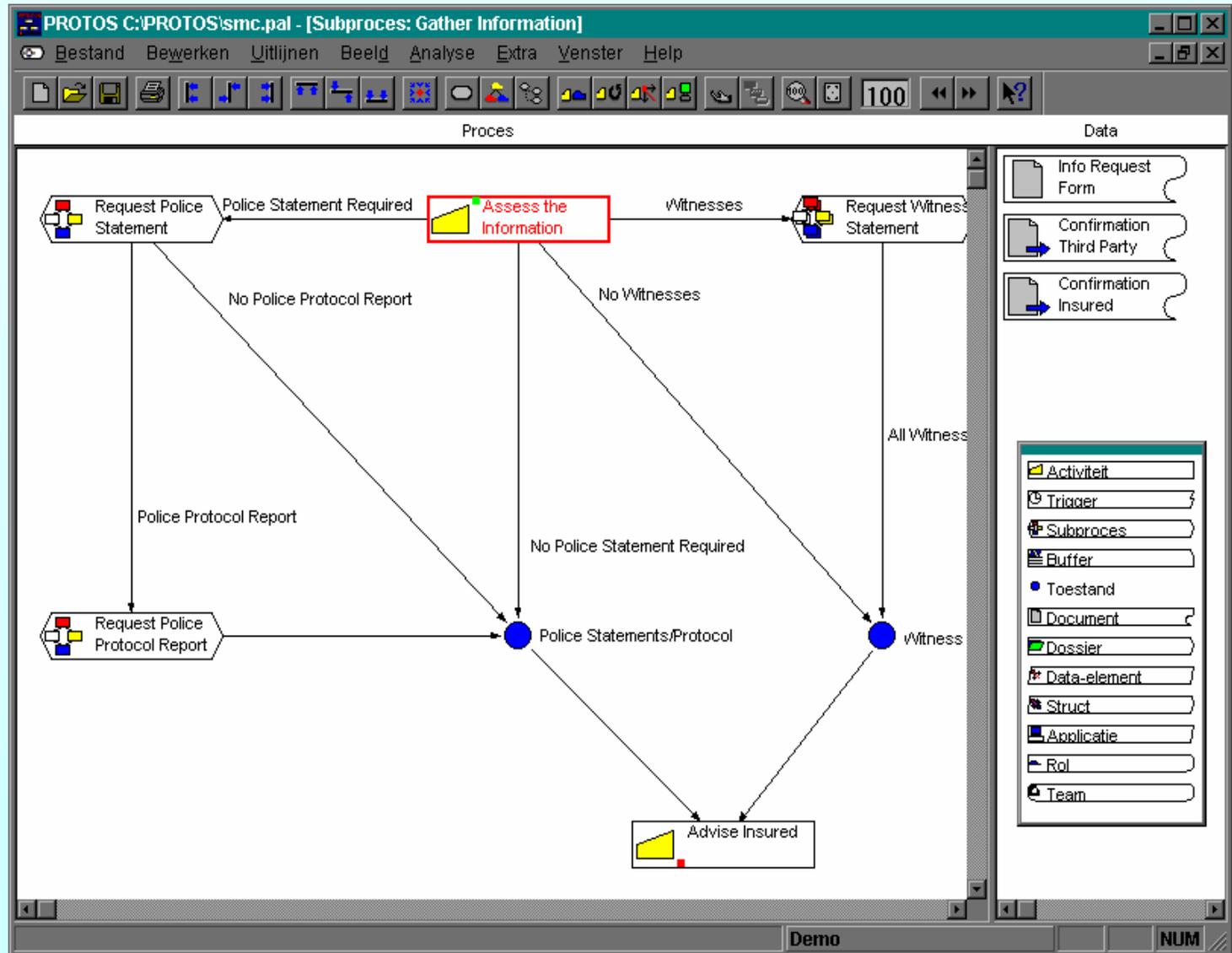
At the bottom of the dialog box, there are buttons for **Simulate**, **Processes...**, **Save**, **Help**, and **Close**.





# PROTOS

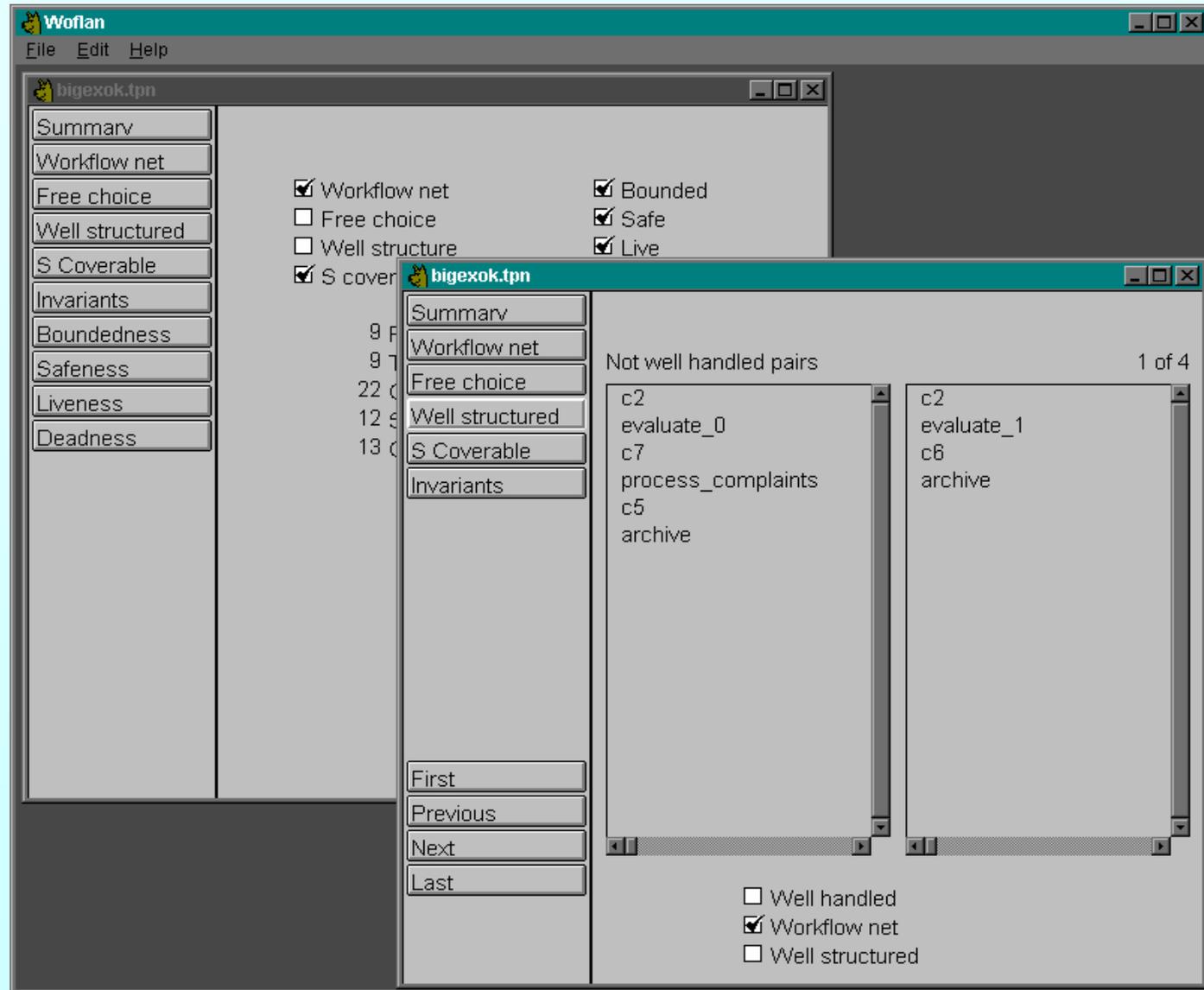
## Business Process Modeling Tool



WOFLAN

Analysis  
Tool

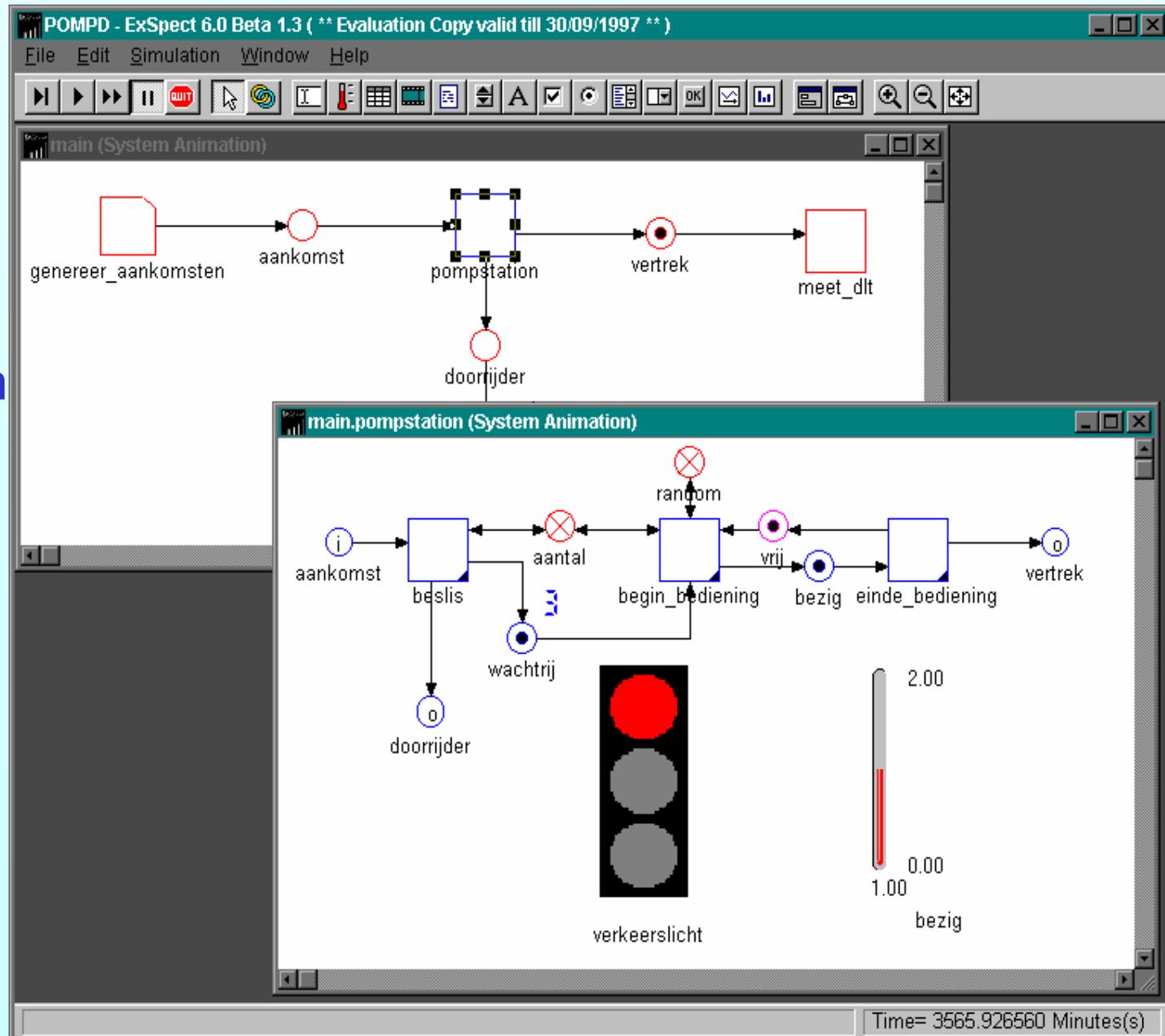
TU Eindhoven



# EXSPECT

## Simulation Tool

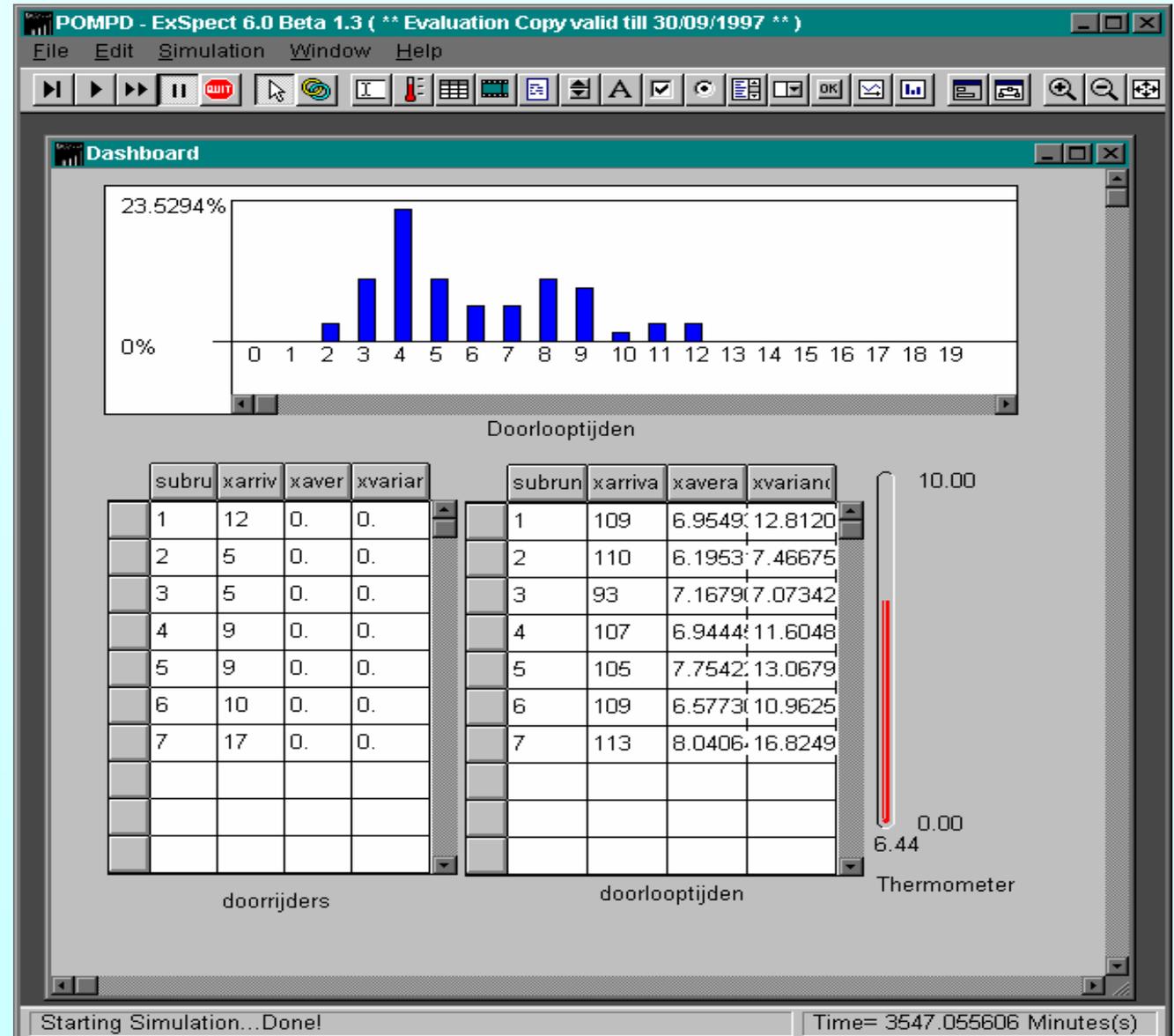
## TU Eindhoven



# EXSPECT

## Simulation Tool

## TU Eindhoven



# TEACHING SCENARIO AND EXPERIENCES

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- **students worked out case studies in groups (2-5)**
  - **modeling / validation**
  - **qualitative analysis**
  - **quantitative optimization**
- **extensive discussions within groups**
- **competitive presentation**
- **very positive evaluation**
  - **students had fun**
  - **students liked the practice-like project work**

# COMPUTER BASED TEACHING

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- **big simulation examples cannot be presented by hand**
- **communication of students via internet**
- **tool integration via internet portals**
- **presentation using the tools**
- **toy simulation tools within virtual courses**
- **students have high motivation for playing with tools**