Simulation and Modeling II

SS 2018

Organization

Prof. Dr.-Ing. Reinhard German
Vitali Schneider
Friedrich-Alexander Universität Erlangen-Nürnberg
Informatik 7 (Rechnernetze und Kommunikationssysteme)

FRIEDRICH-ALEXANDER
UNIVERSITÄT
ERLANGEN-NÜRNBERG
TECHNISCHE FAKULTÄT

Simulation and Modeling II is Project-Oriented

- Motivation
  - get experience with theory from Simulation and Modeling I
  - get experience with project and team work
  - get active, have fun, get the credits
- Organization of course times
  - Thursday, 16:15 - 17:45, 04.137: selected lectures and team presentations
  - Monday, 08:30 - 10:00, Room 04.158: weekly team meetings, start April 16
  - Thursday, 14:00 - 16:00, Room 04.158: computer hours, (implementation, documentation, preparation of presentations), also on other times if available and room not reserved
- Teams
  - 2 to 3 persons, you can choose, we help, choose project topic today
- Credits
  - Schein: project result 50 %, individual interview 50 %
  - Prüfung/examination: project finished, oral examination about project

Project Topics

- Simulation studies:
  - elevator in Martensstr. 3
  - traffic crossing (e.g., Nähe Markuskirche, Einfahrt Handelshof, Äußere Nürnberger Str./Gebbertstr., data may be available from Stadtplanungsamt)
  - bus line (between your home and university)
  - supermarket (e.g., Handelshof)
  - drinks terminal (e.g., Bierlachweg)
  - gas station (e.g., on Äußere Brucker Str.)
  - university canteen (e.g., Mensa Süd)
  - university library (e.g., Technische Fakultät)
  - hospital emergency reception (e.g., University)
  - post office (e.g., Hauptpost)
  - Media Access Control in the FlexRay Protocol Specification
  - <u>your own idea</u>?

need to ask manager/administration

determine waiting times, throughputs, bottlenecks, ... use AutoMod, OMNeT++, MATLAB, or AnyLogic

Coarse Project Plan

- Phase 0: Project Initialization
  - goal: form a team, select a topic, today
- Phase 1: Project Definition
  - define requirements
    - description what the result should be, not how they are obtained
    - objectives of the simulation study
    - approx. 2 pages
- Phase 2: Project Planning
  - identify the main activities, estimate their effort and schedule them (which activity is performed by whom and when)

Coarse Project Plan (continued)

- Phase 3: Project Realization
  - collect data
  - define conceptual model and validate
  - implement model and verify
  - make pilot runs
  - validate model by comparison with existing system
  - design experiments, make production runs, analyze output
  - document the results

Coarse Project Plan (continued)

- Phase 4: Project Finalization
  - present the simulation results
  - analyze your project
  - write a project report
    - 20-30 pages
    - by using parts from earlier project phases

Schedule (preliminary)

<table>
<tr><th>Dates</th><th>Simulation project phase</th><th>Lectures & Team presentations (Thu. 16:15-17:45)</th></tr>
<tr><td>12.4.-20.4.</td><td>Project initialization and definition</td><td rowspan="2">Organization /
Lecture on simulation project management</td></tr>
<tr><td>23.4.-27.4.</td><td>Project planning</td></tr>
<tr><td>30.4.-4.5.</td><td>Conceptual model definition</td><td>Lecture on energy simulation</td></tr>
<tr><td rowspan="2">7.5.-25.5.</td><td rowspan="2"><u>Parallel processes:</u>
Programming your model &
Data collection, input modelling
(no lectures on Thursday 10.5. and Monday 21.5.)</td><td>Team’s presentations:
requirements & project plans and conceptual model</td></tr>
<tr><td>Lecture on variance reduction techniques</td></tr>
<tr><td>28.5.-8.6.</td><td>Programming & validation of input models
(no lectures on Thursday 31.5.)</td><td>Lecture on parallel and distributed simulation systems</td></tr>
</table>

Schedule (preliminary)

Dates	*Simulation project phase*	*Lectures & Team presentations (Thu. 16:15-17:45)*
11.6.-22.6.	Programming: Integrating input models into system model & Verification	Lecture on writing reports
		Team’s presentations: input modeling & runnable model
25.6.-29.6.	Validating system model	Lecture on healthcare simulations
2.7.-6.7.	Calibration production runs, animation programming	Lecture on test-driven agile simulation
9.7.-13.7.	Project finalization	**Final presentations:** simulation results & animation
-13.7.	Writing report	

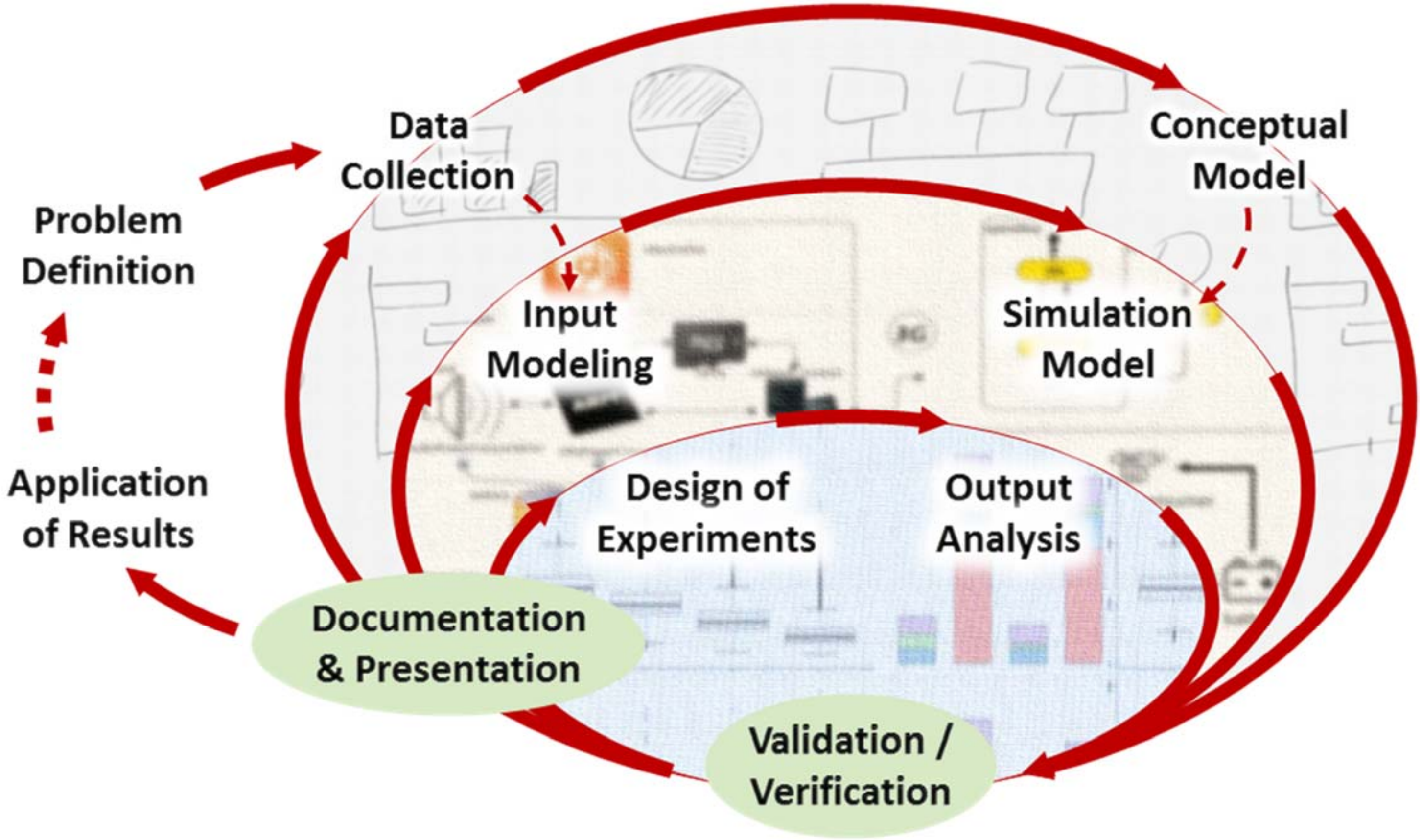
Schedule (continued)

- Report: due July 13

- Questions?

Simulation Projects

- The process for simulation studies:



Simulation studies

- key ingredients
  - input modeling
  - model building
  - output analysis
  - animation (!)

plus validation and verification
plus documentation

⬇

final report (20-30 pages)

- essentials
  - simulation control plus transient period detection
  - quantile-related measure (e.g., does the system fulfill the specification that at least 90% of all delays are below a given bound?)

Simulation Projects

Simulation studies

- service centers (university cafeteria, supermarket, gas station, post office, hospital, street cafe, public swimming pool, ...)
- traffic modeling (bus line, traffic crossing, stadium access, ...)
- technical systems (elevator, Ferris wheel at Bergkirchweih, ...)
- our research labs, e.g.,
  - a web server
  - media access control in protocols (e.g., FlexRay)
- other suggestions

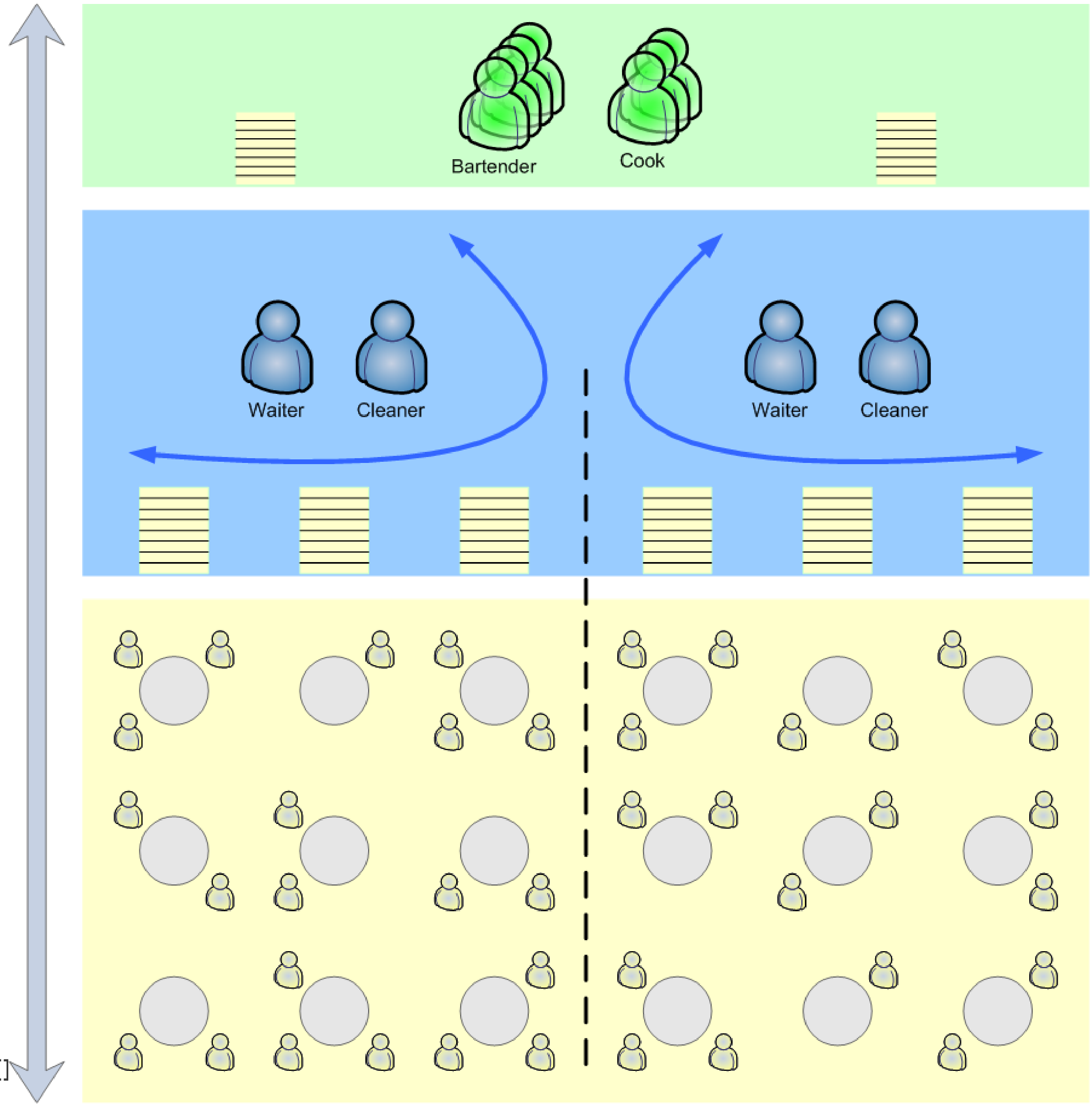
Street Cafe

- Real world

somewhere

in

Erlangen



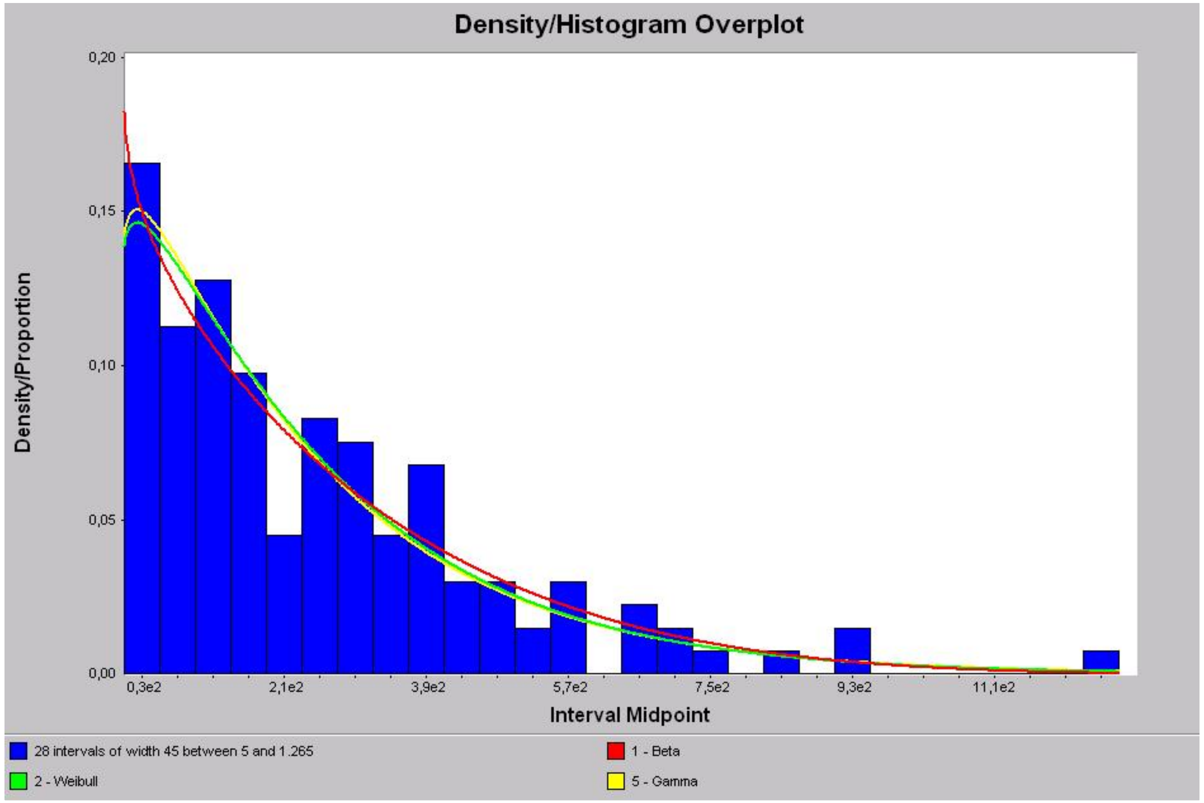
Street Cafe

- possible objectives of study
  - how long do customers have to wait for ordering after arrival?
  - how many customers have to wait for more than 5 minutes? (quantile-related measure wrt impatient customers)
  - how long do customers have to wait for their food after ordering?
  - what is the utilization of the waiters, bartenders, etc.?
  - how do system performance measures change for different personnel numbers? what is optimal?
  - does a radio system to transfer orders from tables to bar significantly improve system performance?
  - . . . .
- objectives have big impact
  - on input modeling (and data collection)
  - on model building
  - on performance measures
  - on overall project planning

Street Cafe

■ Input modeling

- Measurements → Workload (interarrival / service times), …



You decide which data you need!

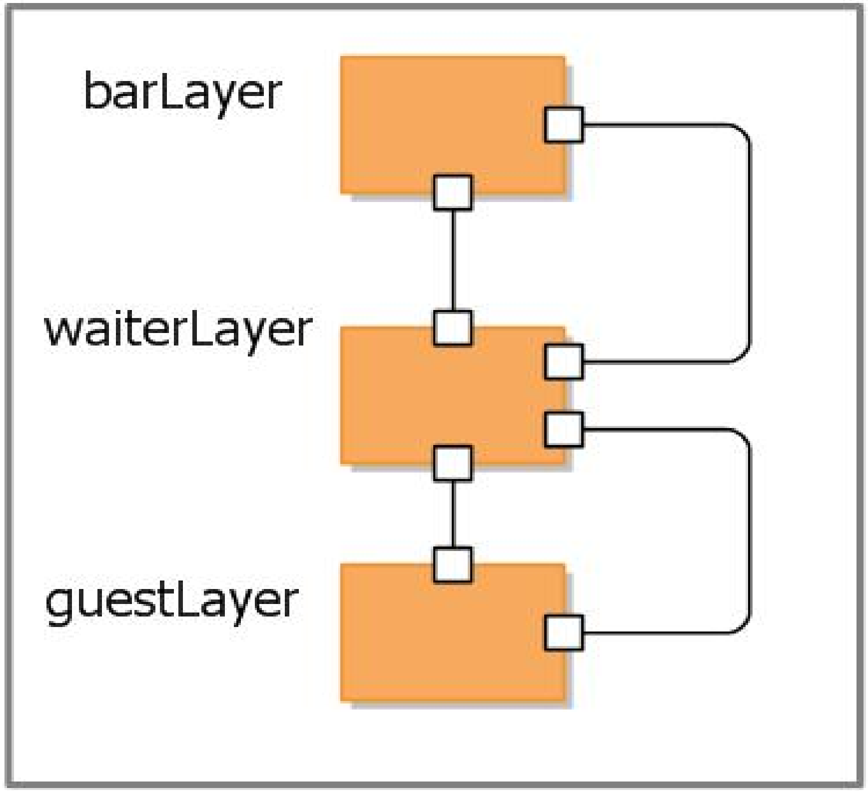
Apply methods from Simulation & Modeling 1 (ExpertFit)!

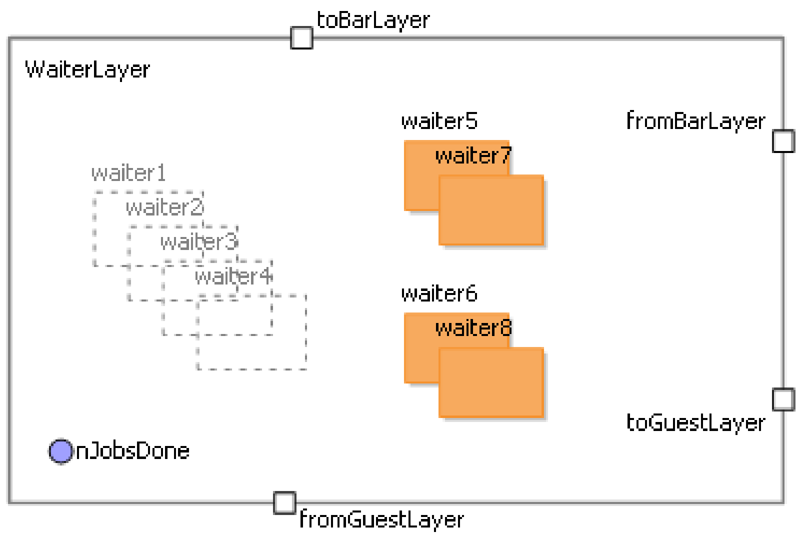
Data must also be collected for a relevant performance measure for validation purposes (comparison of model with real world)!

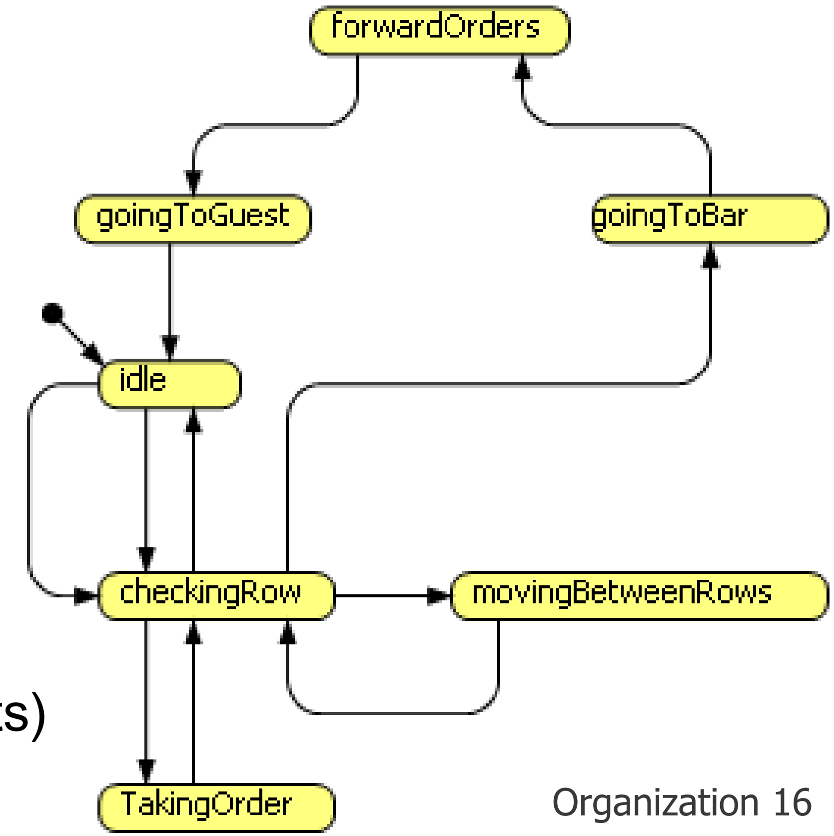
Street Cafe

- The model layers

Main



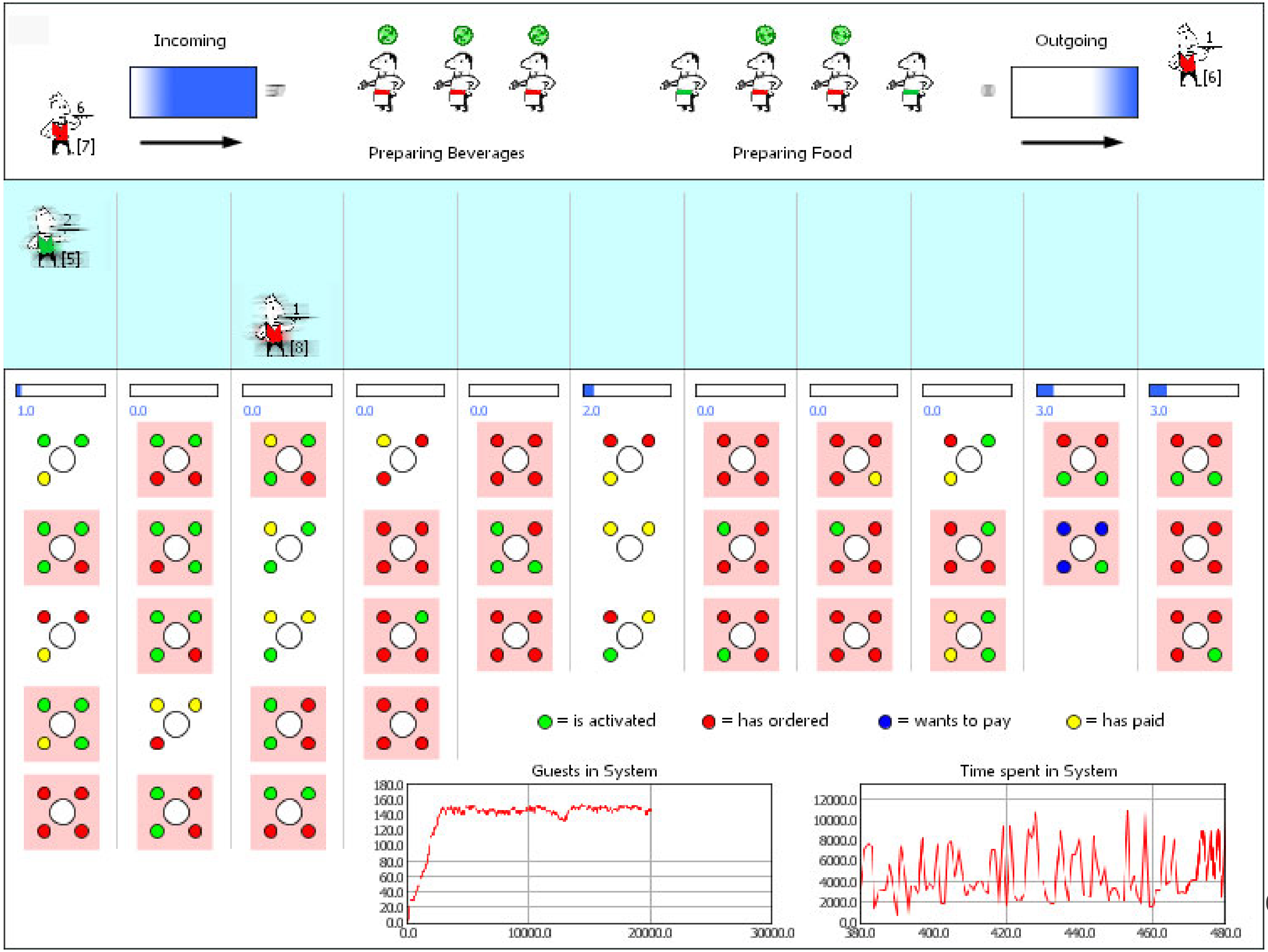




Here: agent-based modeling!
(waiters, guests, etc. as agents)

Street Cafe

- Performance measures and animation



Results (means, distributions, quantiles, utilizations, etc.) may be presented in different ways in AnyLogic and for your final report!

Extension of Java simulation engine in AnyLogic

- key ingredients

  - software design
  - efficient implementation
  - verification and validation
  - demonstration

plus documentation

⬇

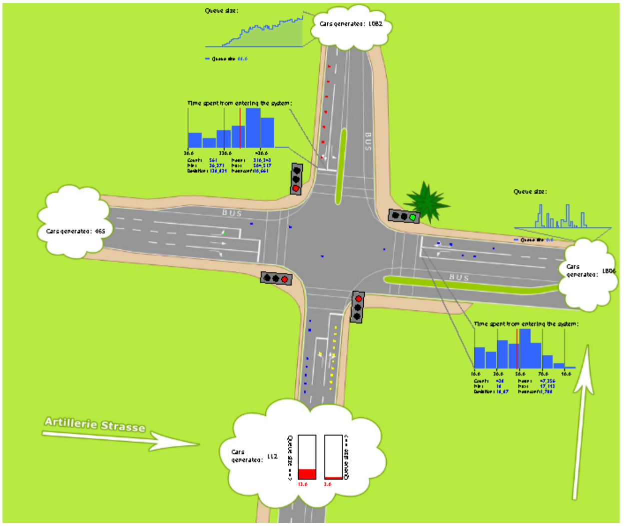
final report (20-30 pages)

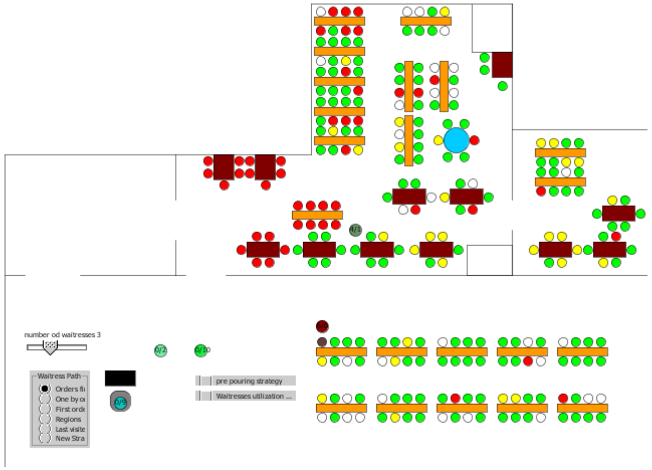
Simulation Projects

- **Simulation studies**
  - service centers (university cafeteria, supermarket, gas station, post office, hospital, street cafe, public swimming pool, ...)
  - traffic modeling (bus line, traffic crossing, stadium access, ...)
  - technical systems (elevator, Ferris wheel at Bergkirchweih, ...)
  - our research labs, e.g.,
    - a web server
    - media access control in protocols (e.g., FlexRay)
  - other suggestions

Simulation Projects

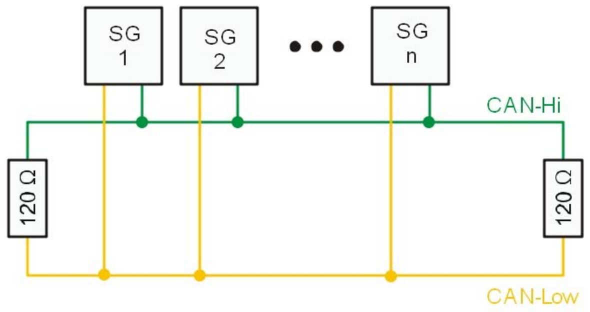
- Some demonstrations
  - CAN Bus Simulation
  - Sensor Fusion in Cars
  - Traffic Intersection
  - City Pub
  - …



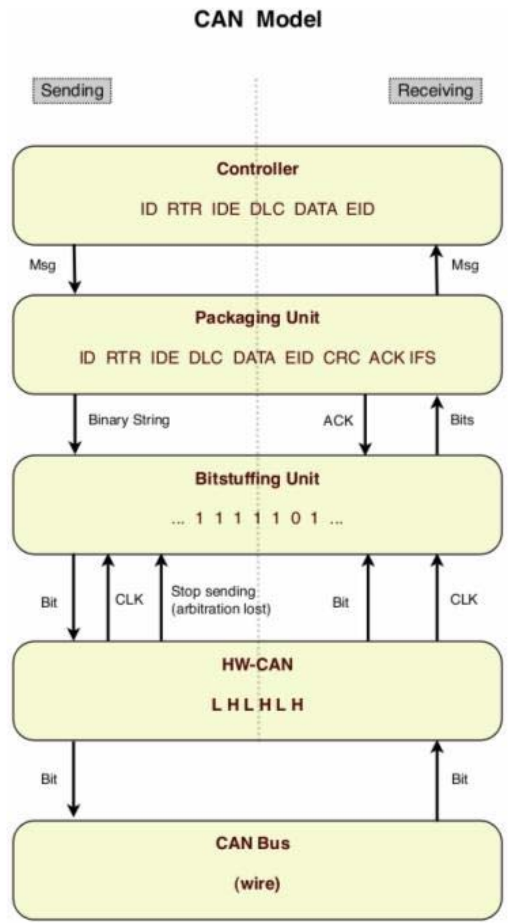


Some Demonstrations

- Controller Area Network (CAN)
  - CAN is common in cars to connect electronic control units (ECUs)

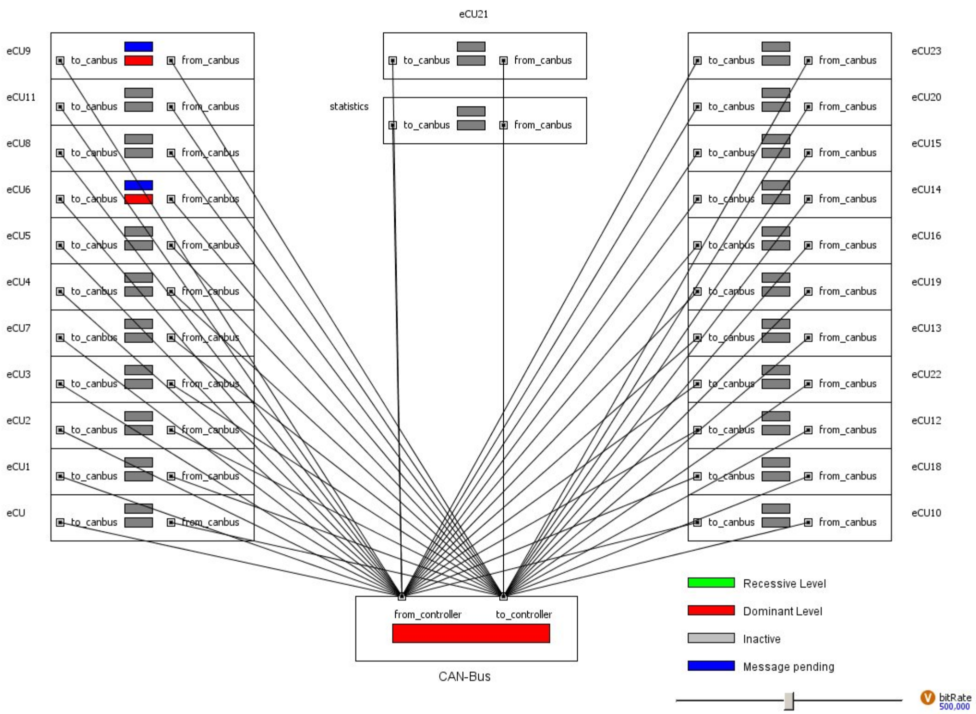


  - a Simulation and Modeling II project in summer 2008
  - conceptional model:



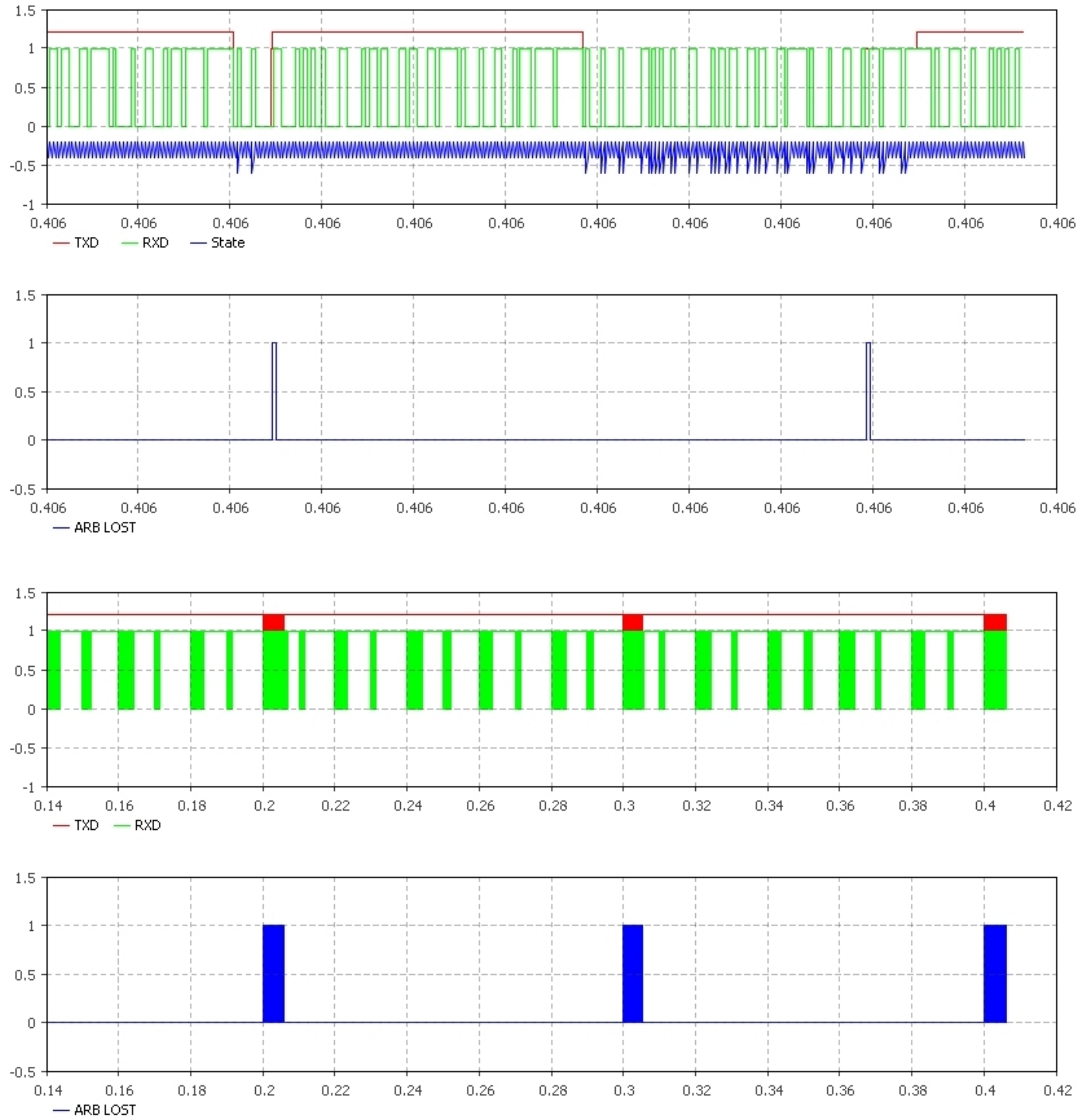
Some Demonstrations

- a simulation model with 22 ECUs is realized in AnyLogic
- realistic data from a current electronic car architecture at the Audi AG
- modeling on a quite detailed level: each bit is sampled a few times, as in the real system
- graphical animation of the overall model:



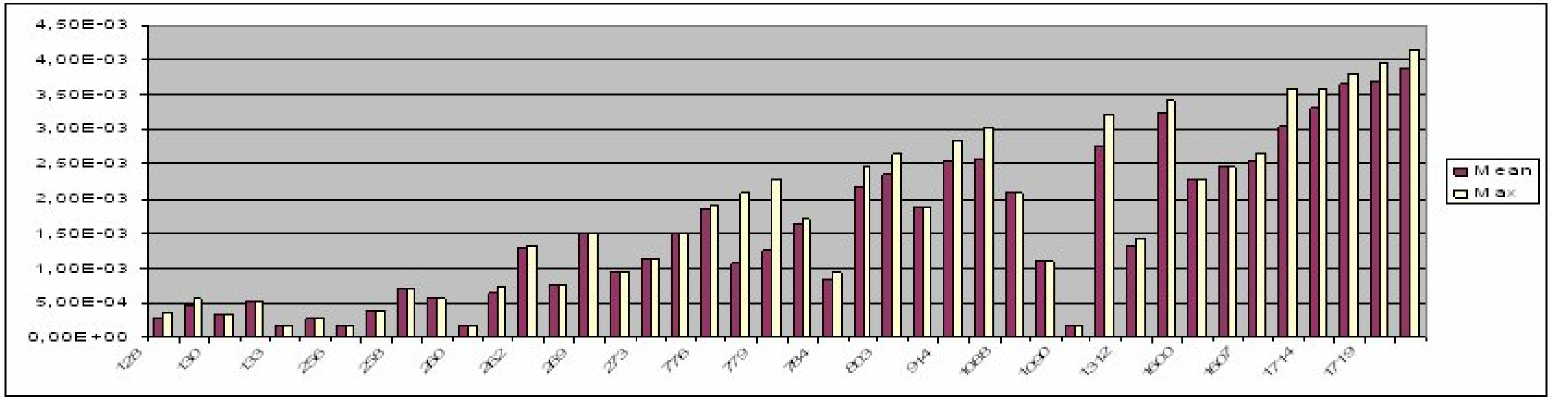
Some Demonstrations

- oscilloscope view of transmission, reception and arbitration loss of one CAN controller



Some Demonstrations

- wakeup periods of ECUs are random
- as relevant performance measures, mean and maximum latencies of messages between ECUs have been determined:

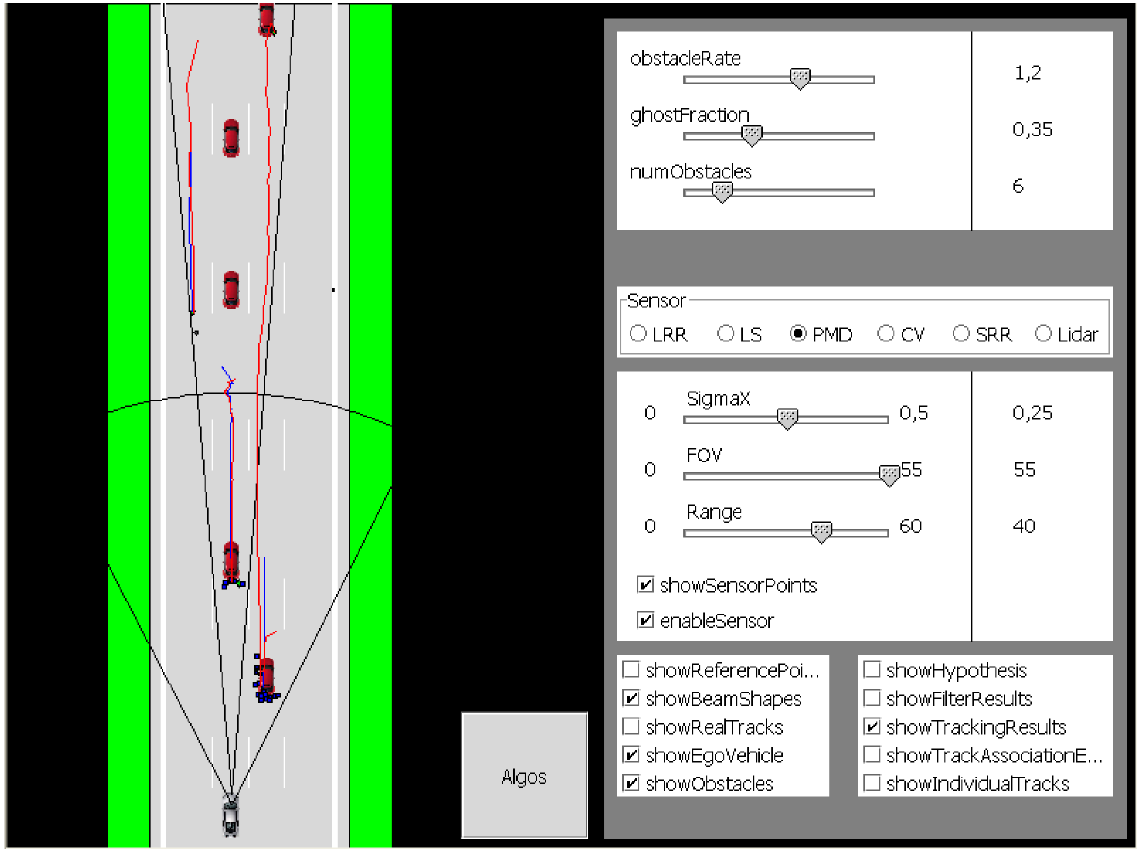


- the team presented the results to developers at Audi, it was well received

- in INI.FAU, a joint PhD-program between Audi and FAU, a researcher works on more elaborated simulation models of car communications

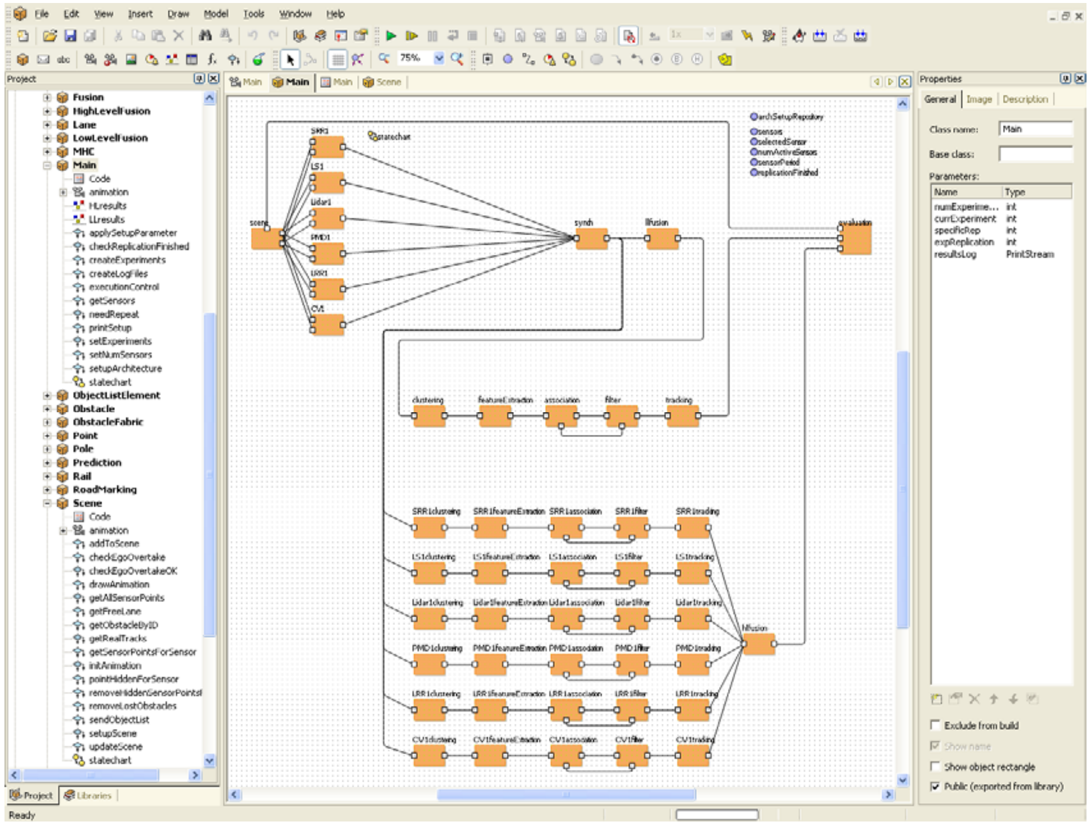
Some Demonstrations

- Sensor fusion in cars
  - in a diploma thesis at Audi an AnyLogic simulation model of a car with various sensors to detect objects has been developed, animation:



Some Demonstrations

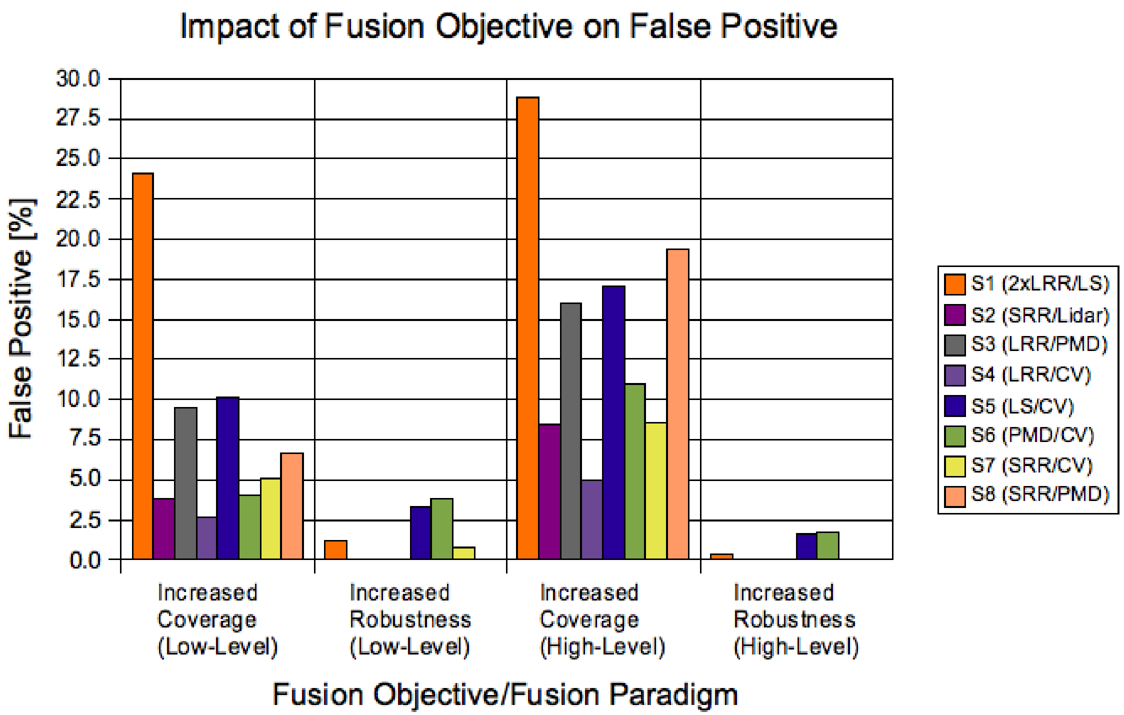
- structure of the simulation model:



- the model comprises a full implementation of the sensor fusion algorithms

Some Demonstrations

- allows to experiment with fusion architecture (vehicular context, used sensors, fusion and filtering algorithms, algorithmic parameters)
- cars and clutter objects are generated randomly, sensor values are subject to Gaussian random noise
- ratio of false positives (detection of non-existent objects in the scene, important for safety reasons):



Simulation Projects

- Layout of drinks terminal: