# Modelling and Computer Simulation

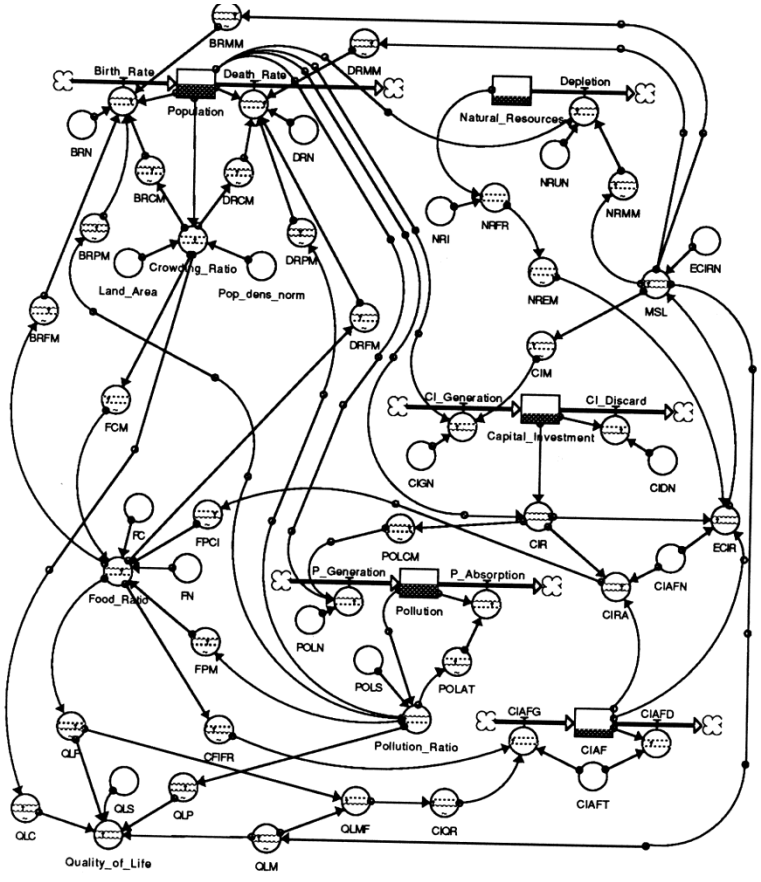
# Definition Simulation

- Definition (J. Banks: Handbook of Simulation, Wiley, 1998):
  - "Simulation is the imitation of the operation of a real-world process or system over time. Simulation involves the generation of an artificial history of the system and the observation of that artificial history to draw inferences concerning the operating characteristics of the real system that is represented."

- Key properties:
  - imitation of the operation of a system
  - generation of an artificial history
  - observation of that artificial history
  - inferences concerning the operating characteristics of real system

Dynamic behavior

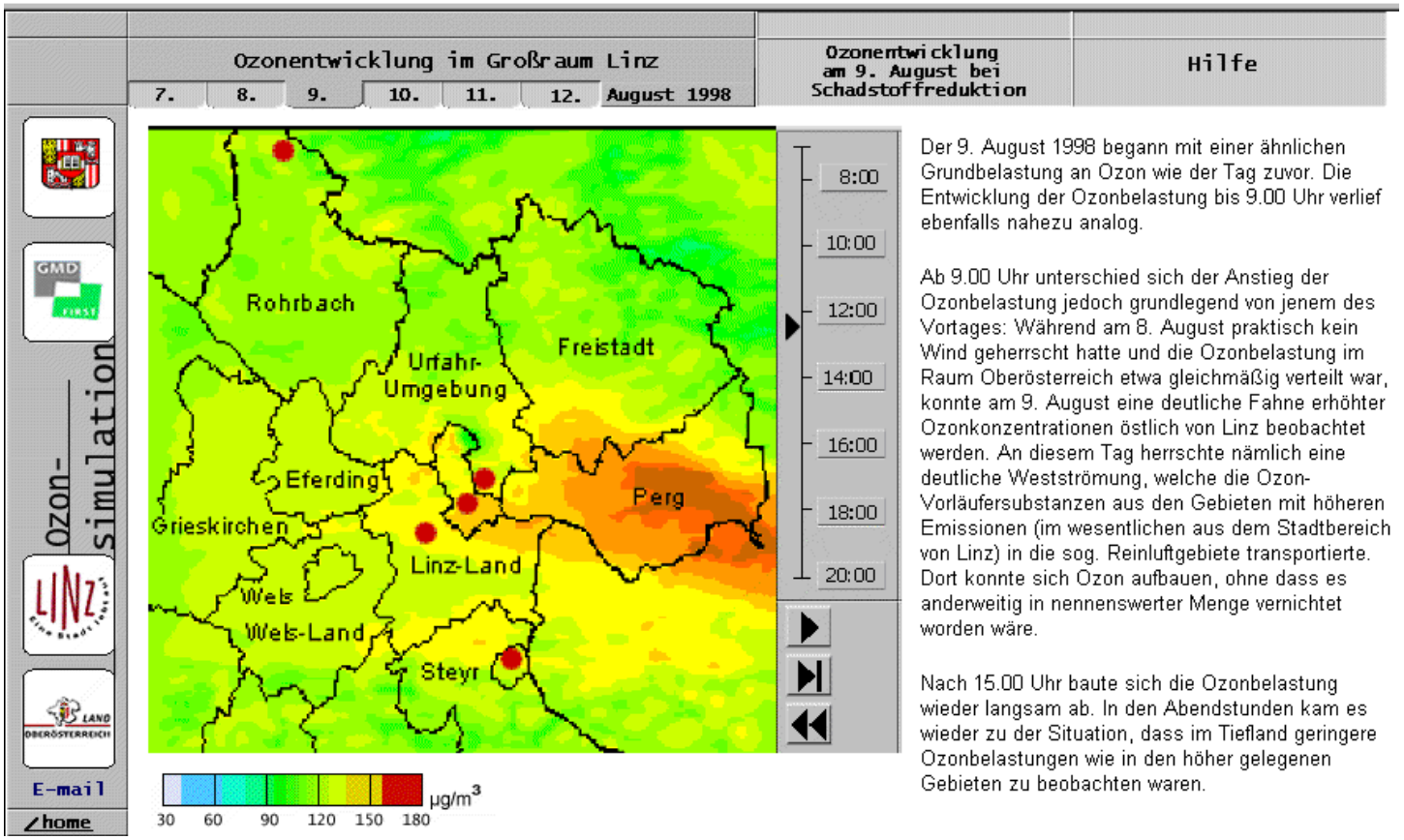
# Verification of hypothesis: Forrester's World Model




- Model for forecasting the world dynamics in terms of
  - ☐ population
  - ☐ pollution
  - ☐ resources
  - ☐ economic development
  - ☐ agriculture

# Forecast: Ozone distribution in Upper Austria

- Simulation of ozone distribution in the Upper Austrian region



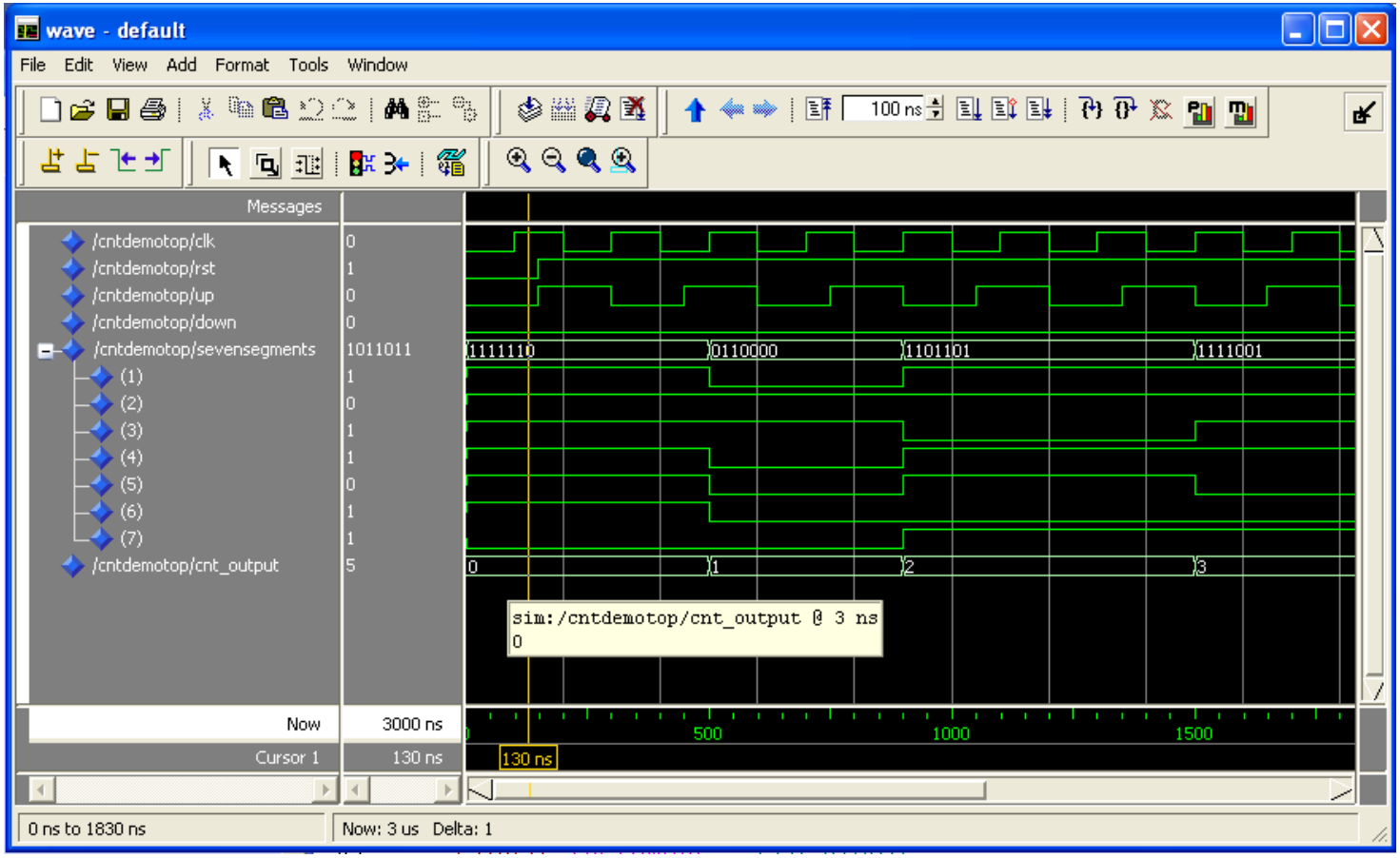

Der 9. August 1998 begann mit einer ähnlichen Grundbelastung an Ozon wie der Tag zuvor. Die Entwicklung der Ozonbelastung bis 9.00 Uhr verlief ebenfalls nahezu analog.

Ab 9.00 Uhr unterschied sich der Anstieg der Ozonbelastung jedoch grundlegend von jenem des Vortages: Während am 8. August praktisch kein Wind geherrscht hatte und die Ozonbelastung im Raum Oberösterreich etwa gleichmäßig verteilt war, konnte am 9. August eine deutliche Fahne erhöhter Ozonkonzentrationen östlich von Linz beobachtet werden. An diesem Tag herrschte nämlich eine deutliche Westströmung, welche die Ozon-Vorläufersubstanzen aus den Gebieten mit höheren Emissionen (im wesentlichen aus dem Stadtbereich von Linz) in die sog. Reinluftgebiete transportierte. Dort konnte sich Ozon aufbauen, ohne dass es anderweitig in nennenswerter Menge vernichtet worden wäre.

Nach 15.00 Uhr baute sich die Ozonbelastung wieder langsam ab. In den Abendstunden kam es wieder zu der Situation, dass im Tiefland geringere Ozonbelastungen wie in den höher gelegenen Gebieten zu beobachten waren.

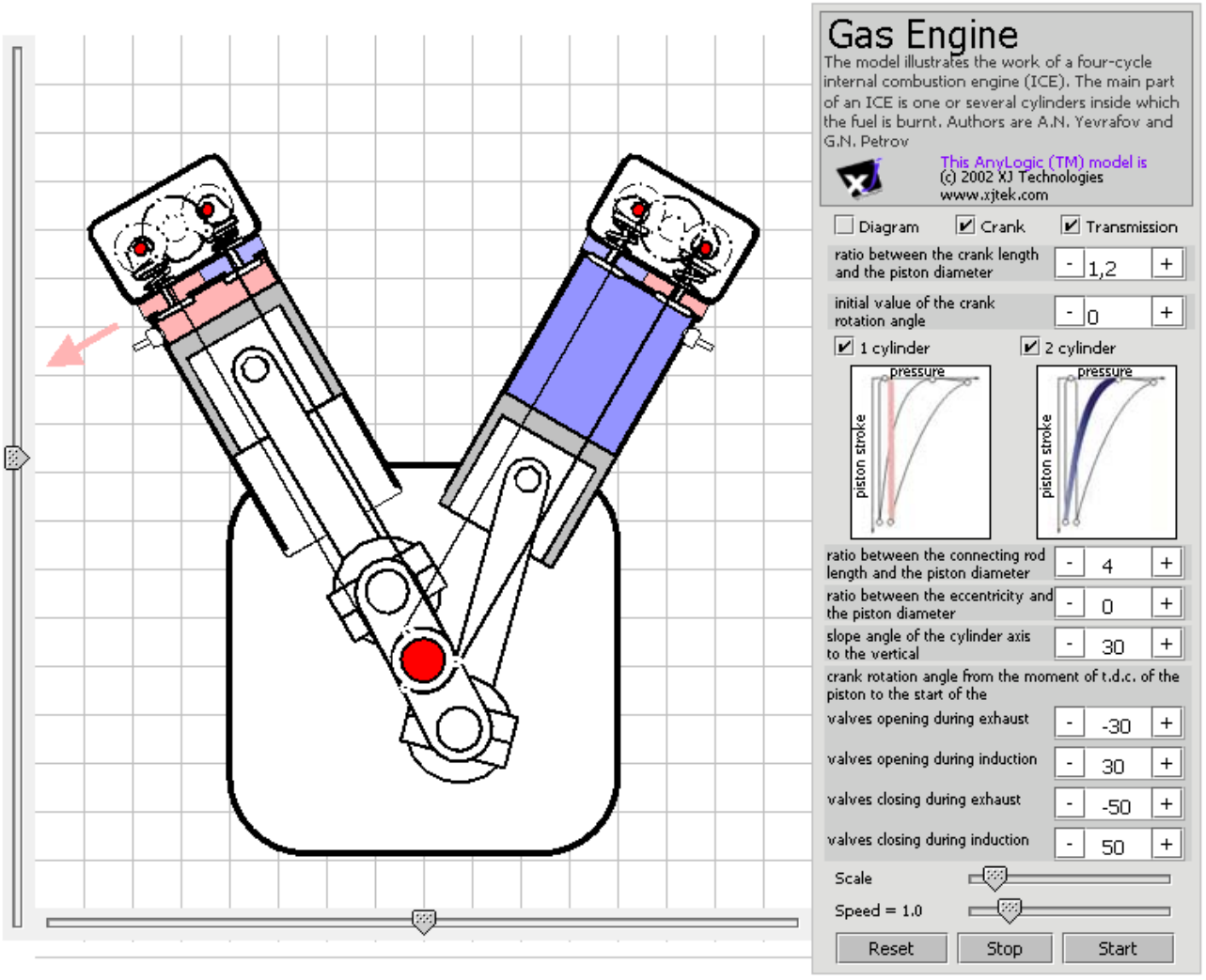
# Design: Digital hardware design

- Simulation of VHDL design at logical level considering gate delays



# Design: Engine simulation

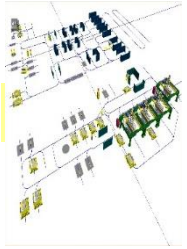
## Simulation of gas engine dynamics



# Improvement and Optimization: Manufacturing system

- Comprehensive model and 3D animation of car manufacturing line

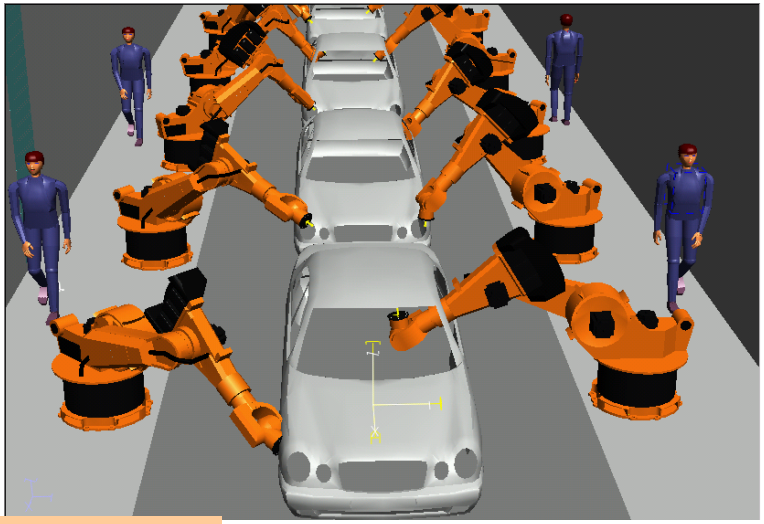
**Question**



**Materialflow**

**Throughput**

**Cycletime**



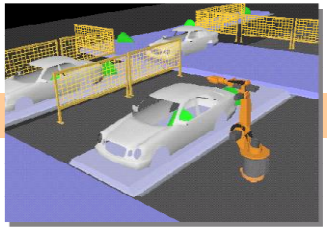
**Visualization**

**Walkthrough**

**Control**

**Interaction**

**DBVIEW**

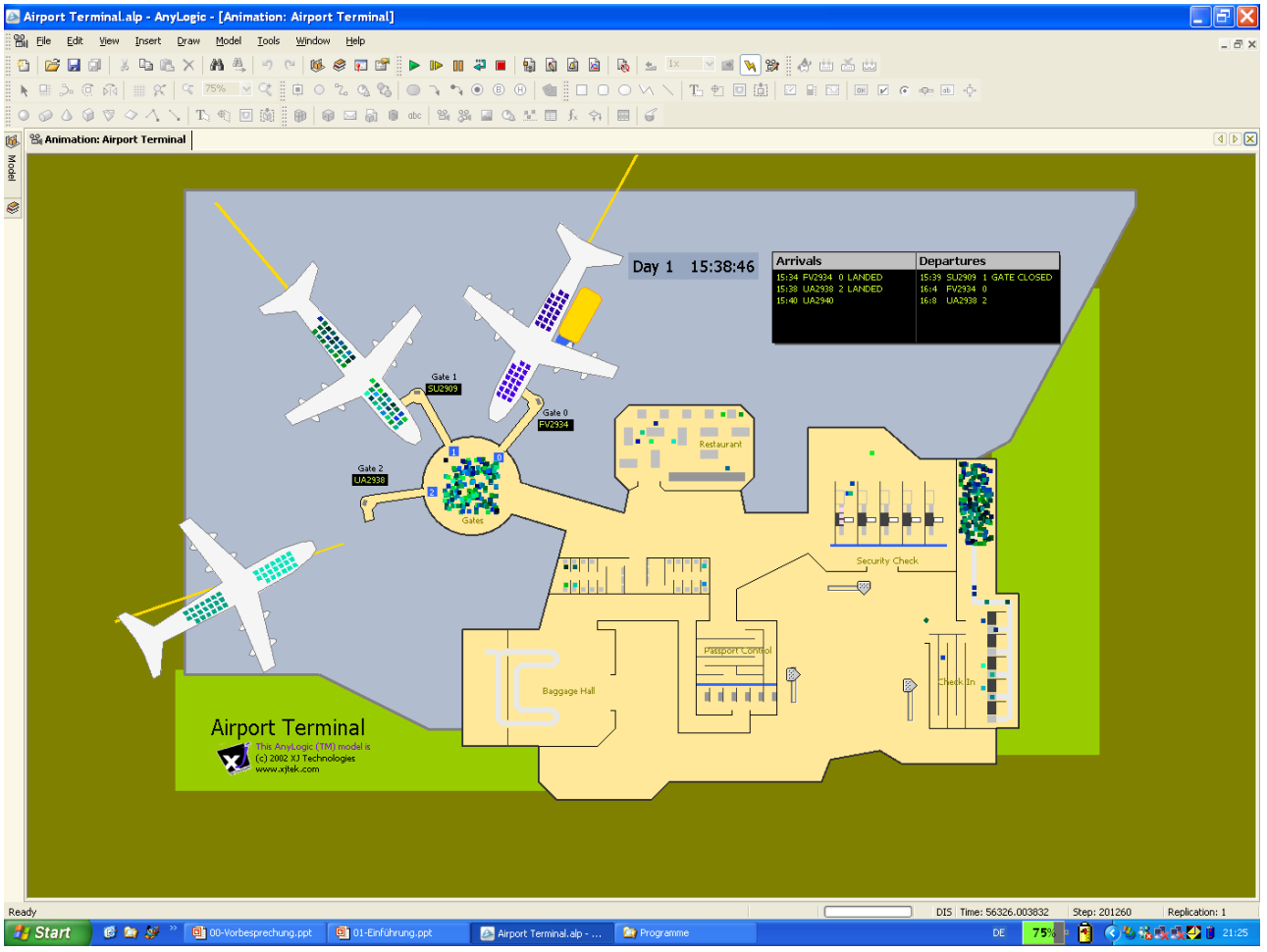


**Virtual Reality**

Simulation, the technique for virtual manufacturing

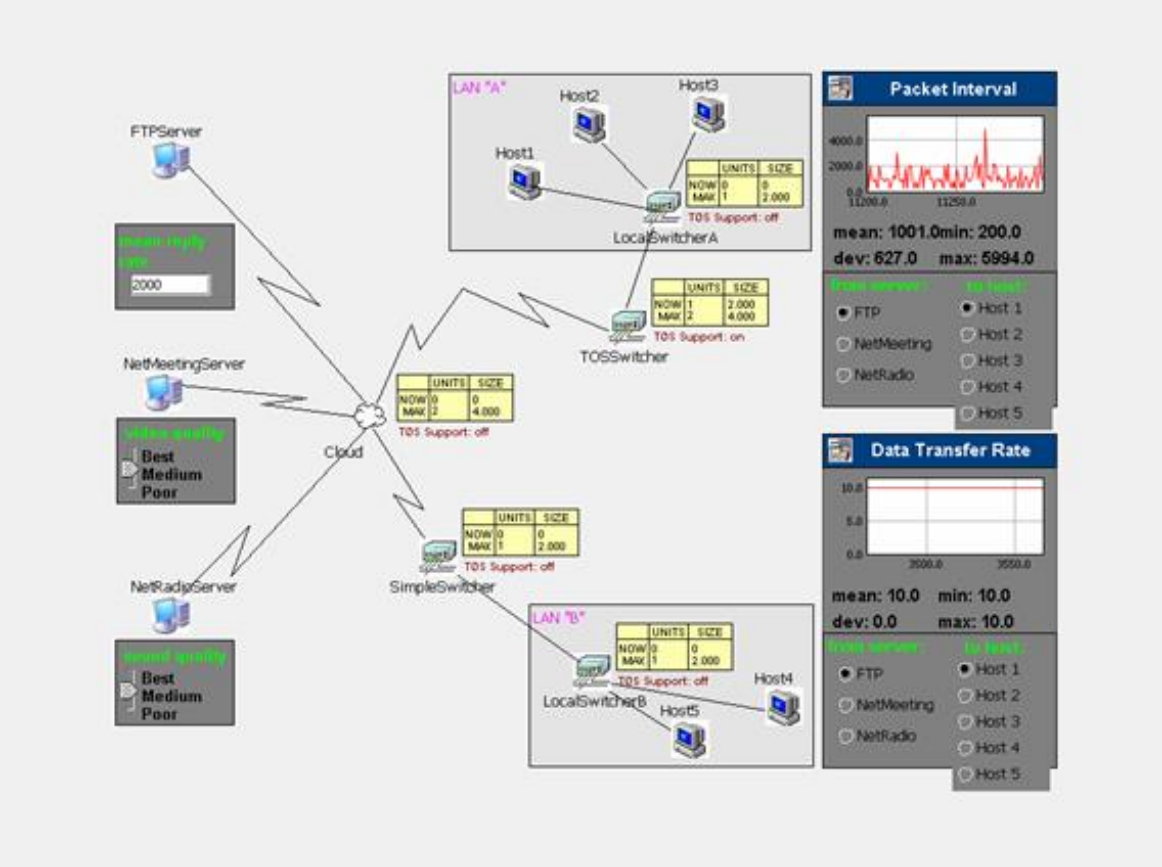
# Improvement and Optimization: Airport terminal

- Simulation of customer traffic and baggage transportation at an airport terminal

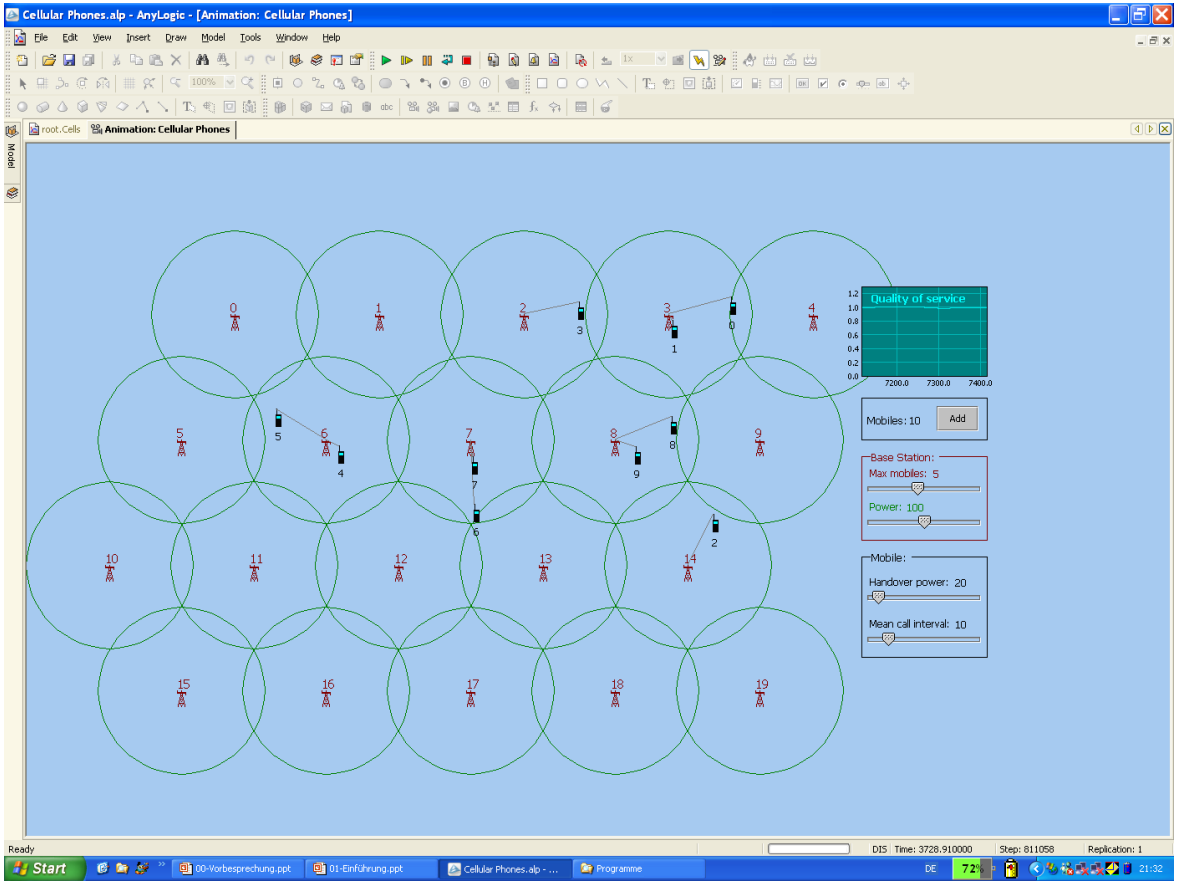


# Improvement and Optimization: Server Farm

- Simulation of request/response activities in server farm
  - considering service times
  - for performance analysis and optimization



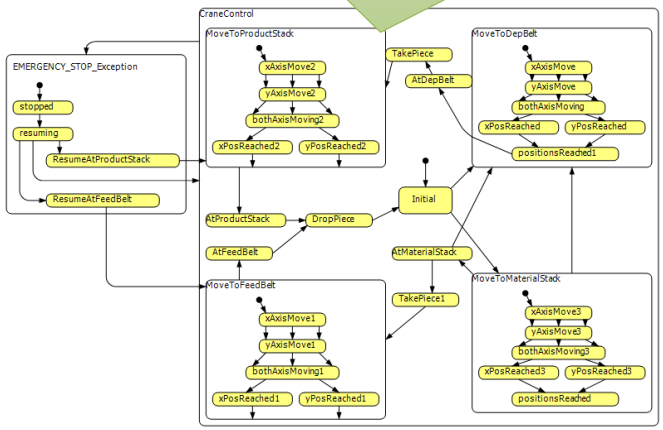
# PROTOTYPING: CELLULAR PHONES

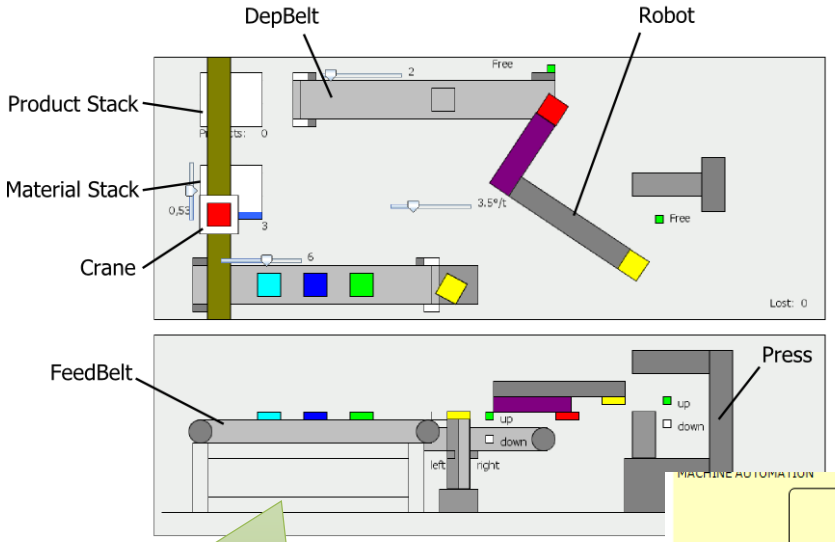


# Prototyping: Manufacturing cell including controller

- Simulation system modeling manufacturing system
- Design of controller logic based on UML/RT

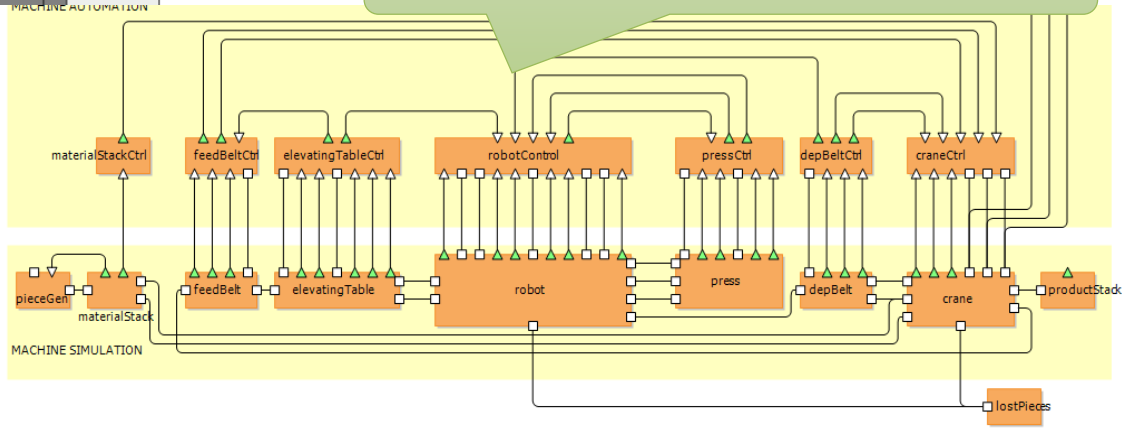
Statechart of robot control



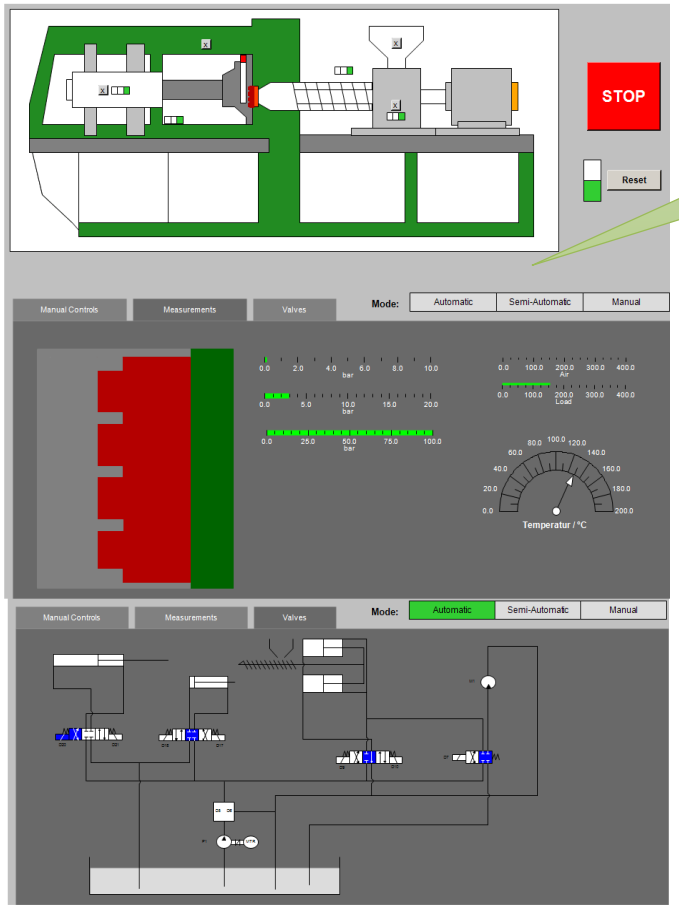

simulation of manufacturing cell

component diagram



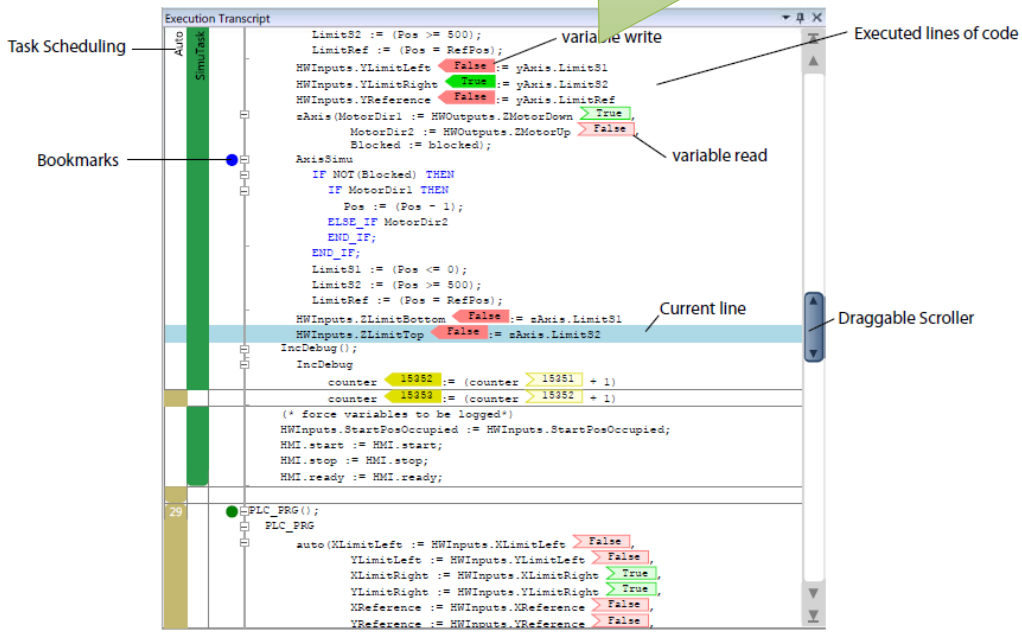
# Prototyping and testing: Machine simulation

- simulation system simulates physical device for a controller application
- used in testing controller software



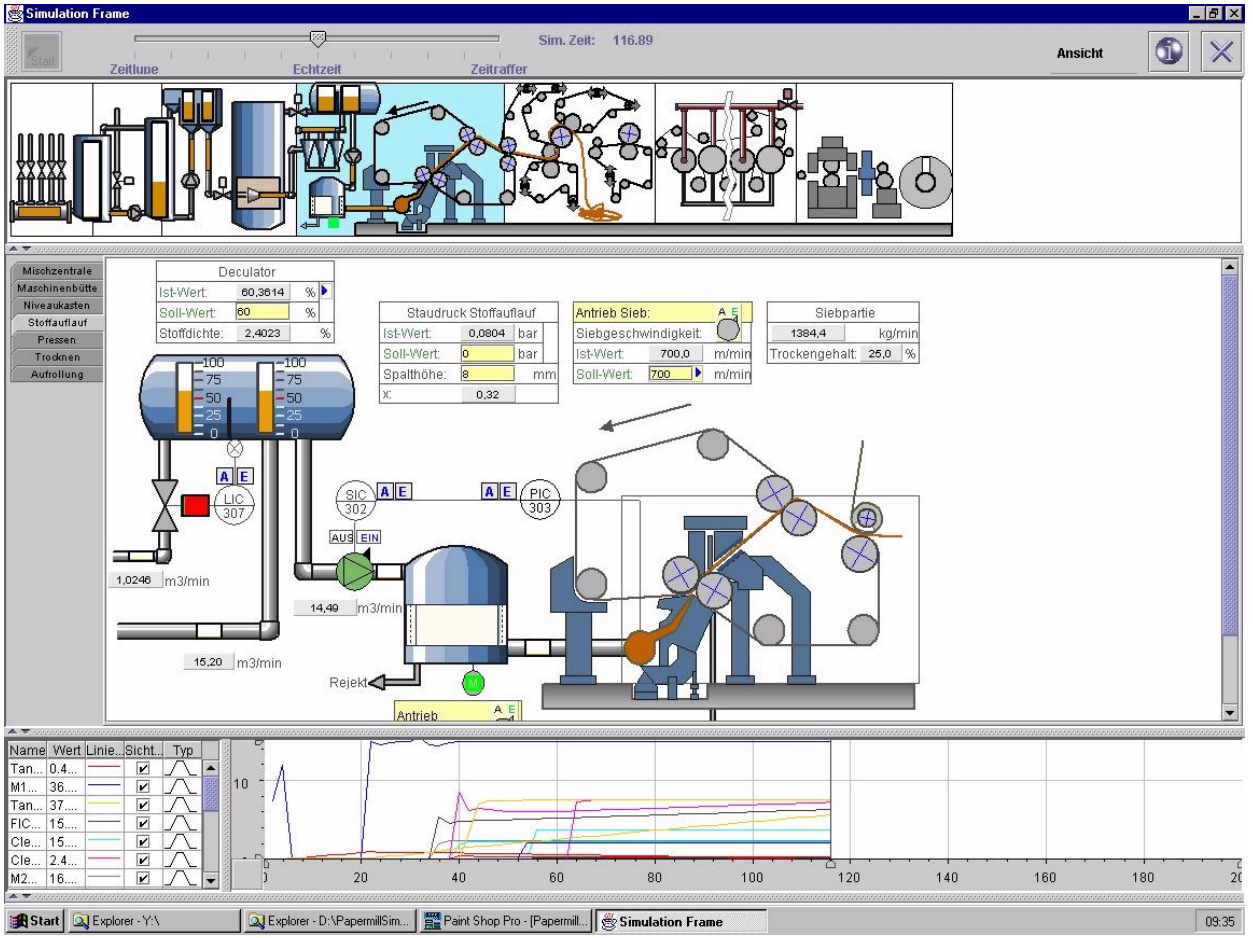

Model of machine

Debug output of controller software



# Training: Training simulator of paper machine

- Training simulator of paper machine for educating machine operators
- Allows interactive control of machine
- Observes performance of trainee in terms of quantity and quality of paper produces



# Application areas

## Discrete Simulation

- manufacturing systems
- transport systems
- traffic systems
- work processes
- logistics
- hardware design
- computer architecture
- computer networks
- communication systems

- Continuous Simulation
  - physics
  - electronics
  - mechatronics
  - control engineering
  - robotics
  - chemistry
  - biology
  - physiology
  - weather
  - environmental system
  - economy
  - social sciences