Standardized Modeling and Simulation of Hospital Processes – Optimization of Cancer Treatment Center

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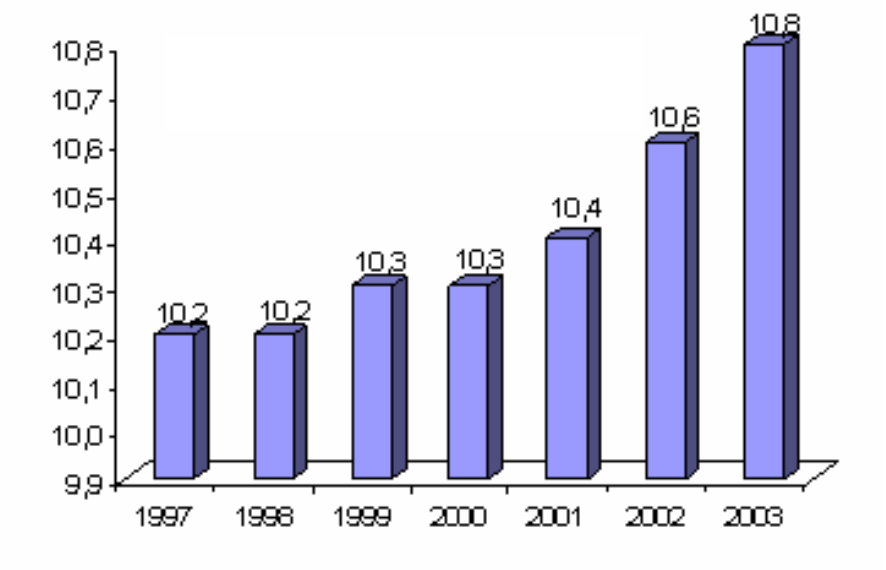
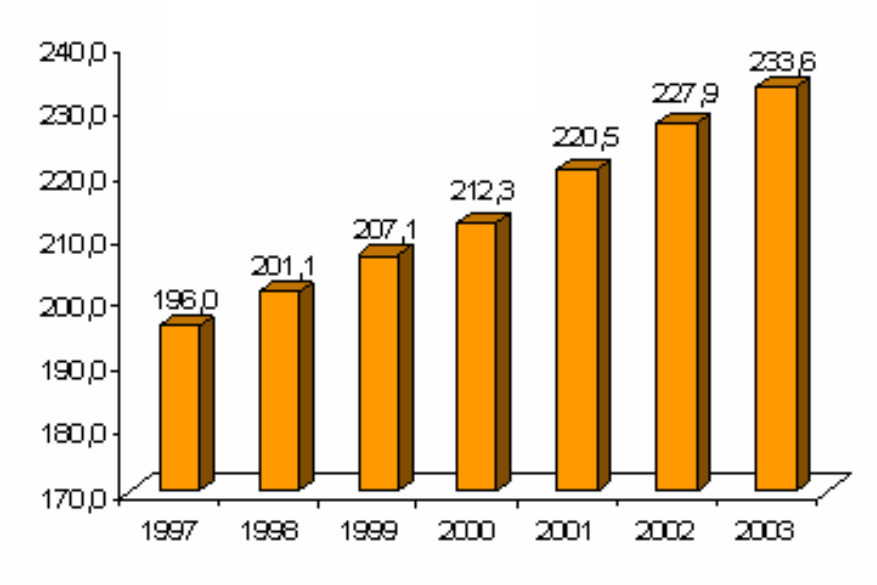
The challenge for German hospitals

Health care costs in Germany have been growing exponentially and are among the highest in Europe

% of GNP



Billions of Euro



The challenge for German hospitals

In 2004 a new reimbursement policy has been introduced by the German government, that pay hospitals based on Diagnosis Related Groups (DRGs)

The profit of a hospital is now

*Profit = (DRGPayment – CostOfCare)*NumberOfPatients*

=> Profit is maximized if

- *CostOfCare* is minimized and

- *NumberOfPatients* is maximized

=> Cost, which do not effect quality of treatment, has to be minimized

=> Attractiveness of a hospitals, i.e., quality of treatment and other image related items have to be maximized

Goal of this research

The goal of this research is to model, simulate, and optimize hospital processes and to provide a basis for comparison with processes in competing hospitals. Analyzed and optimized are

- patient waiting time
- allocation of hospital resources
  - server shared resources like physicians and nurses
  - quantity shared resources like facilities and equipment
- redundancy in information collected for treatment
- patient and health care personal walking time

Constraints: - quality of treatment is not to be reduced

- solution must be attractive, in order to be implemented

Methodology for modeling, optimization and verification

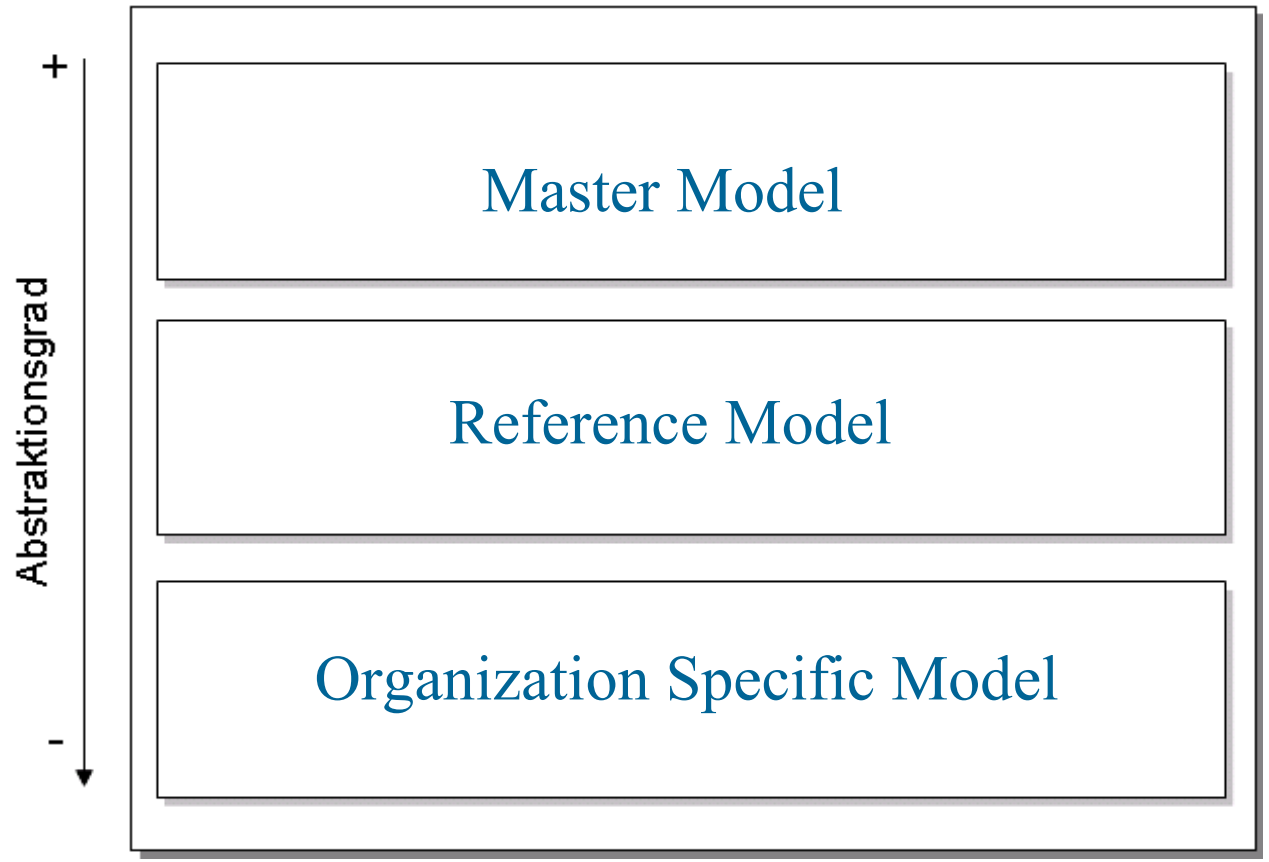
- Tool selection
- Development of standardized library of guideline recommended treatment processes
- Development an validation of existing process for the case of a cancer treatment center
  - Data collection
  - Model development with building blocks from developed standardized library
  - Verification of model and library components
- Optimization of process
- Implementation of optimized process
- Comparison of implemented process with simulation result

Tool selection

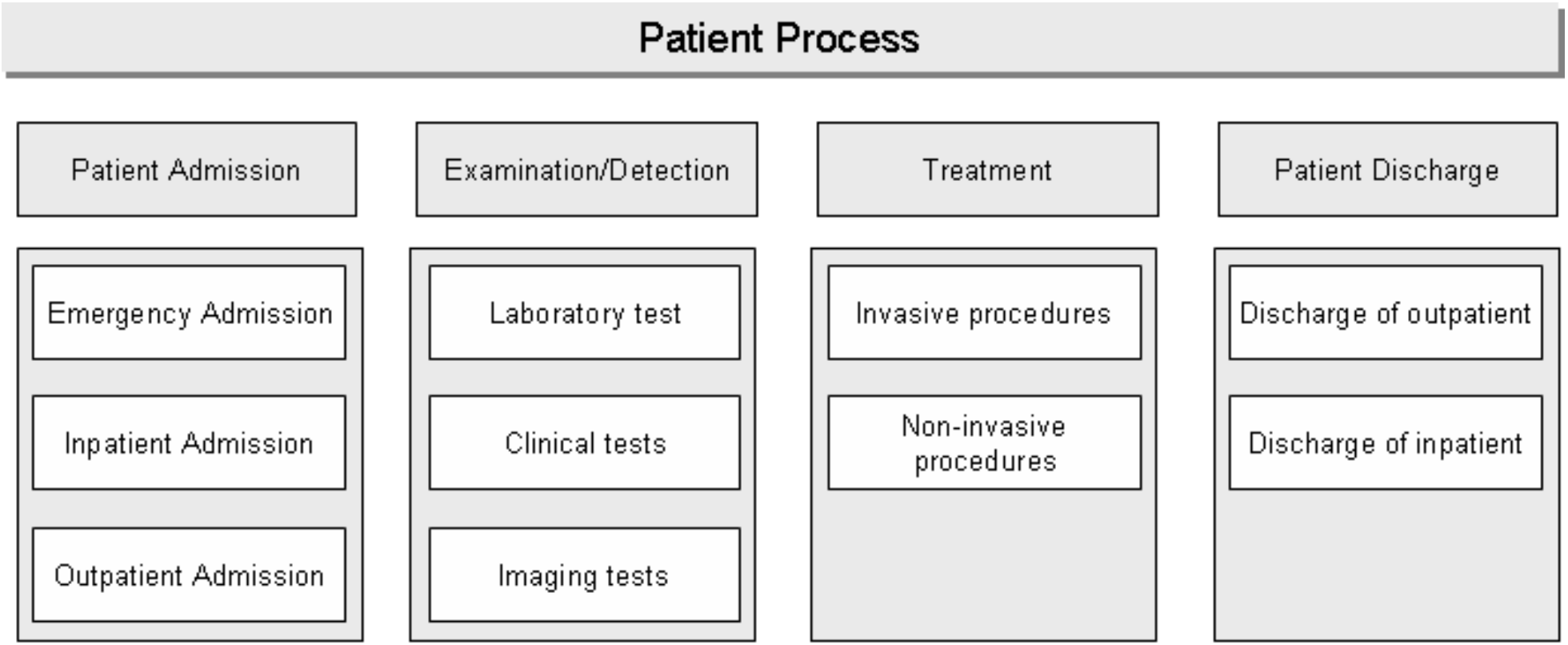
- Specification of tool requirements
  - Execute workflow simulation models and permit optimization of architecture and function
  - Existence of quantity and server resource models
  - Existence of hospital process models
  - Routing optimization and animation
  - Must be completely validated
  - Must have hierarchical GUI based modeling environment
  - Must support distributed Monte Carlo simulation to be able to rapidly analyze the statistical nature of hospital process data
- We presented the requirements to vendors of business and hospital simulation vendors: ARIS, MedModel, ProcessSimulator, Mosaik-M. None came close of meeting the requirements and also could not present a pass for timely update of their tools to meet these requirements
- We decided to use MLDesigner (developed for simulation of networked technical systems), which met all the simulation requirements + develop a new library for modeling and animation hospital processes

Development of library of standardized building blocks for clinical process simulation

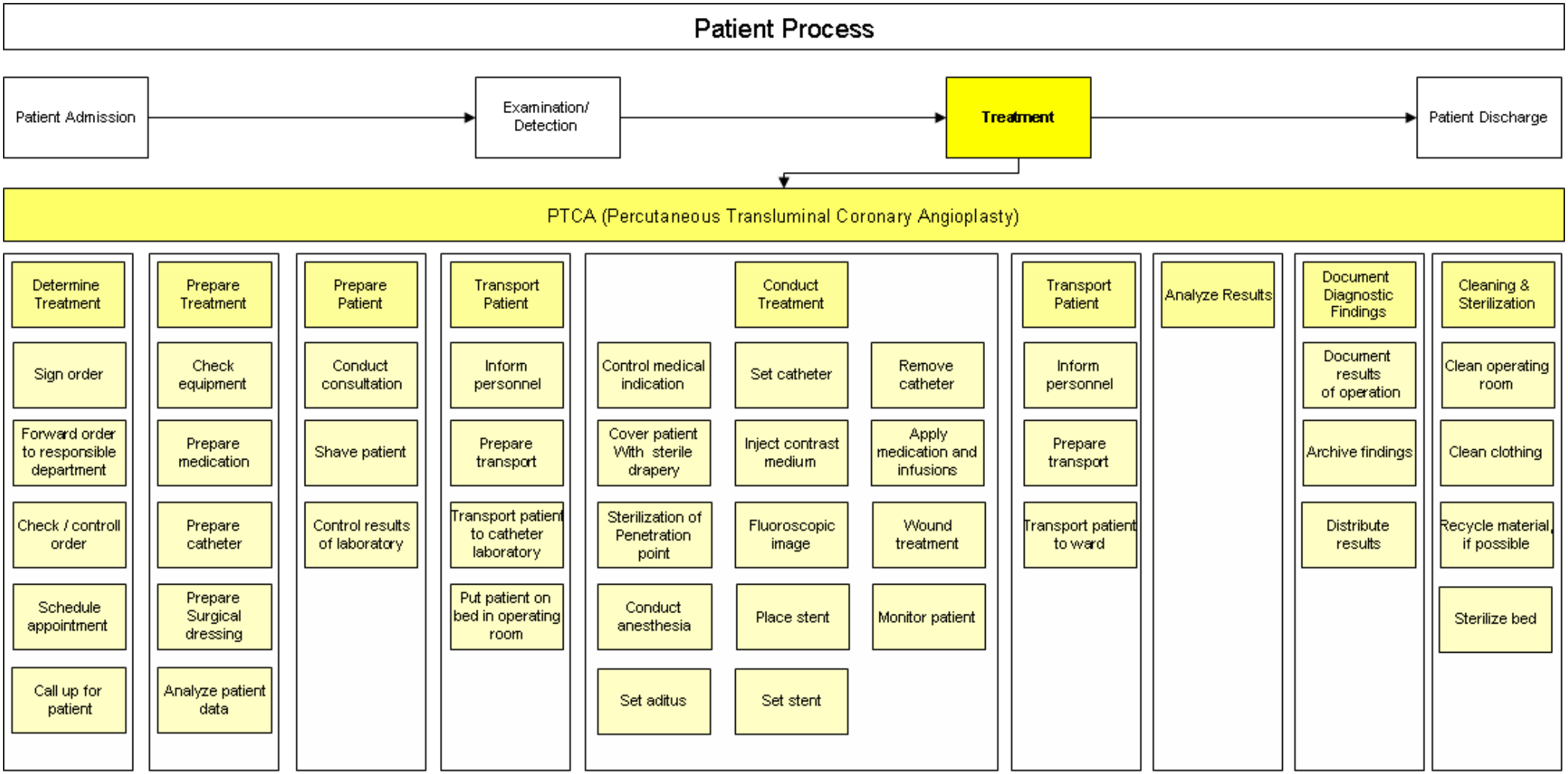
- Library development
  - Development of master clinical process model
  - Development of reference models according to master model
  - Instantiation for specific organization



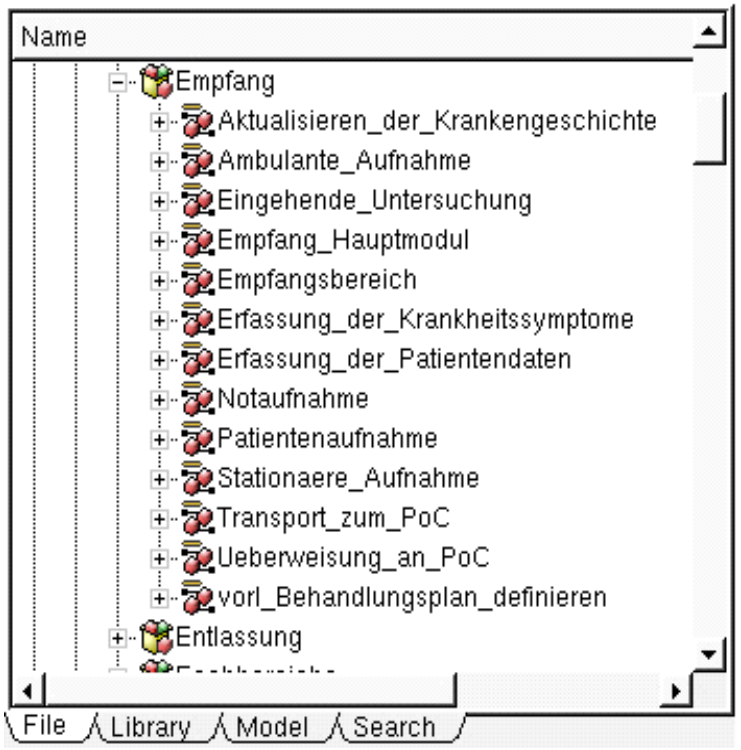
Master Model

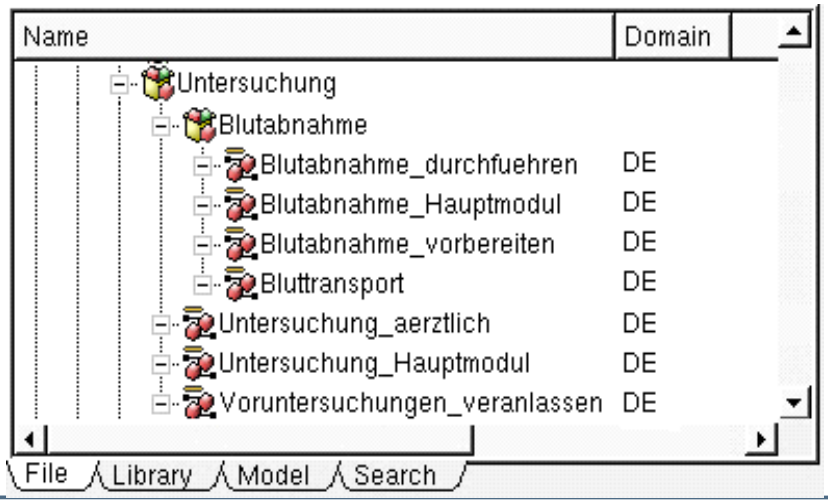


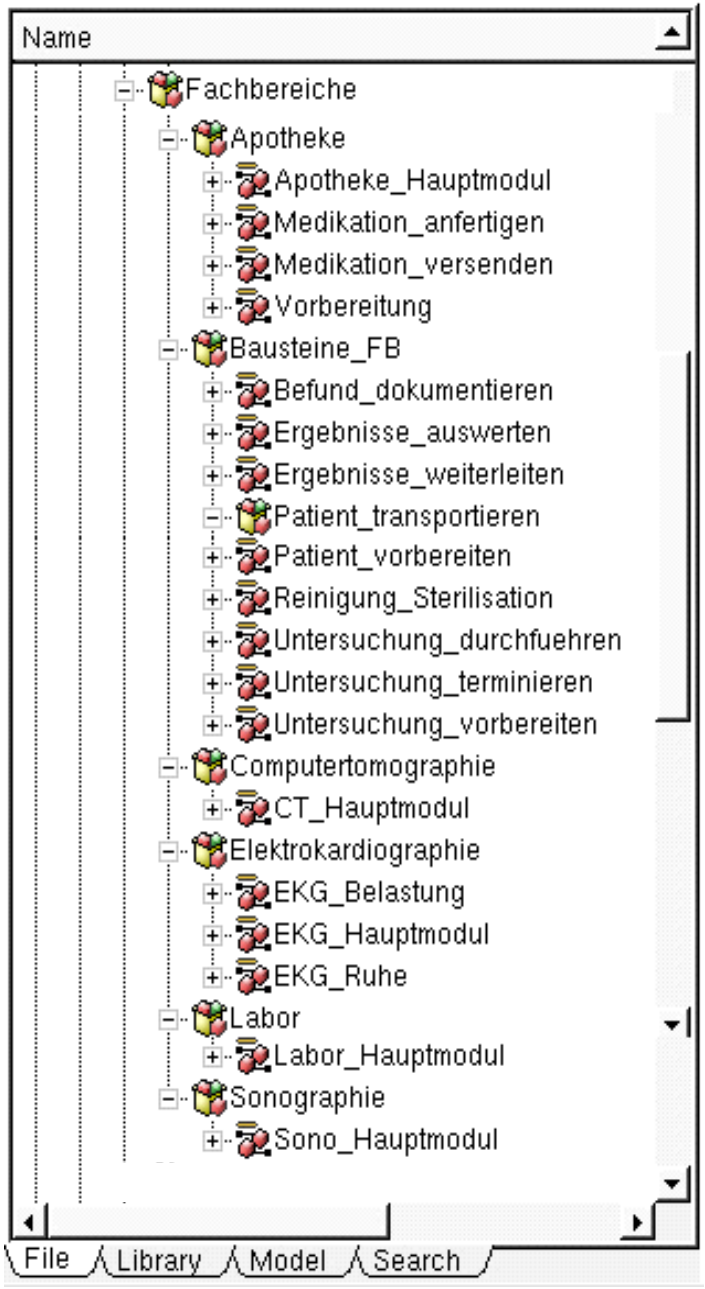
Example: PTCA (coronary angioplasty)



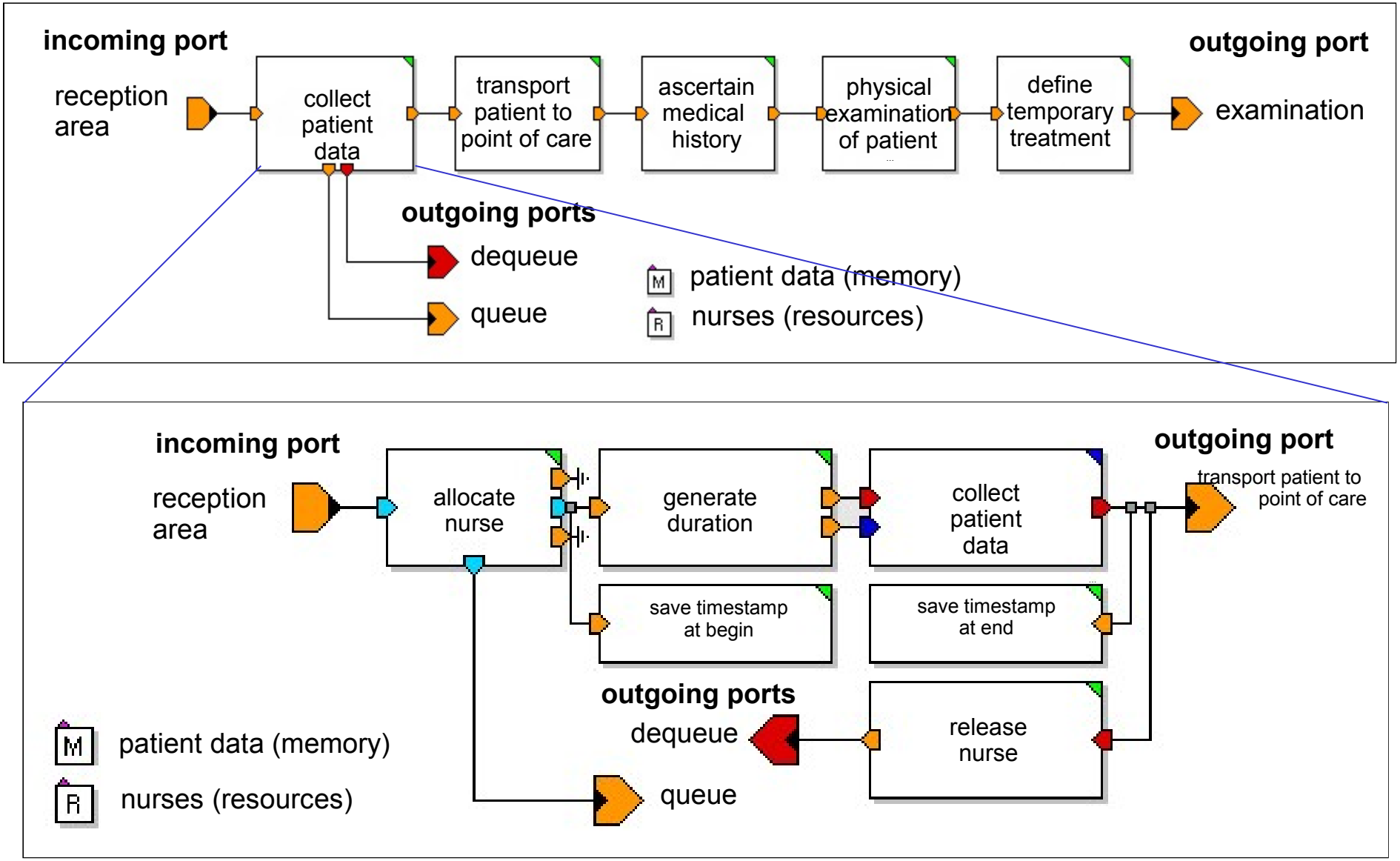
MLDesigner hospital library: Extract



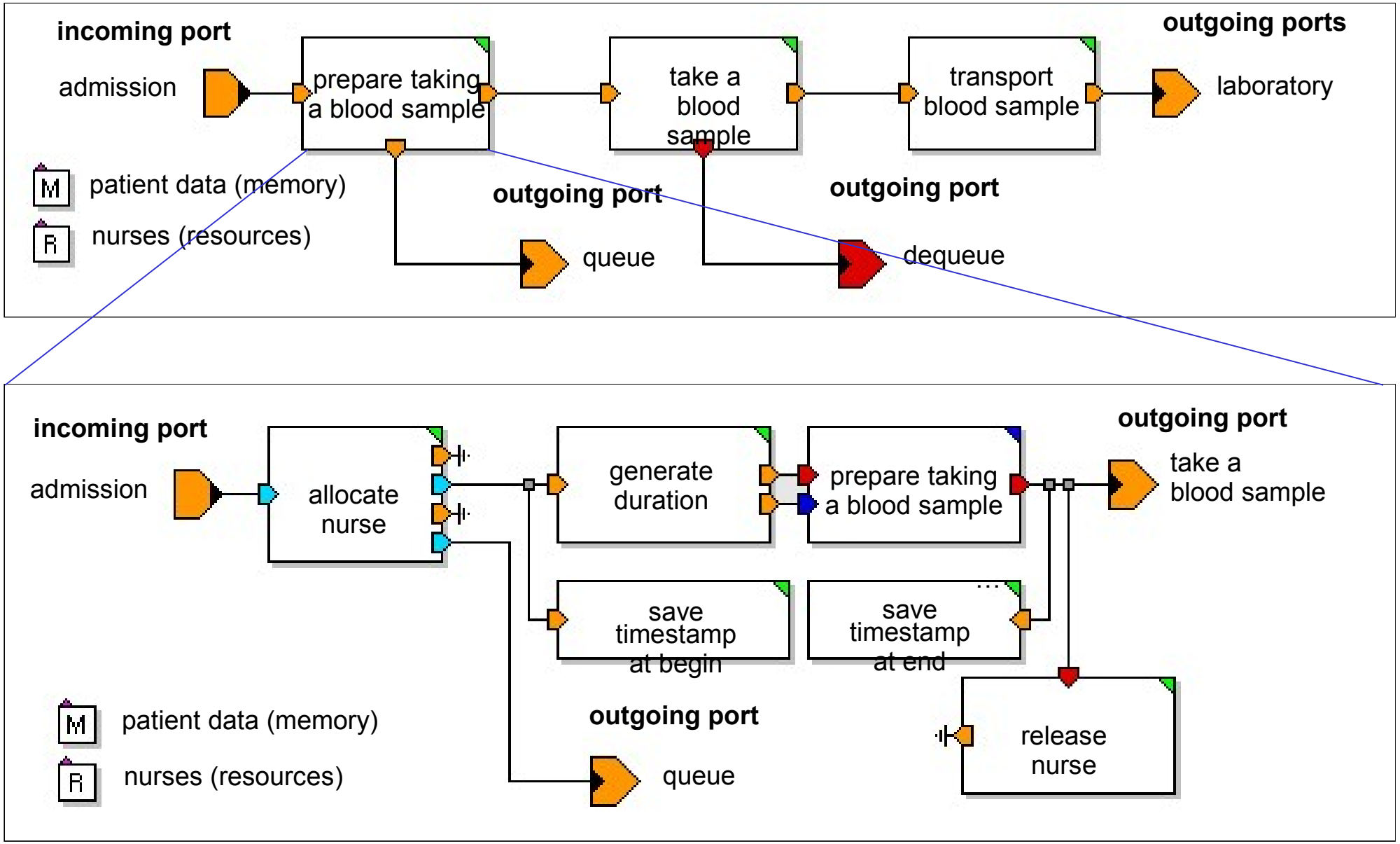




Library block: Outpatient admission

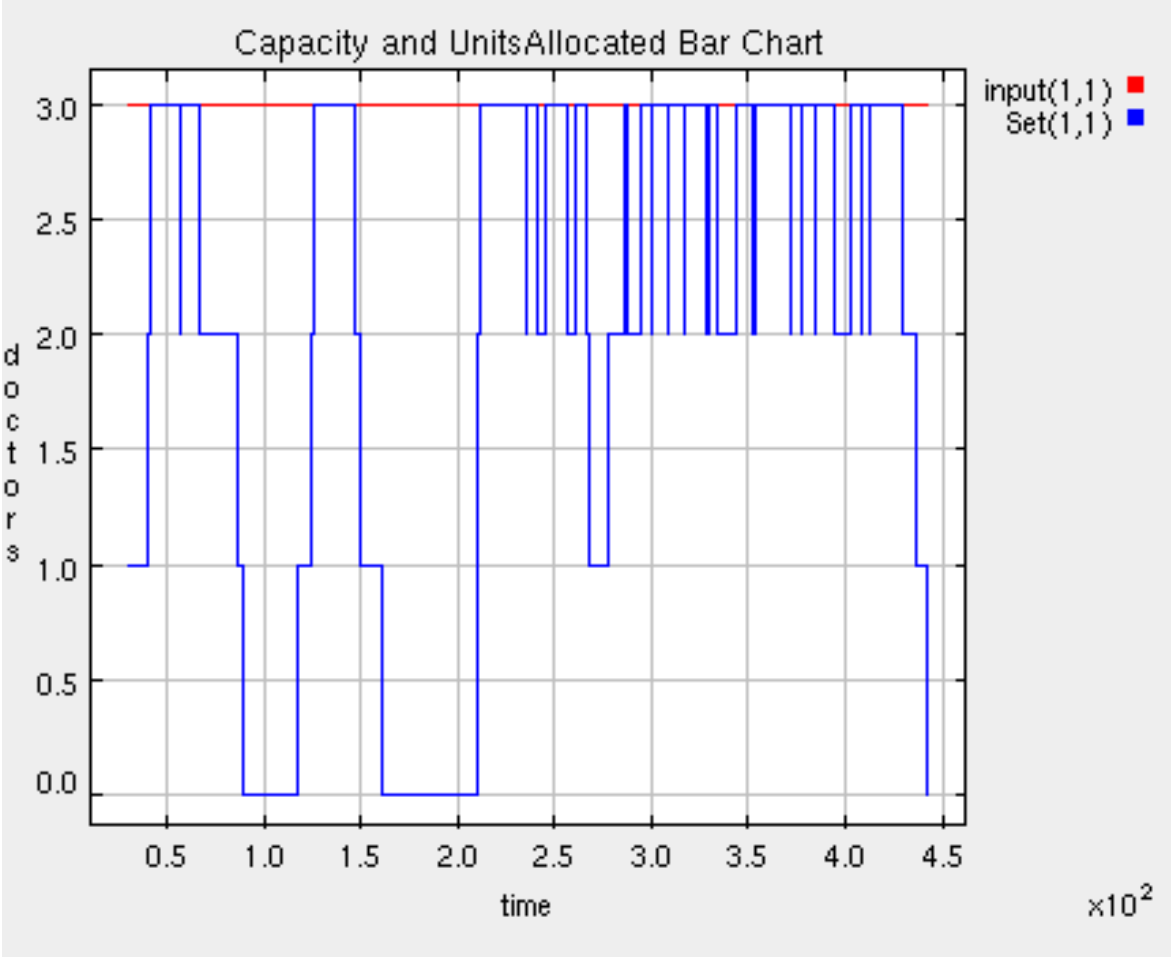


Library block: Preparation for taking blood samples



Deployment of resources

- For analyzing the deloyment of resources, standard quantity and server resources were used
- Example: Resource deployment of physicians

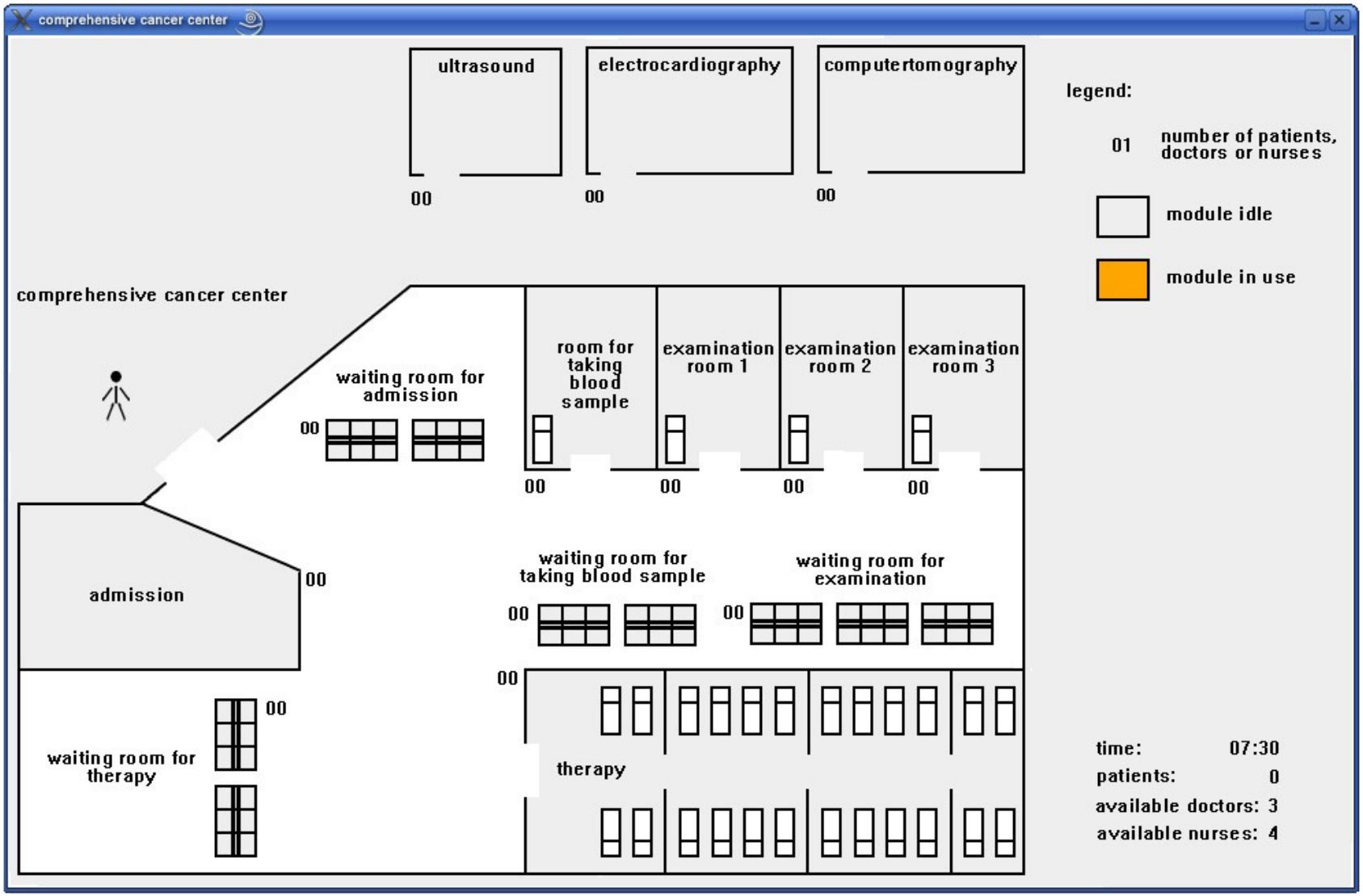


Optimization of Cancer Treatment Center

(1) Analysis of organization and existing process

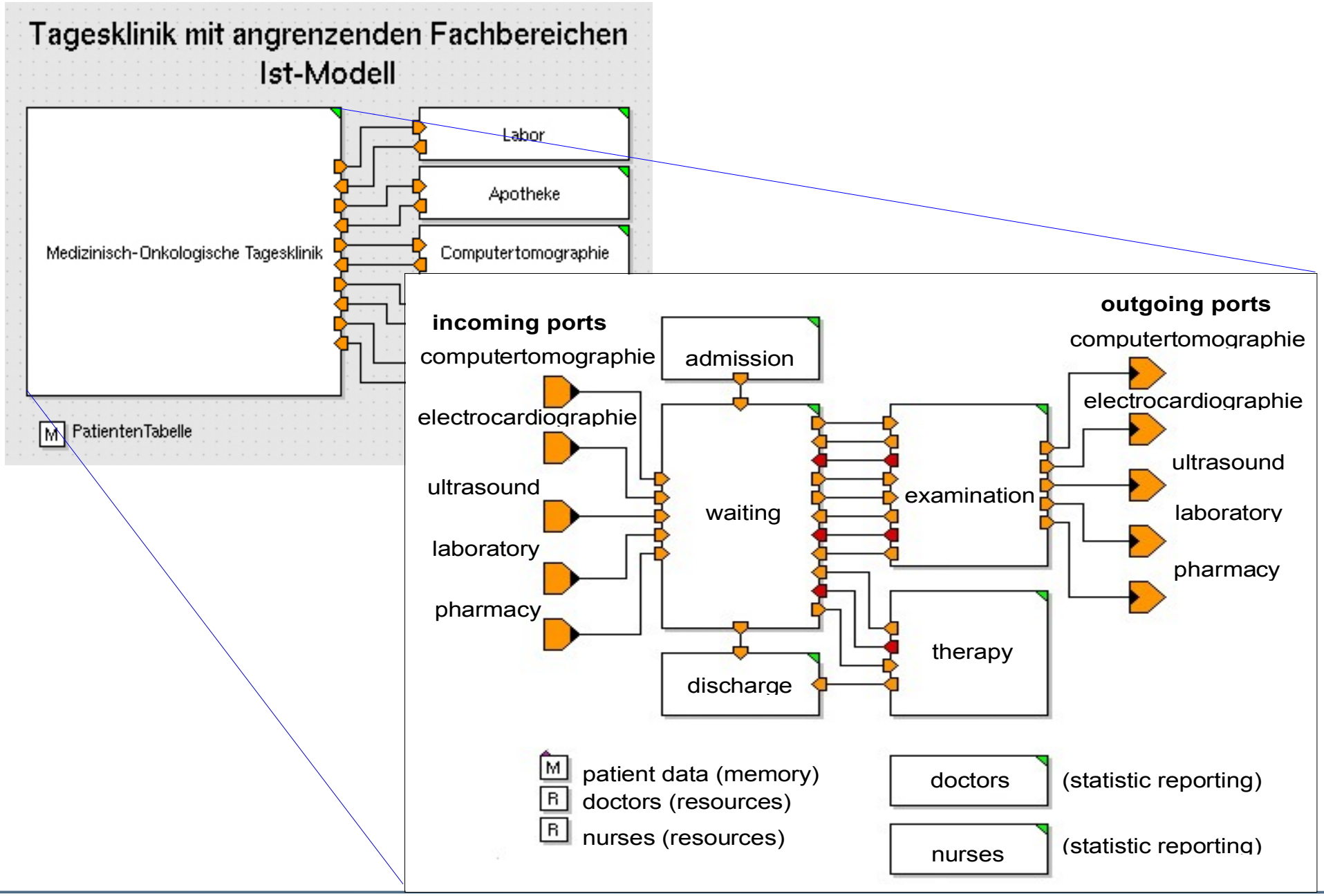
- Analysis of existing data
- Peparation of questionare
  - Arrival time of patients
  - Start and end time of patient admission
  - Start end end time of aking blood samples
  - Start and end time of examination by physician
  - Time for placing rder for chemotherapies in the hospital internal pharmacy
  - Start and end time of chemotherapy
  - Time of patient discharge
  - Utilization of beds and hospital staff
- Training of hospital personal for taking data
- Taking data for 55 days
- Validation of data

Preparation of floor plan for routing/path optimization and animation

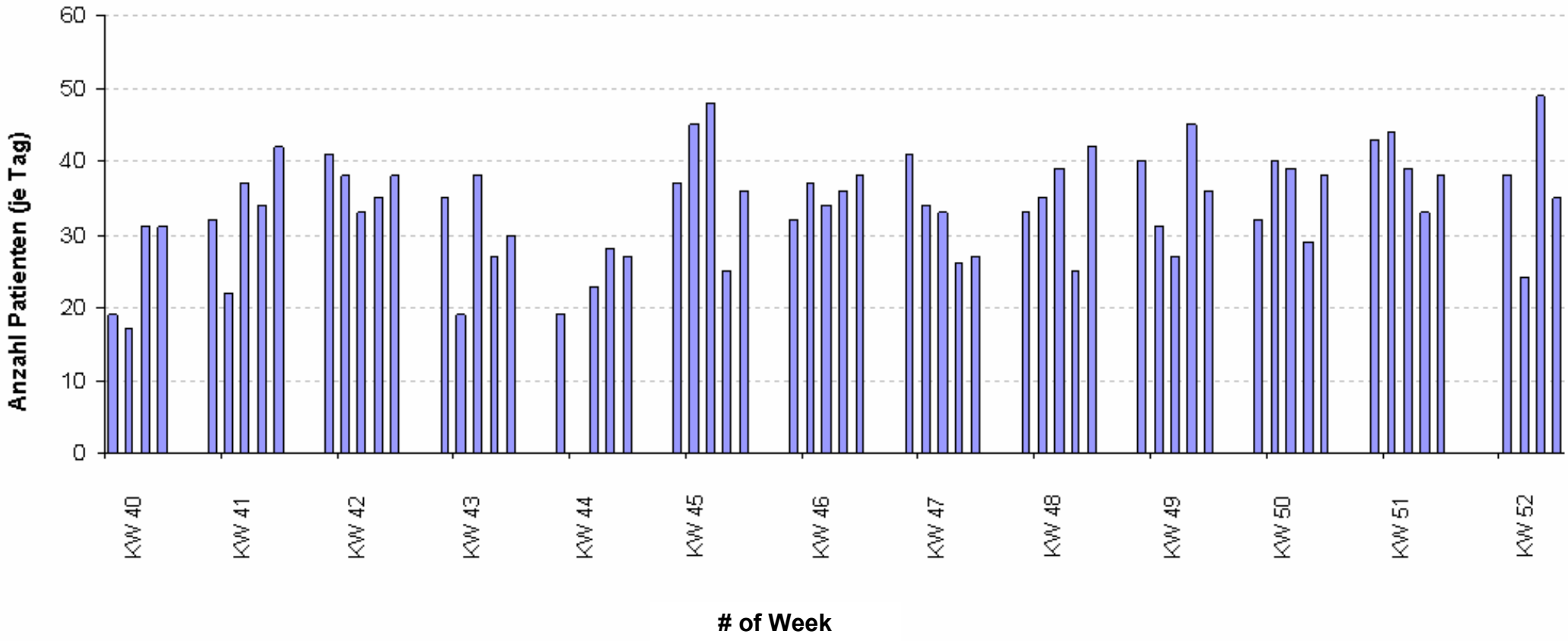


- Path optimization with modified Dijkstra algorithm (developed for path optimization of thru multiple satellite comm systems)
- Animation with info from computed routing table

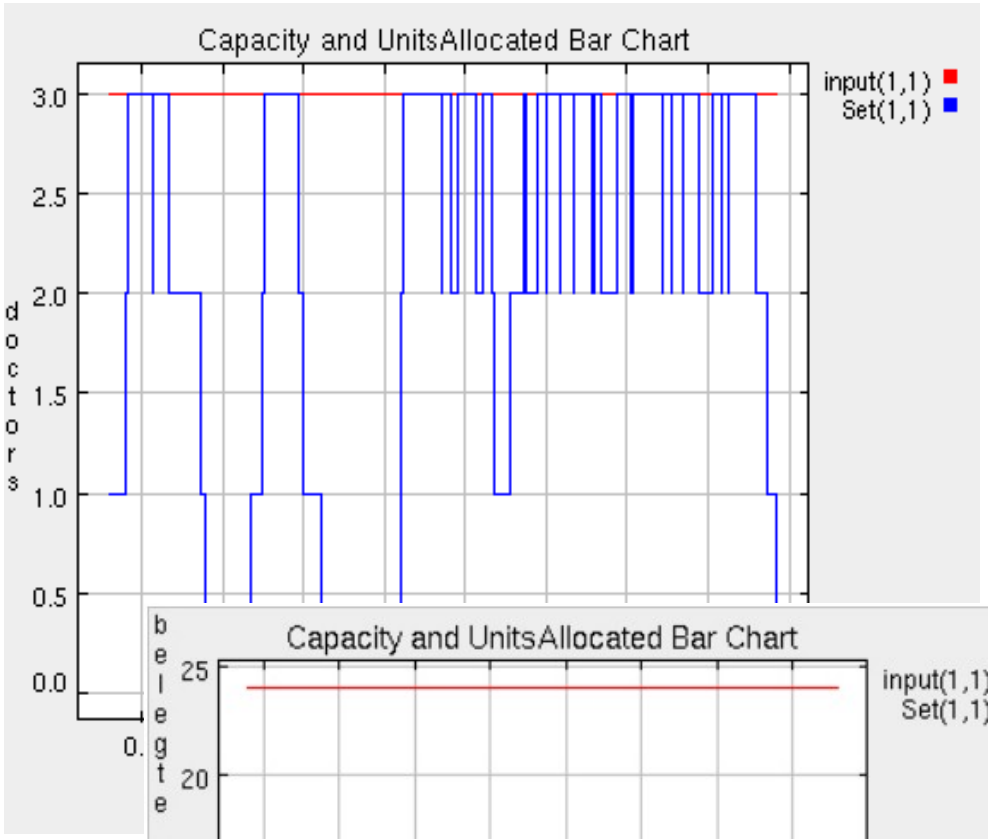
Level 2 Model of Cancer Center

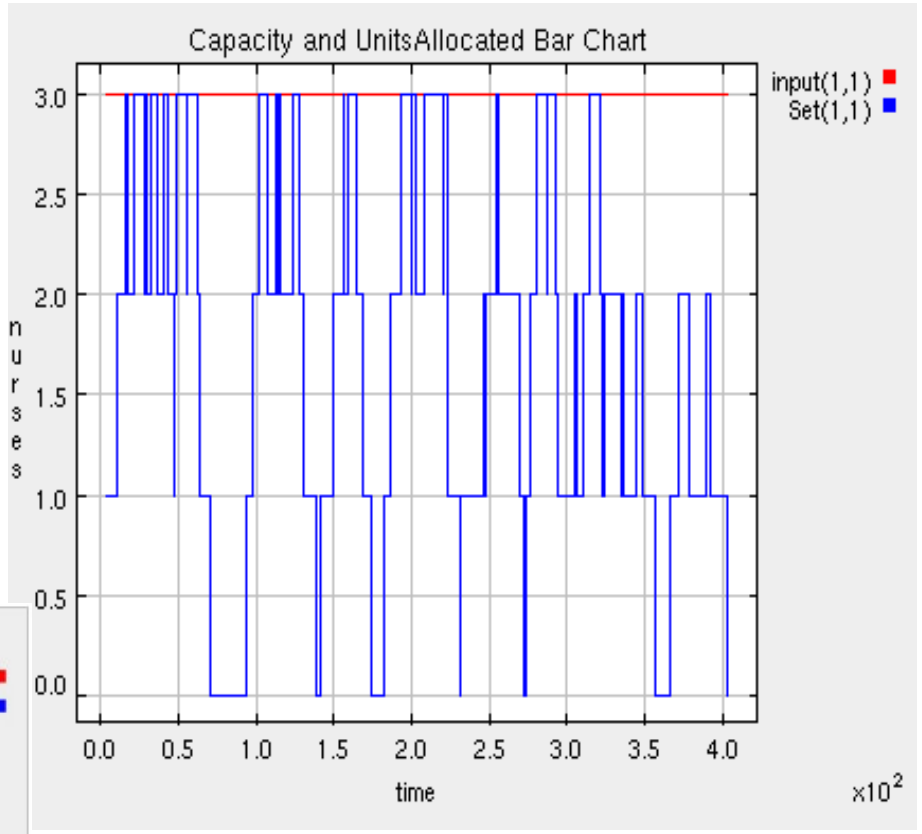


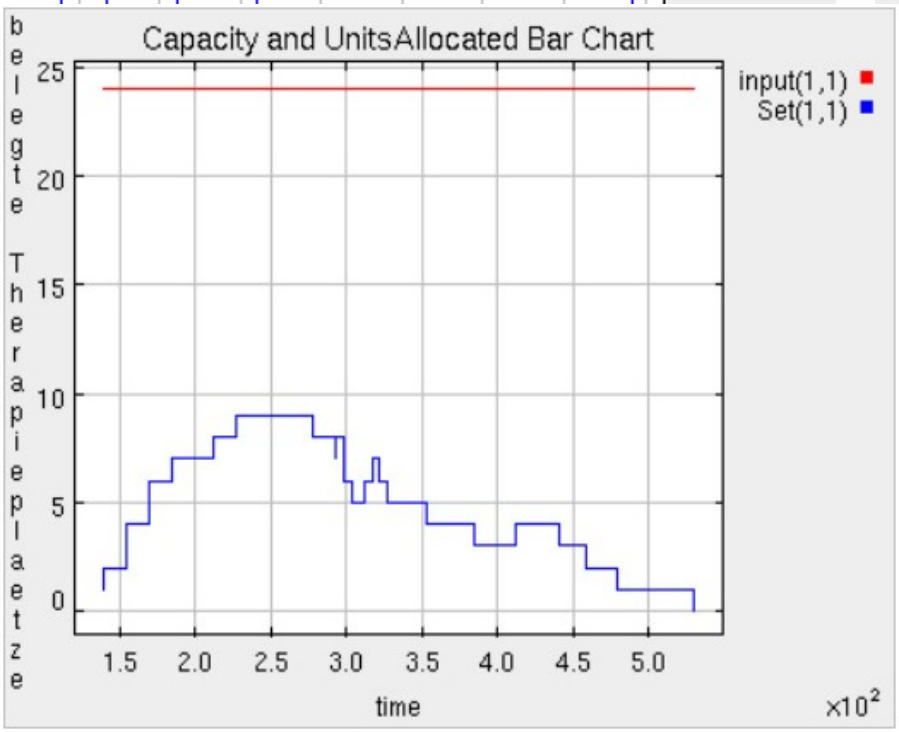
Number of scheduled patients



Validation of existing process



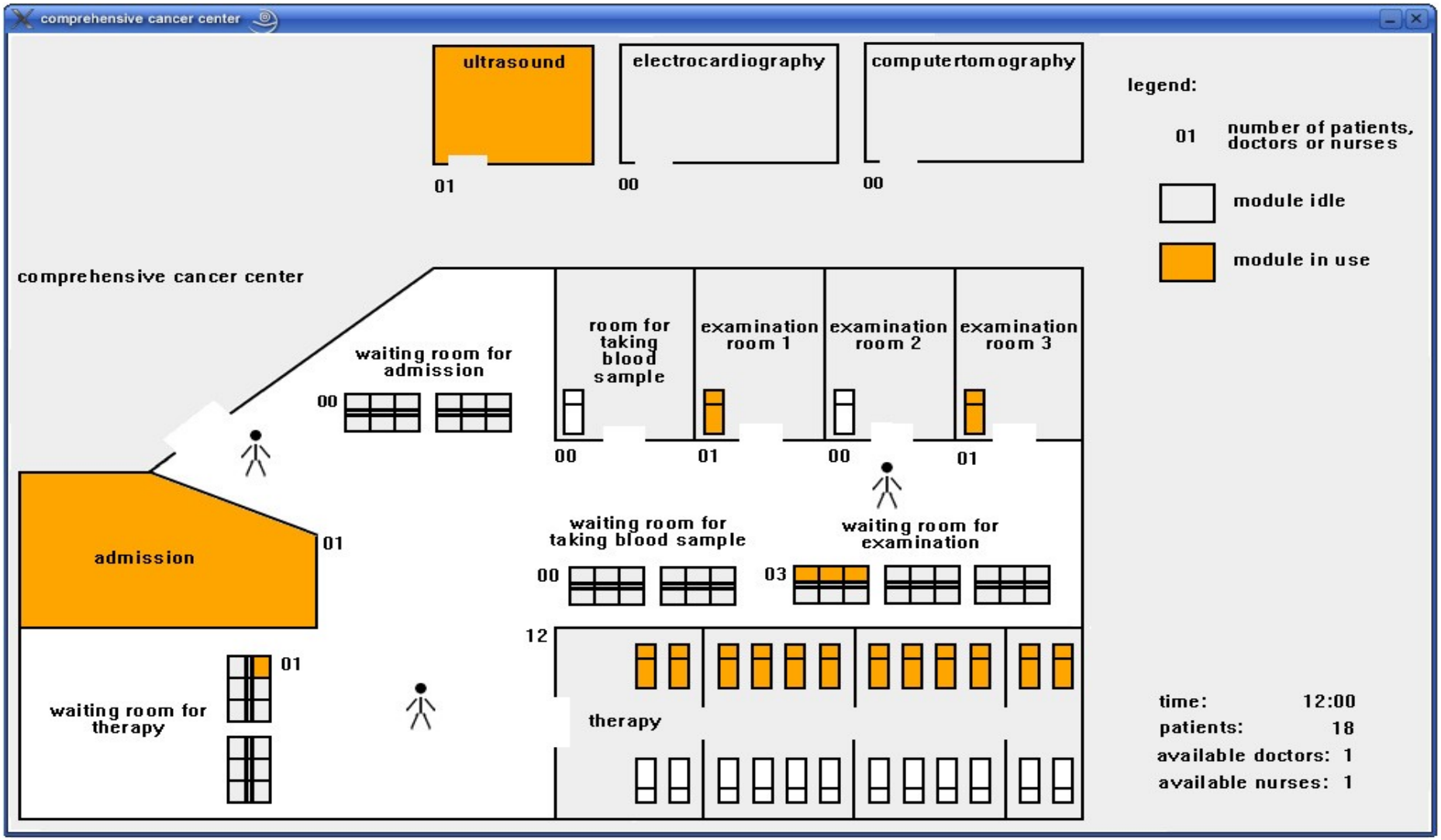




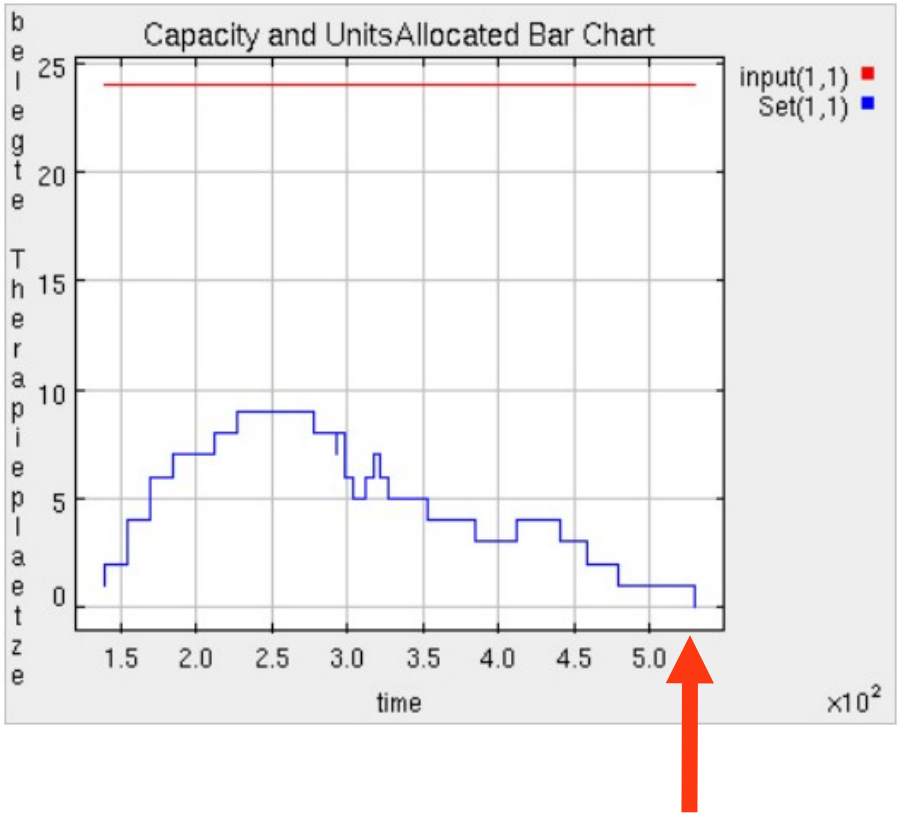
- Development of model from 14 days of data
- Validation with 55 days of data

Path Optimization and animation

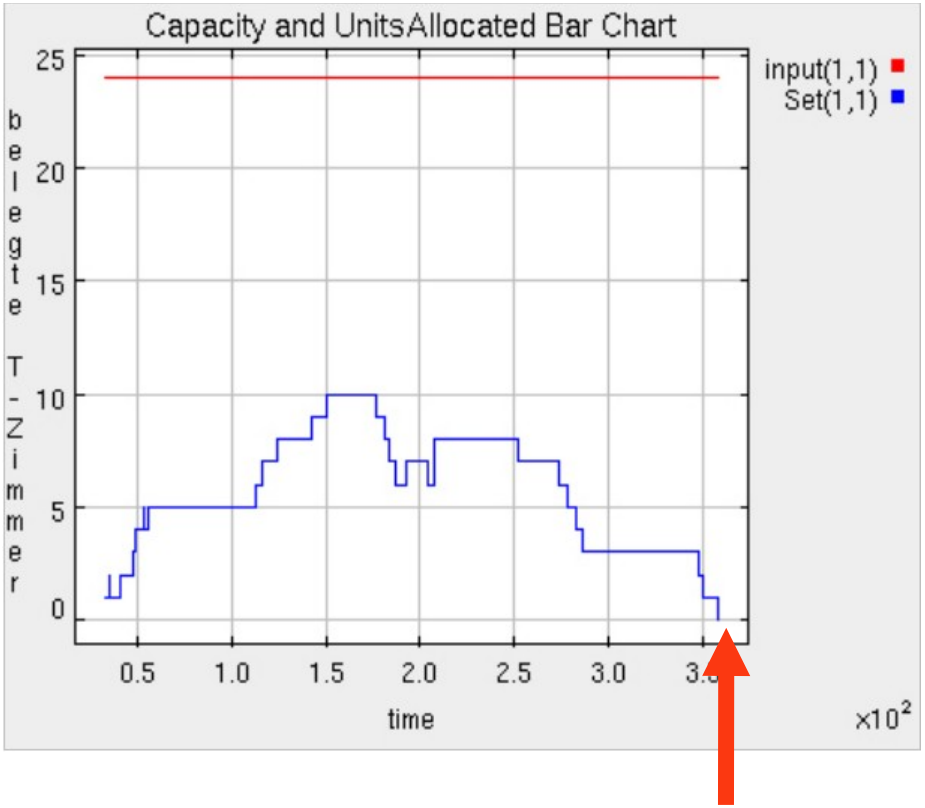
- Path optimization with modified Dijkstra algorithm



Process Optimization of Cancer Treatment Center with genetic algorithm



Before Optimization



After Optimization

Chart of utilization of therapy beds (result of as-is simulation):
- Late start of first therapy compared to opening hours of cancer treatment center
- Peak of utilization around noon

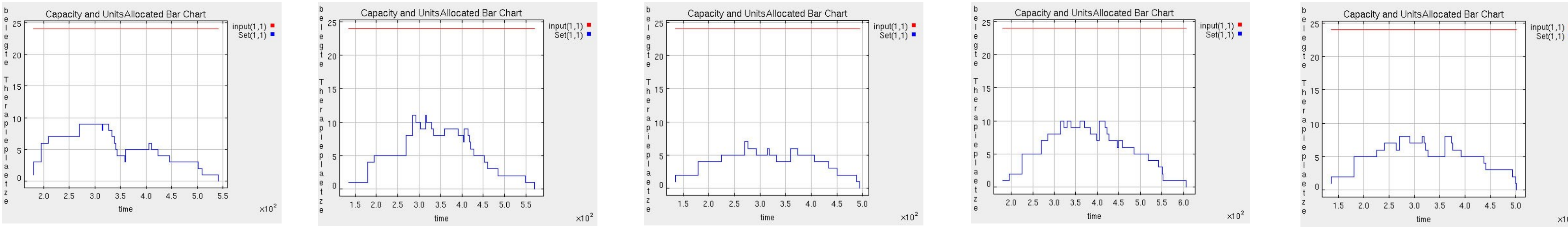


Chart of utilization of therapy beds (result of to-be simulation after optimization of sequence planning of scheduled patients):
- Partially earlier start of first therapy
- Finish of last therapy significantly sooner than in the as-is simulation model

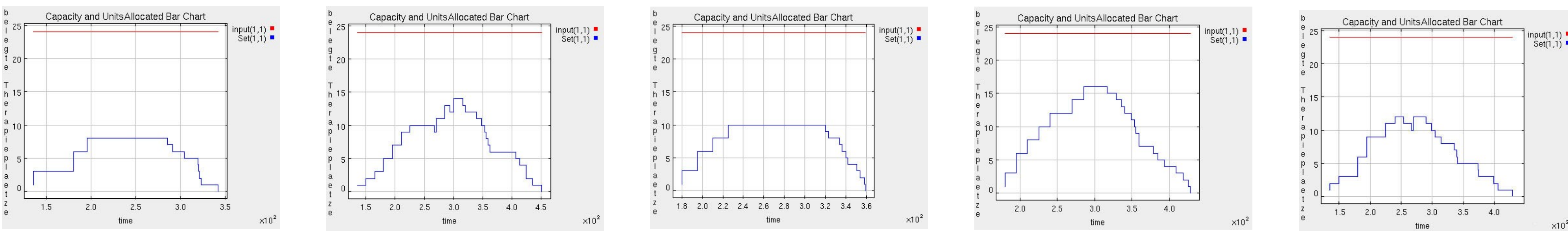
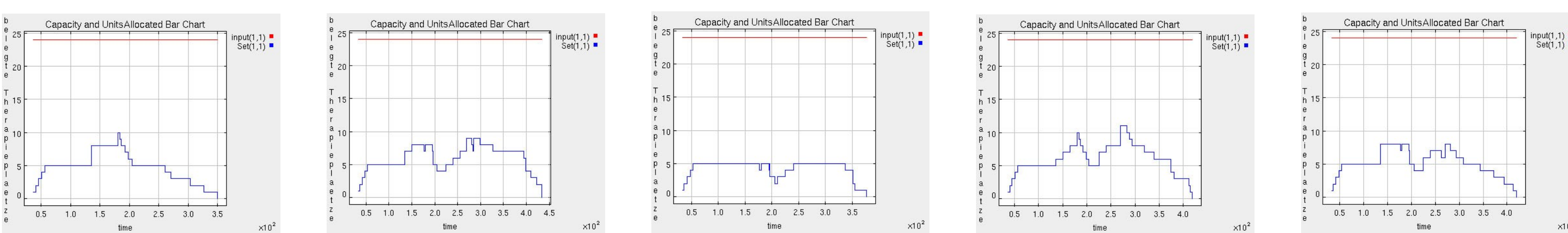


Chart of utilization of therapy beds (results of to-be simulation model after optimization of sequence planning of scheduled patients as well as optimization of blood taking process):
- Earlier start of first therapy on simulated every day
- Start of first therapy significantly sooner than in the as-is simulation model
- Finish of last therapy significantly sooner than in the as-is simulation model



Optimization step 1: Elimination of a redundand process step

In the past, patients who needed to get a computertomography, became a venous access (canula/needle) in the treatment center (for taking blood samples) as well as in the radiology department (for application of radiopaque material). In the optimized simulation modell, this group of patients get only one venous access directly in the radiology department. This access will then also be used in the treatment center for taking blood samples. This saves time and increases the quaility of treatment by only puncturing those patients one time instead of two times in a row.

	in %	Amount / Time
Average number of patients per day		34
Average number of patients who needed to get a	15%	5,10
Average time to apply a venous access (in minutes)		10
Average time savings per day		51

Optimization step 2: Optimization of the sequence planning of scheduled patients

In the optimized model, patients who will receice a chemotherapy will be schedued as the first group of patients. As a second group, patients who will only be examined by a doctor and will not get a chemotherapy, are being scheduled.

	in %	Avg. reduction of waiting time (in minutes)
Average reduction of waiting time in the optimized model compared to the as-is model (after implementation of step 1 and 2)	34%	-54

Optimization step 3: For selected patients, blood samples will be taken the day before their treatment with chemotherapy

For selected patients, blood samples will be taken the day before treatment. This enables the cancer center to receive results from the laboratory the day before treatment and to also order the chemotherapy from the hospital pharmacy the day before treatment. Those patients can then receive their chemotherapy right after their admission in the cancer center, since they don't need to wait for any blood results.

	in %	Avg. reduction of waiting time (in minutes)
Average reduction of waiting time in the optimized model compared to the as-is model (after implementation of step 1, 2 and 3)	44%	-69

Summary and Outlook

- A library of standard building blocks was developed for modeling, simulation and optimization of hospital processes
- The process of a cancer treatment center was modeled, analyzed, and optimized within 6 weeks
- Large reductions in cumulative patient treatment times could be realized
- The results convinced the hospital to implement the new process immediately
- The predicted improvements were fully realized
- Current research is optimizing other departments of the hospital. Multi departmental optimization is being developed
- A new research program was started for optimization of hospital processes within the State of Thuringia

Questions?

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