An Agent-based Approach to ARGESIM Benchmark C6 'Emergency Department – Follow-up Treatment' using Anylogic

Katharina Ölsböck[1*], Michael Noya[1], Patrick Einzinger[1,2]

[1] Inst. of Analysis and Scientific Computing, Vienna University of Technology, Wiedner Hauptstraße 8-10, 1040 Vienna, Austria; *katharina.oelsboeck@tuwien.ac.at

[2] dwh Simulation Services, Neustiftgasse 57-59, 1070 Vienna, Austria

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Abstract. ARGESIM Benchmark C6 'Emergency Department – Follow-up Treatment' on the first glance is a classic discrete process system – with servers (treatment units) and entities (patients). But the different behaviour of doctors causes some modelling difficulties. This contribution presents an agent-based modelling approach, which is much more flexible than the classic DES approach, implemented in the Java-based simulator AnyLogic, which is capable of DES, agent-based, ODE, system dynamics and programming approach.

Simulator. AnyLogic is an object-oriented simulation tool that supports discrete-event, agent-based, and system dynamics simulation. It includes a graphical modeling language and allows the user to extend simulation models with Java code.

Basic Model. According to the C06 specification, several interacting active object classes were defined: Patient, Doctor, InexpDoctor (inexperienced doctors), Registration, XRayUnit and PlasterStaff.

There are 250 predefined patients, belonging to one of 4 different types. The arrival of the patients is modelled as a cyclic timeout-triggered event. On average every 0.3 sec a random patient arrives and receives a registration number. A patient's state reflects his current position and whether he is currently waiting or being treated. The corresponding statechart is depicted in Figure 1.

At every treatment point patients are being treated in the order of their arrival. For example, as a patient enters the emergency department, he receives a new registration number.

If there is at least one patient waiting, the registration object changes its state from "idle" to "working". With a certain probability the patient is assigned either to CW1 or CW2 and receives a new number for the corresponding waiting queue. After processing the patient (which takes a certain amount of time), the registration unit changes its state back to "idle" and checks if there are other patients waiting.

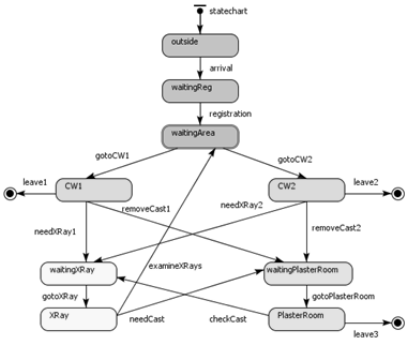

Figure 1: Statechart of a patient. The different states reflect the current position of the patient in the emergency department or whether he is outside.

The other treatment points work in a similar way, but treat patients differently depending on their type. A doctor checks the type of a patient and whether he has already been treated and, consequently, may assign him either to the X-ray room, the plaster room or send him directly home.

The simulation process (Task 1 – Basic Simulation) is visualized on a layout plan of the emergency department (see Figure 2). The agents representing a patient are positioned according to their current state. Every type of patient is depicted with a different color. The two types of doctors are also displayed in either dark (experienced) or light colors (inexperienced).

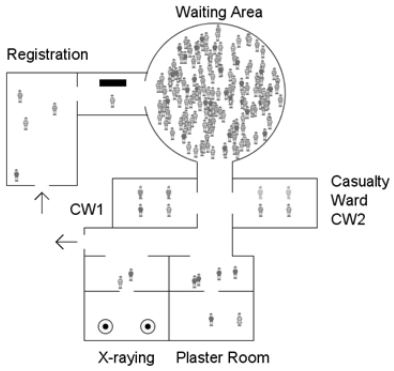

Figure 2: Layout plan of the emergency department showing the current location of patients, doctors and other staff.

Model for Complex Tasks. To provide a solution for the 2nd task *Chang of Experienced Doctors*, every doctor has four possible states instead of two: 'idleCW1', 'workingCW1', 'idleCW2' and '"workingCW2' (see Figure 3). One of the experienced and one of the inexperienced doctors is declared 'changing doctor'. The experienced changing doctor changes his state from 'idleCW1' to 'idleCW2', when there are at least 20 patients waiting for CW2 and the corresponding parameter for task b is activated. He then is treating patients assigned to CW2 instead of CW1. Apart from that, his work is unchanged. Only the treatment time per patient of the inexperienced doctor is increasing, when he starts to work in CW1. If the numbers of patients waiting for CW2 is down to 5, the doctors change back to their original workplace.

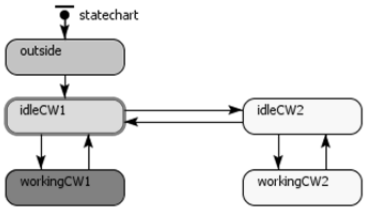

Figure 3: Statechart of a doctor. The states reflect his current workplace and whether he is idle or working.

The 3rd task – *Priority Ranking for Patients* - is implemented by creating a new priority waiting queue at each casualty ward. Patients of type 1 and 3 waiting to enter the casualty ward for the second time receive a number in one of these priority queues. An idle doctor will always prioritize patients waiting in the priority queue over patients in regular queues.

Results. The simulation was run 100 times for each task. Table 1 below shows the results.

1st Task – Basic Simulation: The average overall treatment time is 172 minutes, with significant differences between the patient types.

2nd Task - Chang of Experienced Doctors: Exchanging doctors between the casualty wards increases the average overall treatment time while at the same time increasing the standard deviation and the working hours for the emergency department staff. This strategy yields no advantages for patients of any type.

3rd Task – Priotity Ranking for Patients: Trough the implementation of a priority ranking the average treatment time for patients of type 1 and 3 is reduced by around 70 minutes per patient while the average treatment time for type 2 and 4 is increased by around 30 minutes, thus lowering the standard deviation, while only slightly increasing the working hours for the emergency department staff. Even though patients of type 1 and 3 only constitute 40% of the total, the reduction in their treatment time is significant enough to lower the overall treatment time for all patients.

	Task a	Task b	Task c
Average overall treatment time per patient	172	184	162
Av. treatment time, type 1	235	251	163
Av. treatment time, type 2	135	144	165
Av. treatment time, type 3	246	265	179
Av. treatment time, type 4	126	135	157
Standard deviation	80	92	76
Average closing hour	13:43	14:23	13:52

Table 1: Simulation results.

Conclusions. Agent-based modelling is a useful approach for the simulation of humans working and interacting in a place such as an emergency department. The persons are modelled by individual agents. Their state and progress can therefore be examined at any time and it is easy to visualize all activities.

Model Sources / References. AnyLogic Model files (.alp) and short file documentation can be downloaded (zip format) by EUROSIM societies' members from SNE website, or are availably from the author.

[1] Breitenecker F. Emergency Department – Follow-up Tratment - ARGESIM Comparison C6 – Definition. *SNE Simulation News Europe*. 1992; 2(3):30.