A Process-oriented Solution to ARGESIM Comparison C6 'Emergency Department' using WebGPSS

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Simulator: *GPSS* (General Purpose Simulation System) introduced the transaction-flow modelling paradigm. Under this paradigm, active *consumer* objects, called transactions, travel through a block diagram representing a system, competing for the use of passive *server* objects. This modelling paradigm is extremely general and has been adopted in a large number of simulation languages. At the Stockholm School of Economics, a simulation tool called *micro-GPSS* has been used by almost all students during more than a decade. Micro-GPSS is a streamlined version of GPSS, which, seen over time, is the package for discrete-event simulation that has been most widely used. Micro-GPSS has been focussed on being very easy to learn and use. Micro-GPSS has been developed by Professor Ingolf Ståhl on the basis of feedback from over 5000 students.

A new version presented here, *WebGPSS*, uses a web-based GUI for the very simple input of programs. The main idea behind WebGPSS was that it should be so simple that it could also be used in high schools. For this purpose, it has also been regarded as important to provide this tool freely available on the Web.

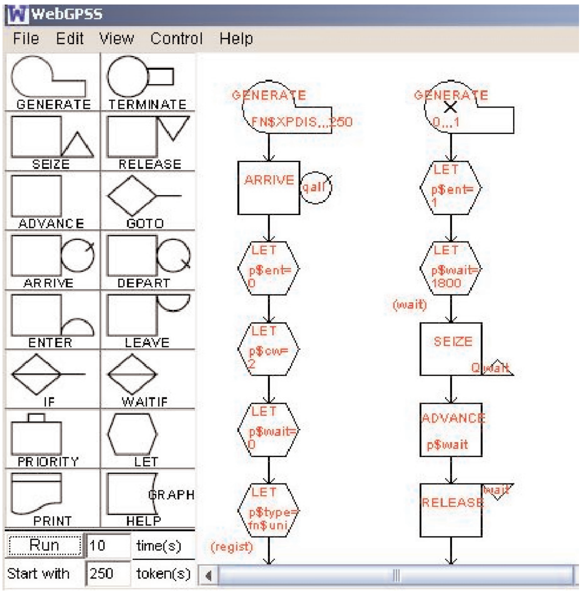

Figure 1: Screenshot of part of WebGPSS model for causality ward system.

Unfortunately, WebGPSS offers only five built-in statistical functions which are not really programmed in a general way. Thus, the necessary distributions are realised through discrete probability density functions provided in WebGPSS. Figure 3 shows the triangular distribution for the treatment time of casualty ward 1.

Another disadvantage of WebGPSS is the limitation of the possible program lines. Only 500 rows of code are accepted for modelling. Otherwise the following error occurs: *Program has too many statements*.

Modelling. An emergency department is modelled, where four kinds of causalities are admitted. Their way trough *Causality Ward*, *X-ray* and *Plaster Room* depends on the severity of their wounds. Figure 1 shows a screenshot of the WebGPSS GUI. Here the user can build simulation models by adding blocks and changing different parameters. There are 16 buttons, corresponding to the 16 different blocks, and a button to start the simulation.

A WebGPSS program has two types of representations: the graphic one as a block diagram, and a textual one, which is the 'classic' way of representing a GPSS program. Figure 1 also shows the so called *block diagram* of the model. The different treatment points are implemented as blocks and the patients (the processes) are represented through the so called *transactions* which are generated in the GENERATE Blocks. Depending on several conditions the transactions are finding their way through the system.

In this model special values are assigned to the generated transactions, telling which kind of patient the transaction represents. Depending on these values, the transaction makes its way trough the system. Every time a patient transaction exits a treatment point new routing values are assigned.

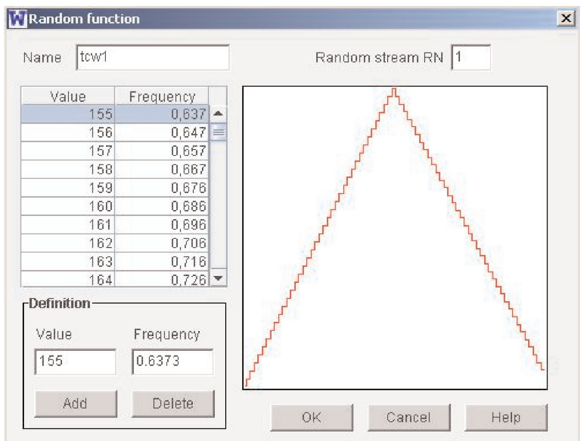

Figure 2: Discrete random density function of WebPPSS used for triangular distribution.

For the purpose and the aim of WebGPSS itself the restriction of lines is not really a problem because the user can build very easily big models using the built-in functions of the program.

A very tricky part of modelling was the implementation of the doctor's starting time. Patients start arriving at 7.30 a.m. and queue for registration. Doctors start work at 8.00 a.m. All patient transactions get a value 'wait' which is set to zero. One extra transaction is created at the beginning with value 'wait' equal to 1800 seconds. All patient transactions have to wait in the queue QWAIT of the SEIZE Block until the extra transaction leaves the FACILITY Block. Now the doctors start their work and the patient transactions can pass the FACILITY Block without loosing time.

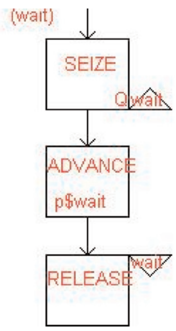

Figure 3: Model part for doctors' delay at begin.

The statistical evaluation is automatically performed by WebGPSS and shown in the *results window* after the simulation.

A -**Task: Simulation – Average Treatment Times.** In WebGPSS, a single simulation run is started within the GUI by pressing the 'Run' button. At the end of the simulation the *results window* is opened where all needed results are generated automatically. Depending on the type of patient the treatment time takes between 94 and 220 minutes (results Table 1).

B - **Task: Doctors' Exchange Strategy**. The model has to be extended by several IF and GOTO blocks, see Figure 5, to model the check points for testing the queue lengths of the causality wards and to route the transactions to the correct doctor block. The difficulty is to implement each doctor as FACILITY Block instead of two STORAGE blocks to realise the exchange of the two doctors. As soon as the queue before causality ward 2 contains more than 20 patients the more experienced doctor takes over.

This strategy yields an increase of treatment times for all types of patients, for the standard deviation and also for the overall treatment time (see Table 1).

C - **Task: Priority Ranking.** Priority ranking is a standard feature of WebGPSS. PRIORITY blocks can be used to give entities (transactions) a priority, which can be used as ranking order in queues or in front of other blocks. Priorities are set after leaving the causality wards after treatment (Figure 5).

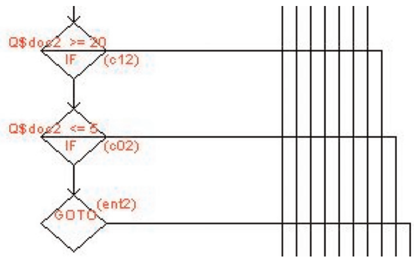

Figure 6: Doctors' exchange strategy modelled by IF and GOTO blocks.

The transaction PRIORITY is used for ranking in front of the causality ward blocks to prioritise patients of type 1 and type 3 if they are visiting the causality wards a second time. Results (Table 1) show a decrease in treatment time for patients of type 1 and type 3, an increase for the others. Standard deviation and the overall treatment time decrease.

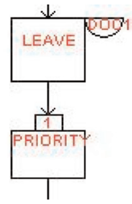

Figure 5: Block for priority modelling

Mean time	Task A	Task B	Task C
patient 1	192	195	122
patient 2	96	119	118
patient 3	220	233	134
patient 4	94	94	122
Std. dev.	88	91	87
ov.treat.time	343	363	342
close hour	13:43	14:03	13:42

Table 1: Results for Task a -c: mean of treatment times, standard deviation and closing time.

R**esume:** This solution is based on classical process-oriented modelling using the WebGPSS, a simplified version of GPSS mainly for educational purposes. As special features for parametrisation of model blocks are not available, given input distributions and the doctors's delay have to be implemented additionally (GUI for random distributions, DELAY submodel). Doctors' exchange stategy requires a nontrivial model extension by using coupled single resources for each doctor, instead of using multiple resources for the ward. However, modelling of priority is a standard feature.

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