An OO Programmed Approach to ARGESIM Comparison C2 Flexible Assembly System with CSIM – C++

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Simulator: CSIM (Mesquite Software) is a process-oriented, general-purpose simulation toolkit, which supports the development of process-oriented, discrete-event simulation models, by using the standard programming languages C and C++. Because of the nature of compiled C and C++ programs and CSIM's dynamic memory allocation, developed models are compact and efficient. CSIM supports the Object-Oriented Simulation (OOS).

Model: We have described the model textually by writing the corresponding C++ code. Each subsystem in our model is an object of the class *Subsystem*. The class *Subsystem* defines the structure of the subsystem, by using the CSIM class *Facility*. We have used *facilities* to model resources, such as the machine and shifting units, of the subsystem. We have defined the class *Segment* to model the space between two subsequent subsystems. The following program lines depict FMS, which is defined as a set of instances of the class *Subsystem* and the class *Segment*:

```
Subsystem ss1(1, 1, 15, 2.0, 1.2, 0.4, 2);
Segment seg12(1, 2, 0.4);
Subsystem ss2(2, 2, 60, 1.6, 0.8, 0.4, 2);
Segment seg23(2, 3, 0.4);
Subsystem ss3(3, 2, 60, 1.6, 0.8, 0.4, 2);
Segment seg34(3, 4, 0.4);
Subsystem ss4(4, 2, 60, 1.6, 0.8, 0.4, 2);
Subsystem ss5(5, 3, 20, 1.6, 0.8, 0.4, 2);
```

Task a:Control Strategy/Statistical Evaluation.

Each pallet in our model is an instance of the class *Pallet*. The method *work()* of the class *Pallet*, which implements the behaviour of the pallet, is defined as a CSIM *process*. In a CSIM model a *process* represents an active entity. The control logic is implemented in the method *work()* of the class *Pallet*. The properties of the class *Pallet* contain the information: loading and unloading times, type of the processing completed, and the current position in the system

Task b: Simulation Results - Throughput. Task c: Simulation Results - optimisation.

The task is to find the optimal number of pallets in the system. We have started the simulation experiments with empty pallets and counted the number of the completed jobs from 7200th second to 36000th second (8 hours). OptQuest may be used with CSIM for searching for the optimal solution.

However, we run the simulation experiments manually, because the number of experiments is limited to a relatively small number.

Number of pallets	Number of jobs	Throughput time [seconds] mean	Throughput time [seconds] s.d.	CPU time [seconds]
13	1320	284.56	42.36	0.70
16	1440	321.25	18.26	0.78
17	1442	341.18	39.13	0.83
18	1442	361.64	48.39	0.85
20	1438	401.03	61.98	0.96
21	1440	420.86	71.67	1.01
22	1442	440.33	78.59	1.07
23	1438	460.79	84.41	1.12
24	1439	480.21	94.59	1.20
25	1440	499.33	126.59	1.25
40	1440	794.10	343.82	2.41

Table 1: Simulation results for different numbers of pallets

Table 1 shows the simulation results for 13/ 16-18/ 20/ 21-25/ 40 pallets. The optimal number of pallets is 17. An object of the CSIM class *Table* is used to collect statistics on throughput times. Simulation is executed on Sun Blade 150 workstation (CPU 650MHz, memory 768MB). The rightmost column (Table 1) shows the CPU time for the evaluation of the model.

Discussion: Three stations A2 represent the bottleneck of the system. Because they together can process, in the best case, three pallets in 60 seconds, it is considered that the maximum of the 1440 processed pallets for 28800 seconds of working time can be obtained from the system. However, recall that we count the number of the processed pallets starting at 7200th second. At this time, in the buffer of A1 may wait pallets with processed parts for unloading. In the first 60 seconds (after starting statistics collection), before the first pallet is processed by one of the A2 machines, several processed pallets may be unloaded by machine A1. We obtained the maximum number of the processed pallets 1442.

There is a constraint in the definition of Comparison 2: "In the beginning empty pallets are circulating in the system. Their positions on the conveyors B1 (not B2!) can be chosen randomly." Therefore, the initialization of the system for 60 pallets is difficult, because the total length of 60 pallets is larger than the total length of B1 belts and the spaces between the subsystems: $60 \times PalletLength > \sum_i B_{1i} + \sum_k Space_k$.

The work described in this paper is supported by the Austrian Science Fund as part of Aurora Project under contract SFBF1104.

C2 Classification: Object- / Process-oriented Modelling

Simulator: CSIM Rec. Release 2003

COMPARISONS