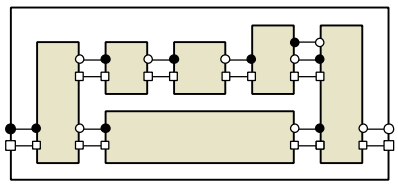
C2 Flexible Assembly System - AnyLogic

Object / Process-oriented Modelling

Simulator: AnyLogic (www.xjtek.com) is a general-purpose simulation environment for discrete, continuous and hybrid systems. It employs UML-RT structure diagrams for building hierarchical models in object-oriented way and *hybrid statecharts* for behaviour specification. Java is used for data types / operations.

Model: The assembly subsystem model consists of five objects: Conveyor (B), Station (Ax), Fork (Sx), Join (Sy), and Subsystem (structure shown below.



Structure of the Subsystem Class

Problem encountered: Due to specification, it is only possible to place up to 40 empty pallets on conveyors B1 and the conveyors connecting subsystems. Therefore, simulation of the model with more than 40 empty pallets circulating is not possible.

Analysis used for model validation: The minimal total time of a pallet processing can be obtained using total length of path the pallet travels in a single loop, that is 22.4m (2.0m*2+1.6m*6+0.4m*16+0.4m*6), its total operation time at stations 135s, and total shifting time 20s (*2.0s*5*2*). This gives us 229.667s (*22.4/0.3+135s+20s*).

As long as pallet entrance to the processing station takes 1.333s (*0.4/0.3*), the utilization of stations cannot exceed the following values:

U_{A1}: 0.918, U_{A2}: 0.978, $U_{A3/A4/A5}$: 0.938, U_{A6}: 0.957.

Using stations operational time (OT) and the formula $?_A = N_A/(OT_A+1.333)$, the maximal throughputs (pallets per second) for each operation type are:

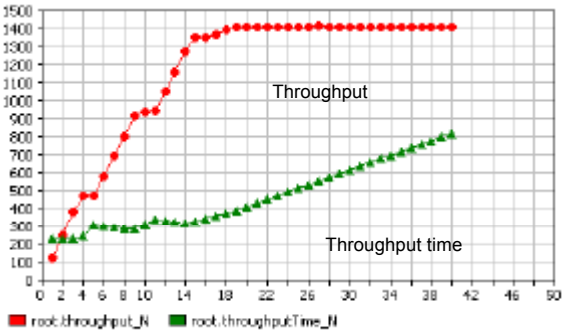
$?_{A1}$: 0.0612, $?_{A2}$: 0.0489, $?_{A3/A4/A5}$: 0.0468, $?_{A6}$: 0.0319.

Assuming the A6 station acting as A3/A4/A5 with equal probability, their actual throughputs are 0.0574 (*0.0468+0.0319/2*). Therefore, the task A2 is the bottleneck of the system. Given this, it is possible to calculate utilization of A1 when the bottleneck is reached: $U_{A1} = OT_{A1}/((OT_{A2}+1.333)/N_{A2}) = 15/(61.333/3) = 0.734$.

A single A2 station can process up to 470 pallets in 8 hours (*8*3600/61.333*). Then, all three A2 stations can process up to 1410 pallets (*470*3*), which is the maximal possible throughput of the assembly system.

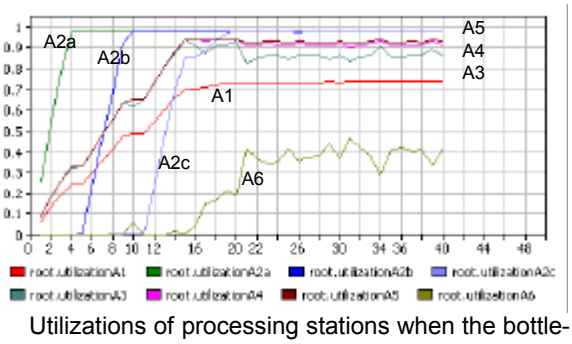
Task a Control Strategy – Statistical Evaluation. A local control strategy was used in the model. It allows us to abstract from implementation details of particular components when combining them together. Statistics are collected within the model and can be observed using AnyLogic Viewer.

Task b Simulation Results – Troughput. The diagram below shows system properties depending on the number of pallets in the system.



Task c Simulation Results – Optimisation. A parameter loop was used for optimisation with respect to total throughput and average throughput time (optimal number of pallets is 19). The following Table is an extraction from the simulation results. Both minimal throughput time (229.667) and the maximal throughput (1410) conform to the analytical results. Utilisation of stations depending on the number of pallets in the system is shown on the diagram below.

N	Time	Throughput	U_{A1}	U_{A6}
1	229.667	125	0.0651	0
12	329.330	1050	0.5464	0
18	373.015	1390	0.7206	0.1653
19	**388.437**	**1407**	**0.7295**	**0.2149**
20	409.066	1408	0.7304	0.1896
40	815.792	1410	0.7379	0.4169



Utilizations of processing stations when the bottleneck is reached (19+ pallets) are: $U_{A1}=0.7379$, $U_{A2}=0.9782$, which conforms to the predicted values.

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