Part I: Assignment

Tecnomatix Plant Simulation 11

Simulation of Production Systems

HOMEWORK

Following eight voluntary tasks are given.
For every task a due date is defined on this date the task will be discussed in class. Please do the task at home before that date so you can benefit from the discussion.

Task 01: FlowShop Discussed on: 31.10.2019

Create a new Frame “FlowShop” in a new data file.

The machine group consists of two machines „A1“ and „A2“; each can process only one job at a time. The two machines are linked to each other through a sufficient storage facility (Buffer [not PlaceBuffer!], capacity: 4, processing time: 1 minute) in the middle, so that “A2” cannot affect the process of “A1”.

Source → A1 → Buffer → A2 → Drain

All 9 jobs, “E1” to “E9”, are coming from a source (“Source”: Interval: 0) and subject to the same production sequence; however they have different processing times. All end in the “Drain” (Processing time: 0).

The production sequence and the processing times are given in the table. The waiting discipline in the “Buffer” is done according to FIFO principle. The jobs cannot overtake each other.

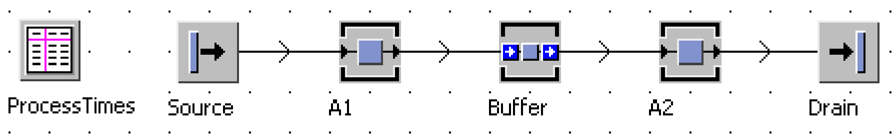
Products Sequence:
E9 → E3 → E5 → E1 → E2 → E4 → E7 → E8 → E6

The table with the processing times for machines “A1” **and** “A2”:

Name	Process time
E9	5 min.
E3	3 min.
E5	2 min.
E1	3 min.
E2	3 min.
E4	2 min.
E7	4 min.
E8	4 min.
E6	1 min.

Example: Job “E9“ needs 5 minutes in “A1” and 5 minutes in “A2”

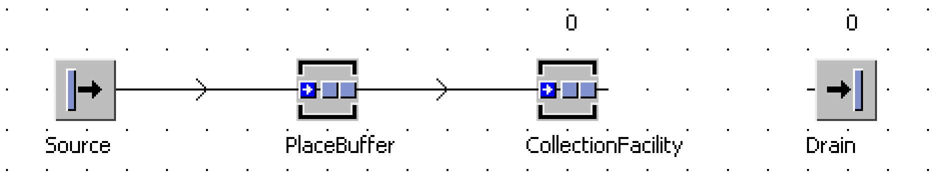
Remark: Here is more than one possibility to solve the task. If you need more or less elements as shown in the picture to model, all points for this task can be reached.



Task: Model the explained system in Plant Simulation and document your approach in short words. How long does the processing for all jobs take?

Task 02: Packaging Discussed on: 07.11.2019

Create a Frame, name this Frame "Packaging" in a new data file and model according to the following picture:



The "Source" generates one job (MU: "Package") per minute and sends it to a buffer ("PlaceBuffer"). In the subsequent collection facility ("CollectionFacility") 5 packages are gathered together and packed into a NEW large parcel (new name: "Package_new"). Then this parcel is moved to the drain (drain's processing time: 0). The packaging process of the "CollectionFacility" takes 4 minutes (the packaging process starts as soon as all packages have arrived).

The capacity of the "PlaceBuffer" is 4 and the processing time is 1 minute. The processing time of the "CollectionFacility" is 1 minute as well.

Remarks:

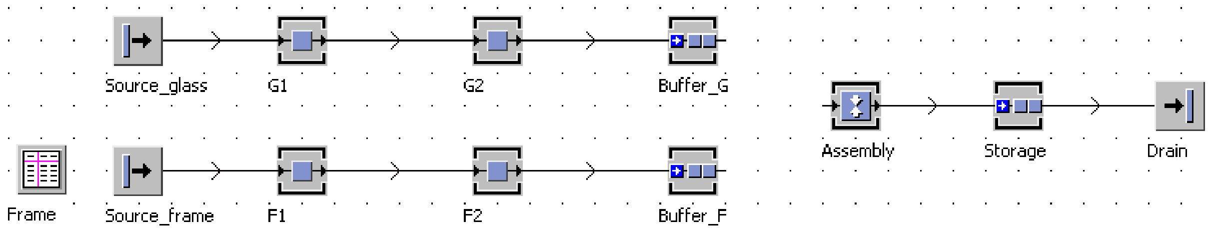
- In order to monitor the content of the buffer it is helpful to use a display.
- "Package_new" is an Entity, duplicate the Entity from the class library and rename it to "Package_new".

Task I: *Model the explained system in Plant Simulation and document your approach in short words. Find a solution to solve the problem between the "CollectionFacility" and the "Drain". How many large parcels ("Package_new") are packed in 1:01:00.0000?*

Task II *(not related to the task above): Figure out the difference between the PlaceBuffer and the Buffer and document your result in short words (Hint: have a look into the Tecnomatix Plant Simulation Help).*

Task 03: AssemblySystem Discussed on: 07.11.2019

Create a new Frame “AssemblySystem” in a new data file.



The figure above shows the assembly problem by windows production. There is a production line for the window inside part (upper line) and another for the window frame (down line). For both of the production lines, there are two workstations. The produced windows inside parts and frames are placed into separate buffers, which are big enough (capacity of “Buffer_F”: 4, Capacity of “Buffer_G”: 10). There is only one type of window inside part and different types of window frames:

- Frame for window having 1 inside part
- Frame for window having 2 inside parts
- Frame for window having 4 inside parts

A finished frame is moved from “Buffer_F” to the assembly station “Assembly”. After the assembly, the frames leave the assembly station “Assembly” as a finished window and moves to the exit warehouse “Drain”. The generation time for “Source_frame” is 1 minutes 30 seconds (cyclical sequence), and 2 minute for “Source_glass”. In the table “Frame” there is the generation order of 3 different frame types. Only one frame of a type should be generated each time. The processing time for “G1”, “G2”, “F1”, “F2”, “Buffer_G” and “Buffer_F” as well as for the “Assembly” and the “Storage” is 1 minute. The “Drain” has a processing time of 0.

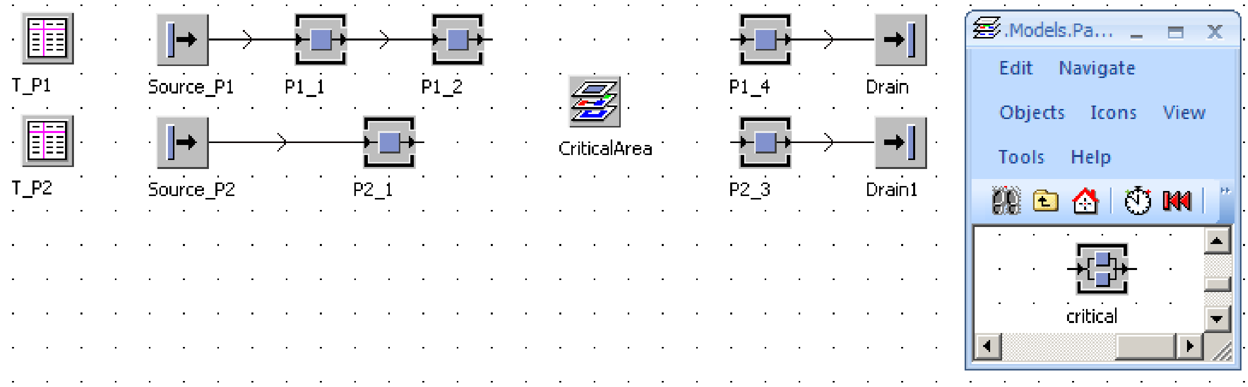
Notes:

1) Generate separate objects (Container) in the class library for each frame (“Frame_1”, “Frame_2” and “Frame_4”, duplicate an entity and rename it “Glass”. Remember to change the capacity of the Frames.
2) You can address to the assembly list of the assembly station “Assembly”, as an ordinary table with its columns and rows: <Object>.AssemblyList[x,y].

Task: Model the system in Plant Simulation and document your approach in short words. How many frames of each type are delivered to the exit warehouse “Drain” after seven days? How many frames of “Frame_1”, “Frame_2” and “Frame_4” enter the exit warehouse after one day?

Task 04: ParallelRunningProcesses Discussed on: 14.11.2019

Create a new Frame "ParallelRunningProcesses" in a new data file.



An important problem that comes up by programming concurrent processes is the mutual exclusion. Every process consists of a sequence of phases (operations), which are one after each other carried out. Two processes, "P1" and "P2" are parallel-running, their steps can be started independently from each other every time. Using the same resource during the critical step for both of the processes must be avoided; as a result one of the processes is suspended. In general, it is used a so called semaphore that organizes the mutual exclusion. The model has two processes:

P1 with 4 Process steps, "P1_1", "P1_2", "critical" (ParallelProc) and "P1_4"
P2 with 3 process steps, "P2_1", "critical" (ParallelProc) and "P2_3"

An individual process step is modeled as a work operation to be done on a machine. The process state for each job P1 and P2 is depicted. Job P1 is created by source "Source_P1" with an interval of 6:00.0000; job P2 with a time interval of 1 minute. The processing time in the critical step ("critical") is 3 minutes for P1 and 1:00 for P2. The processing times for the other stations ("P1_1", "P1_2", "P1_4" as well as "P2_1" and "P2_3") and the drains ("Drain" & "Drain1") is 1 minute.

The capacity of the element "critical" is 2x2.

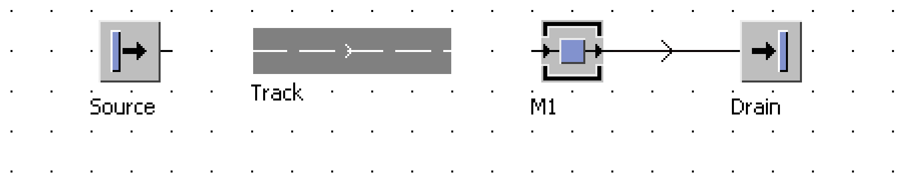
Remarks:

Please make sure that at one time only one MU is in the critical area. The model manages a closed queuing system that finishes after one hour. The process that reaches the critical section first, sets the semaphore. The following process is suspended. As soon as the process in the critical step leaves the resource, the waiting process is activated and enters into the critical step. It is also possible to model correctly without using the 2 tables "T_P1" and "T_P2". The entities that are produced by the sources Source_P1 and Source_P2 are called P1 and P2 respectively. Also don't forget that critical is inside a frame Called CriticalArea.

Exercise: Model the explained system in Plant Simulation and document your approach in short words. How many jobs of each type entered the critical area after 1 hour?

Task 05: TransportationSystem Discussed on: 14.11.2019

Create a new Frame with the name “TransportationSystem” in a new data file.



In the entrance warehouse “Source”, there are 10 jobs that should be processed by the machine “M1” and afterwards directly sent to the exit warehouse “Drain”. A transport robot (a vehicle), having the capacity of 1 at a time, carries the parts to the machine “M1”. For the transport to “M1”, it needs 4 times longer than for the way back. In other words the unloaded vehicle is 4 times faster than the loaded one. The speed of the loaded vehicle is 3.6 **km/h**. The processing time of “M1” is different for each job and 0 for the Source and Drain. The transport robot can deliver its load only if “M1” is not busy. In other case it must wait until “M1” is available to receive the parts, and then it can return (unloaded) to the loading point. After sending the processed job to exit warehouse “Drain”, “M1” remains empty until the next job arrives.

The Track is 6 meters long.

“M1” Processing time for each job:

Jobs	Processing Time
Job1	1:30
Job2	2:45
Job3	1:00
Job4	4:00
Job5	5:00
Job6	3:00
Job7	7:00
Job8	2:00
Job9	0:30
Job10	11:00

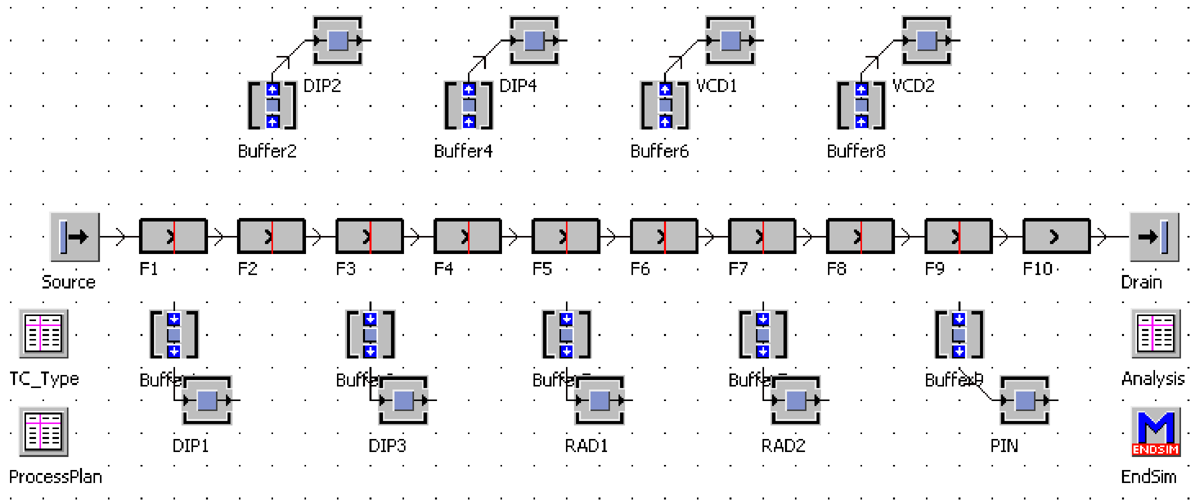
Remarks:

- The robot at initialization is located at the end of the Track (nearby M1).
- The robot waits before unloading until M1 is empty. As soon as the unloading is finished, the robot moves directly back to the Source.
- The Transporter should have the default length of 1.5 meters.

Exercise: Model the explained system in Plant Simulation and document your approach in short words. How long does it take to transport and process the 10 jobs?

This task consists of two pages!

Create a new Frame “FlexibleProductionLine” in a new data file.



The model represents a production system for the assembly of printed circuit boards in THT – Through gets Technology – today displaced by other techniques.

The printed circuit boards are plugged in special transportation containers “TC_Typ_X” (Container). They are created in the “Source”. The “Source” produces with a uniform distribution (0:30, 1:30) and selects the MUs (Container) randomly from the 4 types of containers (e. g.: TC_Typ_1).

A container carries always printed circuit boards of the same type and a container has a length of 600 millimeters. During the manufacturing process, the electronic elements bring automatically a bill of material on the printed circuit board. The connecting leads of the components are plugging, bending and cutting on the printed circuit board. The finished equipped printed circuit boards are finally sent to a warehouse “Drain” and from there to a soldering plant.

Among the electronic elements there are multiplicities of designs, which can be classified as follows:

Type	Description	Working time
RAD	The connecting leads are radial located on a circle (e. g. electrolytic capacitor)	3 min.
VCD	The connecting leads are axially arranged (e. g. resistance)	2 min.
DIP	In the circuits, the connecting leads are arranged along two facing edges (dual Inline Package, e. g. circuits)	2 min.
PIN	All special forms, also forms which possess only one connecting lead (e. g. measuring points)	1 min.

There is not universal automatic equipment that would be capable to process all designs. Rather it is needed a special machine for every of the specified basic forms. The represented production system consists of 9 machines: 4 DIP machines (“DIP1” to “DIP4”), 2 radial machines (“RAD1” and “RAD2”), 2 axial machines (“VCD1” and “VCD2”) and 1 machine for special elements (“PIN”).

All machines are connected by lines (“F1” to “F10”). Each transportation (line) section is 3 meters long and has in the middle a sensor. The transport system carries the containers with the printed circuit boards only in the following order:

Source → DIP1 → DIP2 → DIP3 →DIP4 →RAD1 →VCD1 →RAD2 →VCD2 →PIN →Drain

The structure corresponds approximately to a flow line. In contrast to a classical flow line, the containers can overhaul mutually. This is possible, because in front of each machine there is a buffer that can take maximum 2 containers (processing time: 1 minute). Only if the buffer is full, the upstream lines are blocked automatically if the capacity of the accumulating lines is utilized. After being processed the container is moved to the beginning of the next transportation line (e.g. from DIP3 to the beginning of F4).

The process plan data file (“04 process plan”) can be downloaded from ISIS, as well as the source text for the method “EndSim”. The simulation must run for 8 hours.

At the end of the simulation, you should full fill the table “Analysis” with the format shown as following:

	string 0	real 1	real 2	real 3	real 4	real 5	real 6	real 7	real 8	real 9
string		DIP1 %	DIP2 %	DIP3 %	DIP4 %	RAD1 %	RAD2 %	VCD1 %	VCD2 %	PIN %
1	Working									
2	Empty									
3	Blocked									

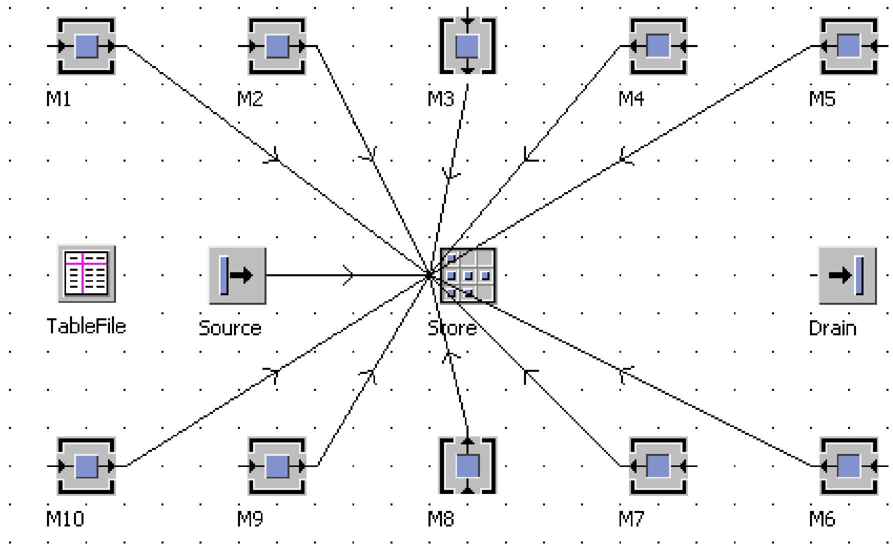
Table for the generation of containers in the source:

	object 1	real 2	string 3	table 4
string	MU	Frequencies	Name	Attributes
1	.MUs.TC_Ty	3.00	TC_Typ_1	
2	.MUs.TC_Ty	3.00	TC_Typ_2	
3	.MUs.TC_Ty	3.00	TC_Typ_3	
4	.MUs.TC_Ty	3.00	TC_Typ_4	
5				

Task: How many printed circuit boards are processed after 8 hours? Document your approach in short words. Explain in maximum 5 sentences the meaning of Frequencies in the Table for the generation of containers, and in which way this attribute affects your model.

Task 07: Workshop Discussed on: 28.11.2019

Create a new frame "Workshop" in a new data file.



The structure of this production system is comparable to a workshop: There is a collection of machines. Each job is different and requires a different production sequence. There is almost no restriction concerning the movement of the jobs between the stations, in other words, any job can be send from any machine to another in the workshop. The production processes in workshop are particularly complex and confusing when compared to flow shop.

Description:

This production system consists of 10 machines, named as "M1" to "M10". All jobs, from "1" to "10" are firstly in the entrance warehouse, "Source" and moved to the exit warehouse "Drain" in the end. Each job must be processed once on each machine. The production sequence and the processing time for each job are different and described in the included table. In order to avoid collisions as much as possible, the jobs are not moved directly from one machine to another, but stored in a buffer warehouse between two successive operations. The queuing type of the buffer allows the jobs to overtake each other.

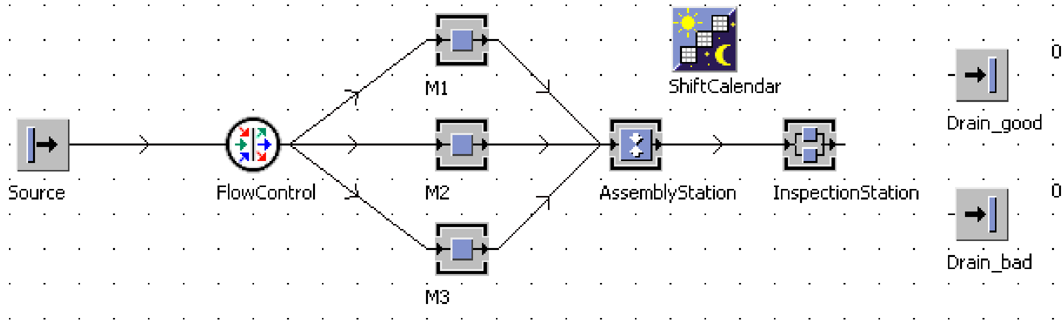
Remark:

- You will find additional data in the folder "Additional Material Task 7" (ISIS). Please import in the table "TableFile" the data file "05 Table" and "05 a" to "05 j".
- Source and Drain have a processing time of 0.
- The Store has a capacity of 3x3 and a cycle time of 1 minute.

Task: Model the system in Plant Simulation. Document your approach in short words. How long does it take until all MUs passed the "Drain"?

Task 08: **Branching** **Discussed on: 28.11.2019**

Create a new frame "Branching" in a new data file.



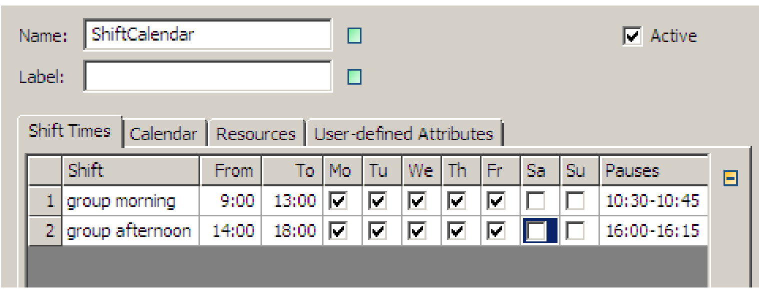
The figure above can suit to a small production system with an integrated quality control. The central operation is carried out by a machine group, which consists of three machines, "M1", "M2" and "M3".

Processing times of the machines:

- "M1": 1 min.
- "M2": 50 sec.
- "M3": 45 sec.

The "FlowControl" moves the parts to a free machine among the group. Then the parts are assembled in the "AssemblyStation", the main part is coming from "M2" and the result is a new MU called "FinalProduct". The subsequent "InspectionStation" can be considered a manual work station, in which two operators work. As a result, the capacity of this "InspectionStation" is 2. The processing time for the manual work is stochastic. The inspection time varies uniformly +/-20% from the set mean value of 1 minute (consider seed: 5). The assemblies are sorted as "good" and "bad"; afterwards they are sent to the corresponding warehouse, "Drain_good" or "Drain_ bad" (rejected). The possibility of rejecting an assembly is (uniformly) 10% (stream 3, seed: 10). The source produces the parts continuously according to a Poisson distribution (Lambda=5; Seed: 2).

The company works two shifts a day (Create therefore a "ShiftCalendar"): In the morning and in the afternoon. For the detailed shift see the following screenshot:



	Shift	From	To	Mo	Tu	We	Th	Fr	Sa	Su	Pauses
1	group morning	9:00	13:00	☑	☑	☑	☑	☑	☐	☐	10:30-10:45
2	group afternoon	14:00	18:00	☑	☑	☑	☑	☑	☐	☐	16:00-16:15

Run the simulation for 7 days.

Task: How many parts are sorted as "bad" after 7days? Document your approach in short words.