Manufacturing System Analysis Experiment

Basic Factory Dynamics(2)

1. Experiment Overview

- Title

Analysis of production system through simulation –ARENA Simulator

- Objective
  - Analyze the changes in various production system indicators (e.g., WIP, TH, CT) through simulation of a simple production system
  - Analyze the changes in indicators by product or station for the entire production
  - Analyze the 1) best case for the production system and 2) case with changes through simulation, and discuss of ways to improve the performance

2. Theoretical Background

- Basic terminology
  - Workstations: Collection of one or more machines or manual station that perform identical function
  - Part: A piece of raw material, a component, a subassembly or an assembly worked on at the workstation in a plant
  - Routing: The sequence of workstations passed through by a part
  - Capacity: An upper limit on the throughput of a production process
  - Throughput(TH): The average output of a production process per unit time
  - Work in process(WIP): The inventory between the start and end points of a product routing
  - Cycle Time(CT): The average time from release of a job at the beginning of the routing until it reaches an inventory point at the end of the routing
  - Utilization: The fraction of time workstation is not idle for lack of parts
  - Variability: Quality of non-uniformity of a class of entities

3. Experiment Design

YD plant's production system consists of 10 stations, and produces two products (A type & B type) simultaneously. Number of each station and its capacity is shown below, and each product does not have to go through every station.

<Table 1>		1	2	3	4	5	6	7	8	9	10
# of Machine (M/C)		8	4	2	1	12	5	2	3	1	15
M/C Capacity (min/job)	A	15	12	15		15	8	5			20
	B	15			2	12	2		5	2	20

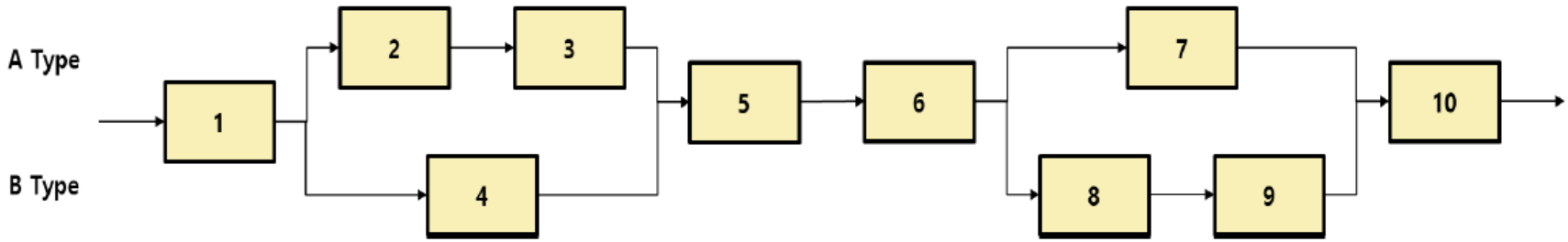
There exists the infinite buffer in front of each station. Through simulation, verify the Little's Law for both best case and case with changes for the production system.

1. Record TH, WIP, and CT for **the entire system**, and verify the Little's Law.
2. Record TH, WIP, and CT for **each product**, and verify the Little's Law.
3. Record TH, WIP, and CT for **one specific station**, and verify the Little's Law.

3. Experiment Design

The production system of the YD plant consists of 10 stations, and each product is produced through different routes as shown in the <Figure1>. We will collect the TH, WIP, CT values of each product and for each station.

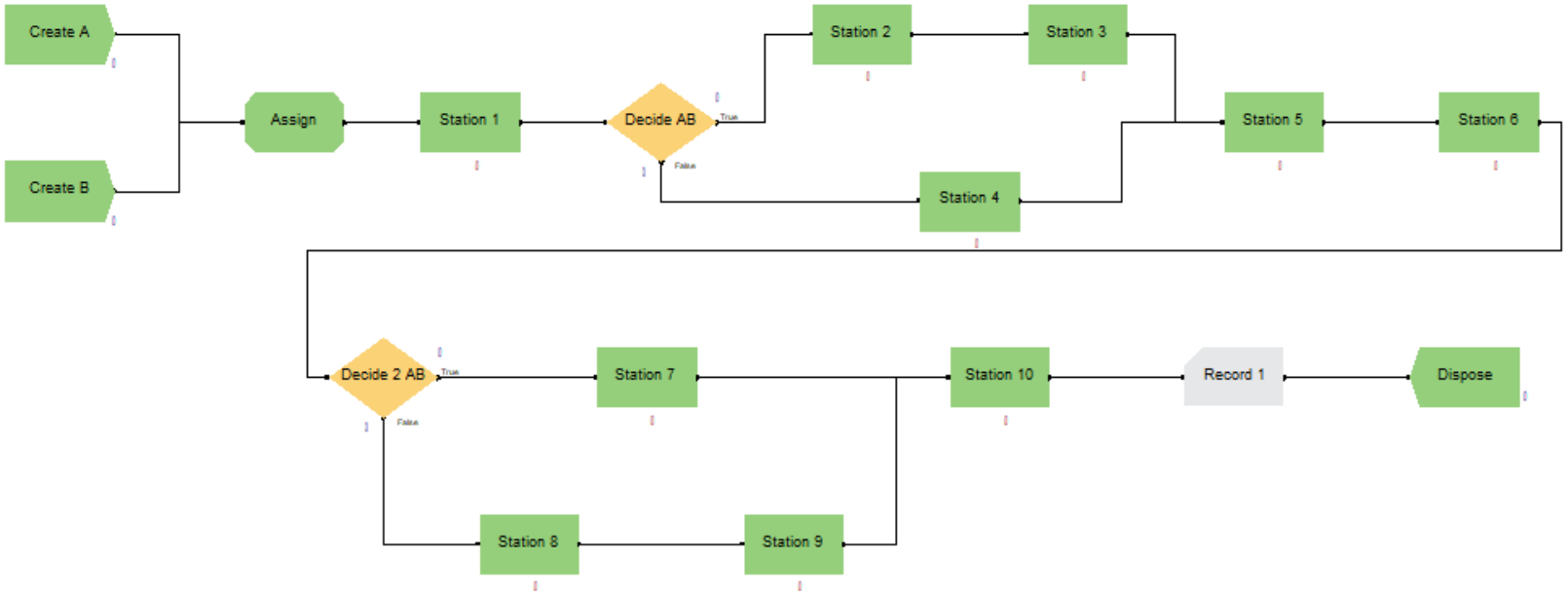
Simulation will run for 1000 minutes, and for the system stability and accuracy of the statistic values, we will have 100 minutes of warm-up time.



<Figure 1> Manufacturing System of YD factory

4. Experiment Procedure

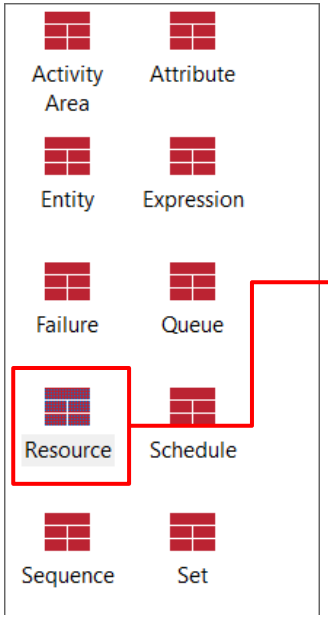
- Step 1-1. Create basic simulation model & resources
  - Basic simulation model is as the picture shown below
  - For production of 2 products, 2 Create modules, 2 Decide modules to classify the routes, and Assign module and Record module to record CT



4. Experiment Procedure

■ Step 1-1. Create basic simulation model & resources (cont.)

- Click the Resource icon from Basic Process Panel and add Resource by double clicking settings for each modules UI
- Set the Name (Station ID) and Capacity (# of Machine) for each Resource (=Machine) from the manufacturing system



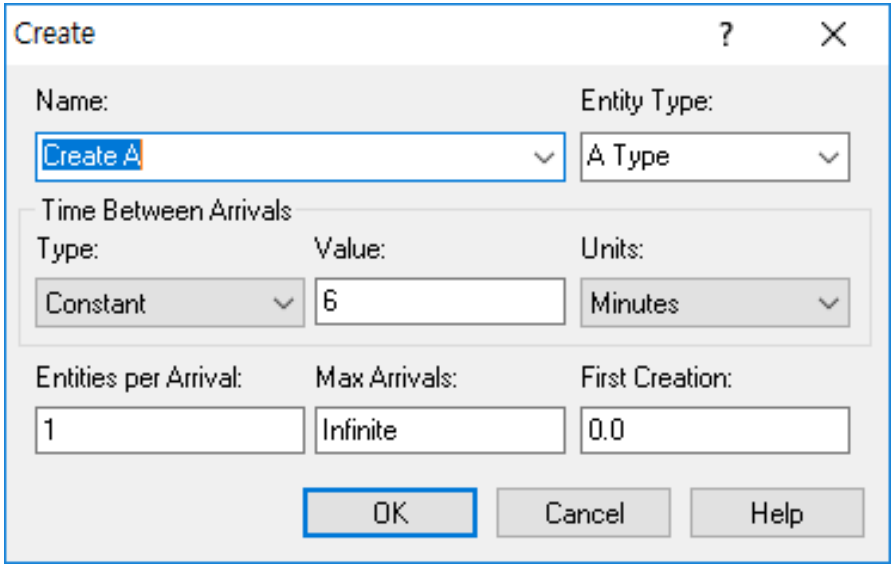
Resource - Basic Process

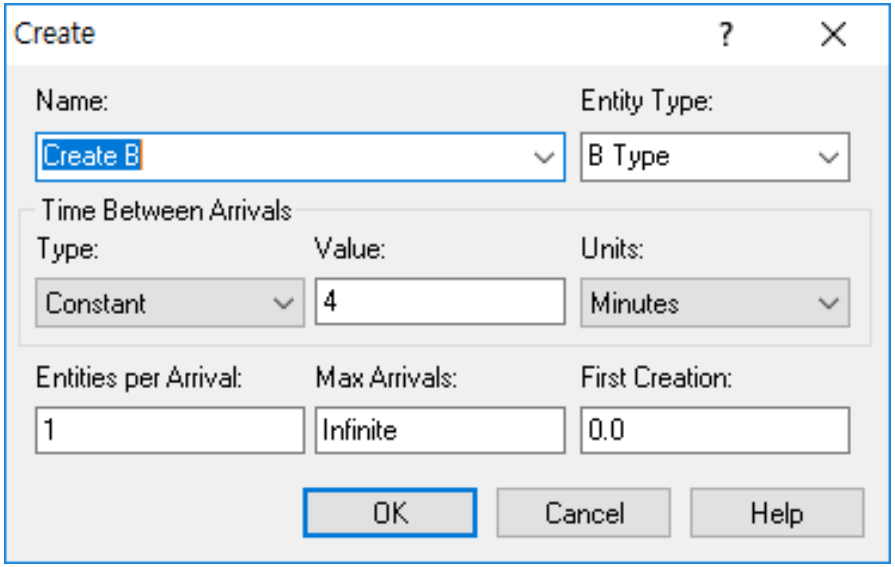
	Name	Type	Capacity	Busy / Hour	Idle / Hour	Per Use	StateSet Name	Failures	Report Statistics
1	MC1	Fixed Capacity	8	0.0	0.0	0.0		0 rows	☑
2	MC2	Fixed Capacity	4	0.0	0.0	0.0		0 rows	☑
3	MC3	Fixed Capacity	2	0.0	0.0	0.0		0 rows	☑
4	MC4	Fixed Capacity	1	0.0	0.0	0.0		0 rows	☑
5	MC5	Fixed Capacity	12	0.0	0.0	0.0		0 rows	☑
6	MC6	Fixed Capacity	5	0.0	0.0	0.0		0 rows	☑
7	MC7	Fixed Capacity	2	0.0	0.0	0.0		0 rows	☑
8	MC8	Fixed Capacity	3	0.0	0.0	0.0		0 rows	☑
9	MC9	Fixed Capacity	1	0.0	0.0	0.0		0 rows	☑
10	MC10	Fixed Capacity	15	0.0	0.0	0.0		0 rows	☑

※ Capacity data → Table 1 from Slide 4

4. Experiment Procedure

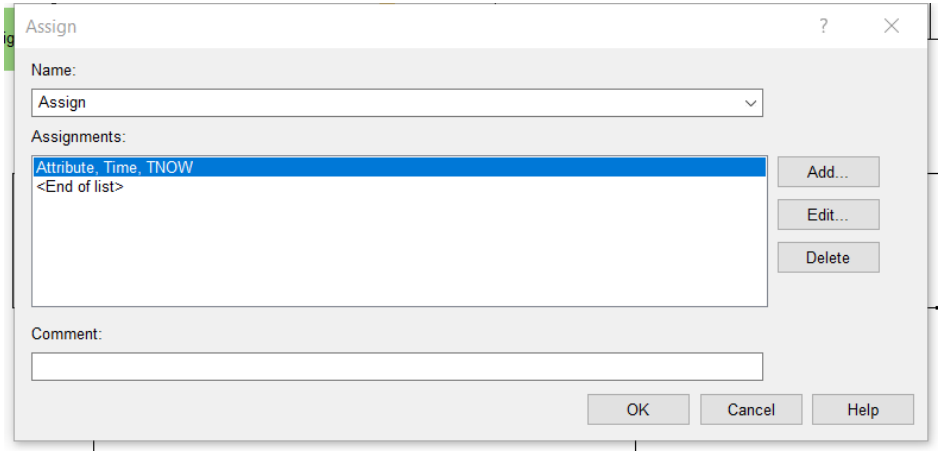
- Step 1-2. Create module (double click Create module)
  - Create module creates the entity going into the manufacturing system, and change the entity type for two different products (A type & B type)
  - Time Between Arrivals sets the input rate of the entity, leave the value as shown below since we will proceed the experiments by changing this value

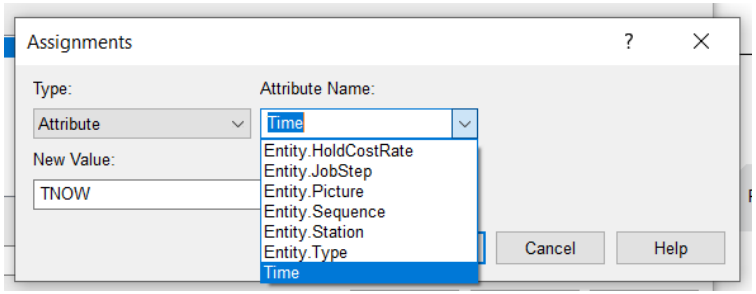




4. Experiment Procedure

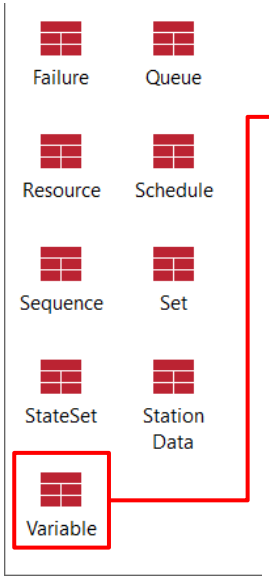
- Step 1-3. Assign Module (double click Assign module)
  - Use the Assign module to record the cycle time of the production system separately
  - Assign module records the time raw material enters the system (TNOW), and Record module records the time duration in the system before Dispose





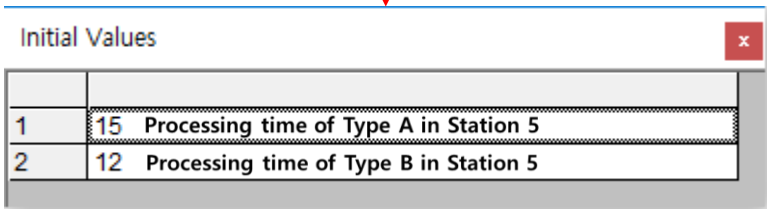
4. Experiment Procedure

- Step 1-4. Variable
  - For station 5 and station 6, processing time is different for each entity type
  - Define variables and use it for delay time in each Process module
  - Define 2 variables by clicking variable icon from Basic Process Panel and double-clicking settings for each module UI (Variable Name: **Capa5**, **Capa6**)



	Name	Rows	Columns	Data Type	Clear Option	File Name	Initial Values	Comment
1	Capa 5	2		Real	System		2 rows	
2	Capa 6	2		Real	System		2 rows	

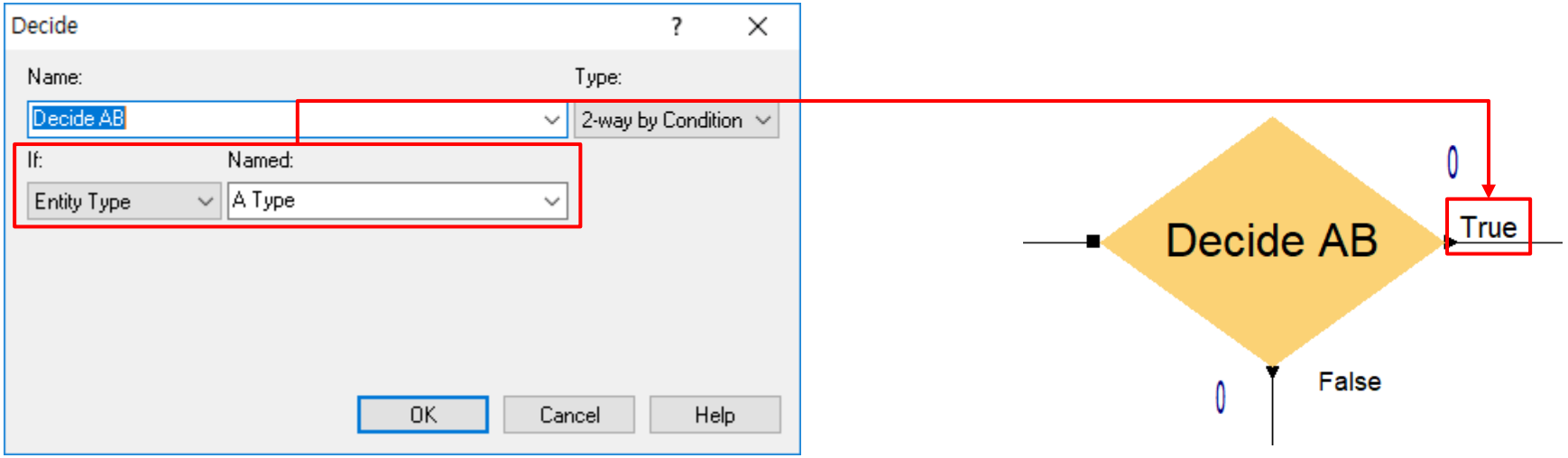
Double-click here to add a new row.



Workstation		5	6
# of Machine (M/C)		12	5
M/C Capacity (min/job)	A	15	8
	B	12	2

4. Experiment Procedure

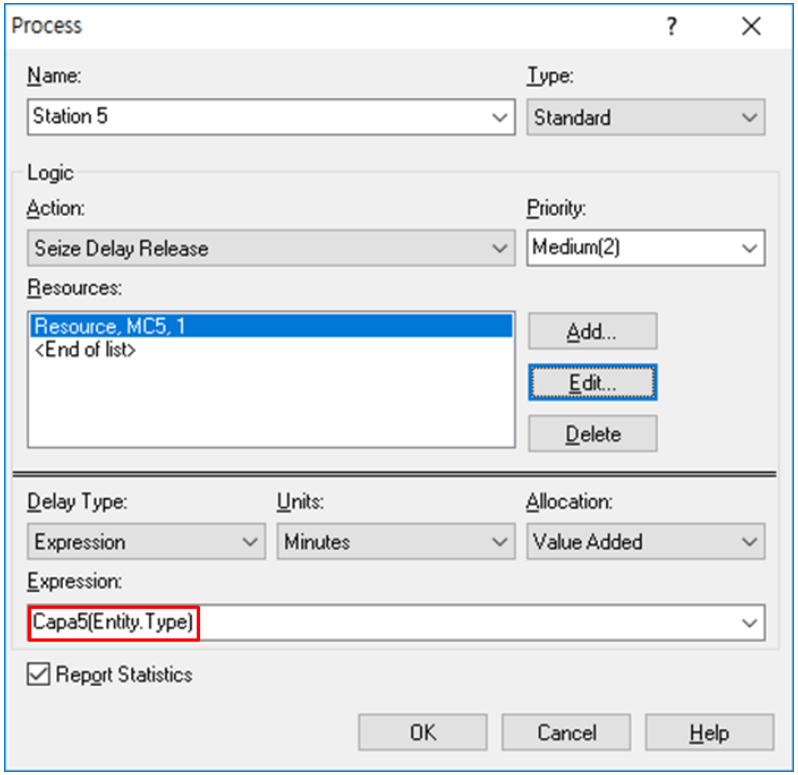
- Step 1-5. Decide Module (double click Decide module)
  - After job is finished at Station 1 and Station 6, use the Decide module to model production lines for each entity type
  - Entity satisfying the condition of Decide module flows to right (true), and entity not satisfying the condition flows to bottom (false)



4. Experiment Procedure

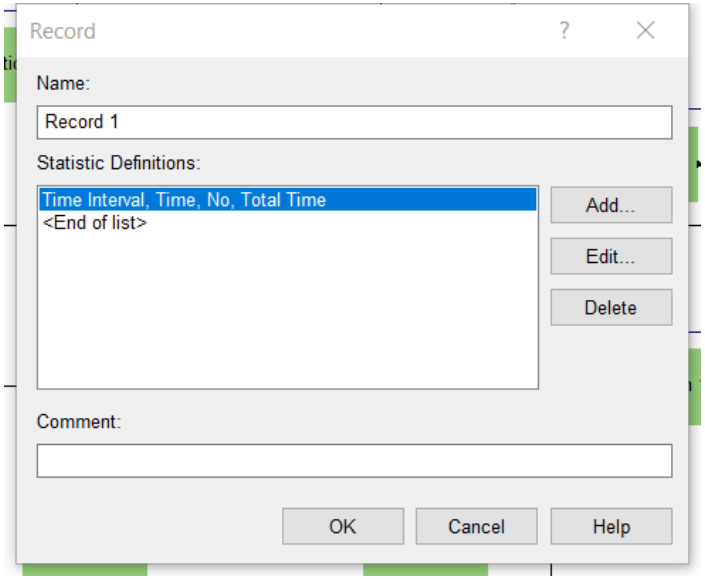
- Step 1-6. Process Module
  - Different processing time for each entity type needs to be applied at Station 5 and Station 6
  - Use the variable defined in Step 1-4, define the expression for Delay time (input: Entity.Type)
  - For the Case with variability, change the expression

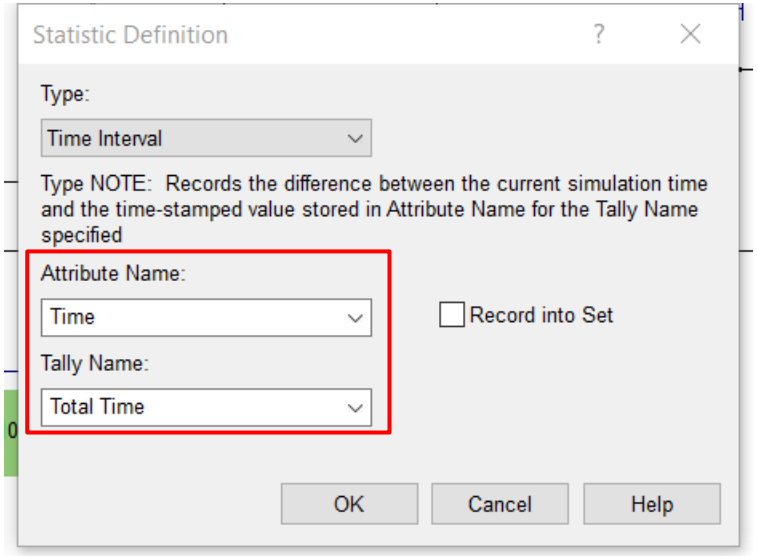
    (e.g., for exponential distribution, **EXPO(Capa5(Entity.Type))**)



4. Experiment Procedure

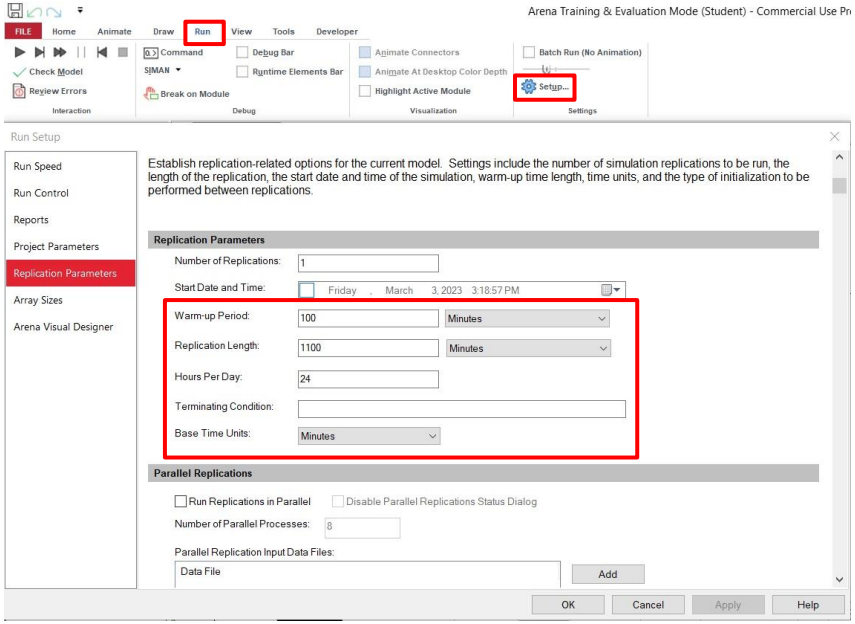
- Step 1-7. Record Module
  - Record module is to record the cycle time for the entire production system
  - Based on the TNOW recorded in Assign module, time duration in the system (how long an entity stayed in the system) for each entity type is recorded
  - User Specified in the report shows the Total time





4. Experiment Procedure

- Step 1-8. Run Setup
  - 100 minutes of warm-up time (for system stabilization), actual experiment 1000 minutes, total of 1100 minutes (Run Tab → Setup → Replication parameters)
  - For future experiments, change the Input rate in Create module to verify the Little's law (Lab report)



4. Experiment Procedure

- Notes for additional analysis for the lab report
  - Experiment 1: analyze by changing the Time Between Arrival for whole production system

    -- Variability(exponential distribution) for M/C 5 and M/C 6 are considered simultaneously

    (Case 1): Type A → 6min/job, Type B → 4min/job)

    (Case 2): Type A → 9min/job, Type B → 3min/job)
  - Experiment 2: analyze case 1 from experiment 1 for each product

    -- Variability for M/C 5 and M/C 6 are considered simultaneously
  - Experiment 3: analyze case 1 from experiment 1 for each station

    -- Variability for M/C 5 and M/C 6 are considered respectively
  - Exponential distribution is considered for all experiments (explained in Step 1-6)

Q & A