

# Manufacturing System Analysis Experiment

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Push and Pull

# 1. Experiment Overview

- Title

**Comparing PUSH and PULL system in production system**

- Objective

- Understand the concept of PUSH and PULL system
- Measure and compare the order waiting time, CT, WIP for each system

## 2. Theoretical Background

- Basic Terminology
  - PUSH systems schedule work releases based on demand, and PULL systems authorize work releases based on system status.
  - In PUSH systems, a job is entered into the production process when it is required by the work releases. The timing of input does not change depending on the process.
  - In PULL systems, a job is allowed to enter into the shop floor only when a signal indicates that the changes in a production line occurs. The signal shows if a certain job is finished in a production line like Kanban.

# 3. Experiment Design

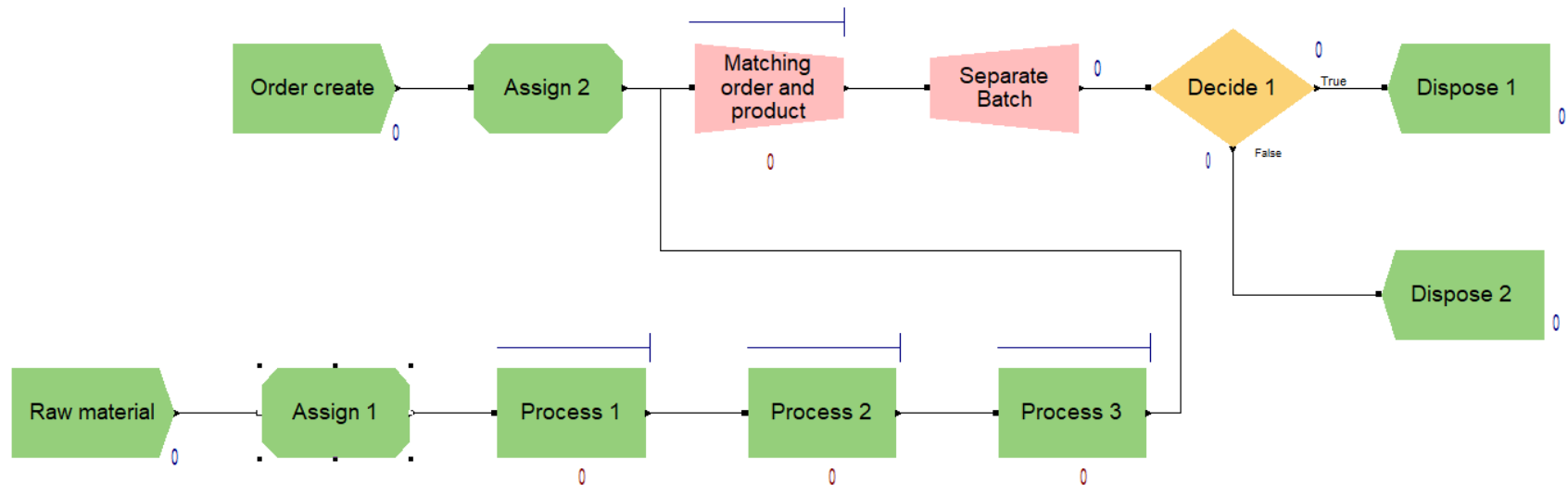
Yonsei Co. has a production line with 3 stations, and each machine processes one product at a time. Information of each station is given below.

<Table 1>	Workstation 1	Workstation 2	Workstation 3
# of Machine (Resource Capacity)	1	1	1
Processing Time	EXPO(4) min/job	EXPO(3) min/job	EXPO(4) min/job

Simulation runs for 1000 minutes, and for system stabilization and statistic accuracy, set warm-up time as 100 minutes.

## 4. Experiment Procedure (1: push case)

- **Step 1-1. Creating a simulation model and resources setting**
  - Basic simulation model is as the picture shown below
  - Modules used: 2 Create, 3 Process, 2 Assign, 1 Batch, 1 Separate, 1 Decide, 2 Dispose



# 4. Experiment Procedure

## (1: push case)

- **Step 1-1. Creating a simulation model and resources setting**
  - Click the resource icon in the Basic Process Panel, and ass resource by double-clicking Module Settings UI.
  - Set up name and capacity (station ID and #of machine) of each resource (machine).

Activity Area

Attribute

Entity

Expression

Failure

Queue

Resource

Schedule

Sequence

Set

StateSet

Station Data

Variable

	Name	Type	Capacity	Busy / Hour	Idle / Hour	Per Use	StateSet Name	Failures	Report Statistics	Comment
1 ▶	Resource 1	Fixed Capacity	1	0.0	0.0	0.0		0 rows	<input checked="" type="checkbox"/>	
2	Resource 2	Fixed Capacity	1	0.0	0.0	0.0		0 rows	<input checked="" type="checkbox"/>	
3	Resource 3	Fixed Capacity	1	0.0	0.0	0.0		0 rows	<input checked="" type="checkbox"/>	

## 4. Experiment Procedure (1: push case)

### ■ Step 1-2. Create module settings (Double-click Create module)

- Create module creates the entity going into the production system, and Yonsei Co. has two different kinds of entity: raw material and order.
- Time Between Arrivals sets the input rate of entity, and the values will be changed for the further experiments. (1st Create: Raw material, 2nd Create: Order release)

The screenshot shows the 'Create' dialog box with the following settings:

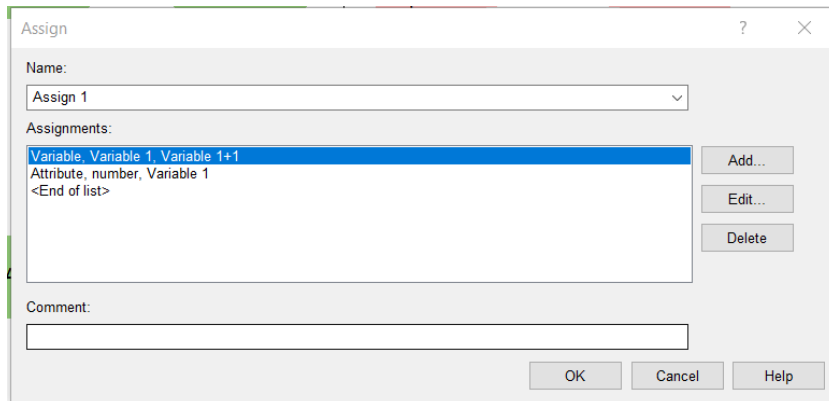
- Name: Raw material
- Entity Type: product (highlighted with a red box)
- Time Between Arrivals:
  - Type: Constant
  - Value: 5
  - Units: Minutes
- Entities per Arrival: 1
- Max Arrivals: Infinite
- First Creation: 0.0
- Comment: (empty text box)
- Buttons: OK, Cancel, Help

The screenshot shows the 'Create' dialog box with the following settings:

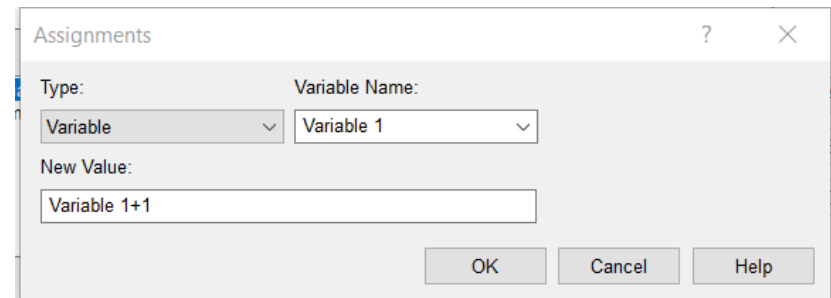
- Name: Order create
- Entity Type: order (highlighted with a red box)
- Time Between Arrivals:
  - Type: Random (Expo)
  - Value: 5
  - Units: Minutes
- Entities per Arrival: 1
- Max Arrivals: Infinite
- First Creation: 0.0
- Comment: (empty text box)
- Buttons: OK, Cancel, Help

## 4. Experiment Procedure (1: push case)

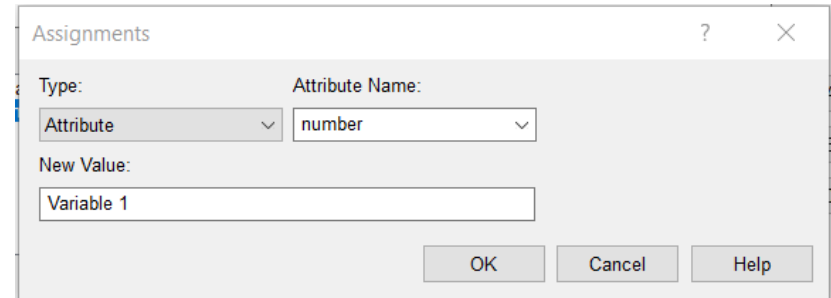
- **Step 1-3. Assign module settings (Double-click Assign module)**
  - Place Assign modules for raw material Create module and order Create module
  - For raw material Assign module, define and add one variable and one attribute.
  - Remember that this is the process to match the order number and the product number.



The 'Assign' dialog box is shown. It has a title bar with a question mark and a close button. The 'Name' field contains 'Assign 1'. Below it, the 'Assignments' list contains 'Variable, Variable 1, Variable 1+1', 'Attribute, number, Variable 1', and '<End of list>'. To the right of the list are 'Add...', 'Edit...', and 'Delete' buttons. At the bottom, there is a 'Comment' text area and 'OK', 'Cancel', and 'Help' buttons.



The 'Assignments' dialog box is shown. It has a title bar with a question mark and a close button. The 'Type' dropdown is set to 'Variable' and the 'Variable Name' dropdown is set to 'Variable 1'. The 'New Value' text field contains 'Variable 1+1'. At the bottom right are 'OK', 'Cancel', and 'Help' buttons.



The 'Assignments' dialog box is shown. It has a title bar with a question mark and a close button. The 'Type' dropdown is set to 'Attribute' and the 'Attribute Name' dropdown is set to 'number'. The 'New Value' text field contains 'Variable 1'. At the bottom right are 'OK', 'Cancel', and 'Help' buttons.



## 4. Experiment Procedure (1: push case)

- **Step 1-3. Assign module settings (Double-click Assign module)**
  - For order Assign module, define and add one variable and one attribute.

Assign

Name: Assign 2

Assignments:

- Variable, Variable 2, Variable 2+1
- Attribute, number, Variable 2
- <End of list>

Add... Edit... Delete

Comment:

OK Cancel Help

Assignments

Type: Variable Variable Name: Variable 2

New Value: Variable 2+1

OK Cancel Help

Assignments

Type: Attribute Attribute Name: number

New Value: Variable 2

OK Cancel Help

## 4. Experiment Procedure (1: push case)

- **Step 1-4. Process module settings (Double-click Process module)**
  - Define 3 processes, and details are shown below.

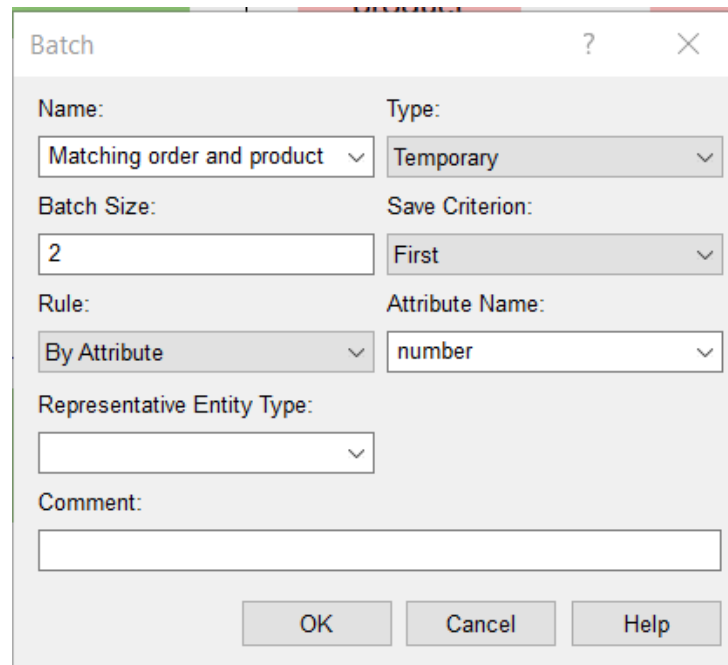
The image displays three screenshots of the 'Process' dialog box, showing the configuration for three different processes. Each dialog box has the following fields:

- Name:** Process 1, Process 2, and Process 3.
- Type:** Standard.
- Logic:**
  - Action:** Seize Delay Release.
  - Priority:** Medium(2).
- Resources:**
  - Resource 1, 1 (Process 1)
  - Resource 2, 1 (Process 2)
  - Resource 3, 1 (Process 3)
- Delay Type:** Expression.
- Units:** Minutes.
- Allocation:** Value Added.
- Expression:** EXPO( 4 ) (Process 1), EXPO( 3 ) (Process 2), and EXPO( 4 ) (Process 3). These fields are highlighted with red boxes.
- Report Statistics:** Checked.
- Comment:** (Empty text box).

At the bottom of each dialog are buttons for OK, Cancel, and Help.

## 4. Experiment Procedure (1: push case)

- **Step 1-5. Batch module settings (Double-click Batch module)**
  - Set up Batch module as shown below, Batch size is 2.
  - When order comes in, it matches a manufactured product at that moment to the order number and leaves the system as a batch of a order and a product.



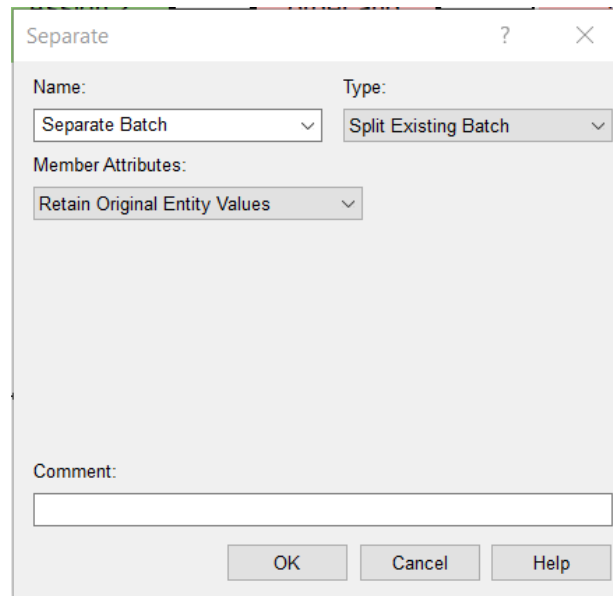
The screenshot shows a 'Batch' dialog box with the following settings:

Field	Value
Name:	Matching order and product
Type:	Temporary
Batch Size:	2
Save Criterion:	First
Rule:	By Attribute
Attribute Name:	number
Representative Entity Type:	
Comment:	

Buttons: OK, Cancel, Help

## 4. Experiment Procedure (1: push case)

- **Step 1-6. Separate module settings (Double-click Separate module)**
  - Separate module splits an order and a product which are batched together from the Batch module.
  - It is a technical step to calculate the number of the order and products, and settings are shown below.



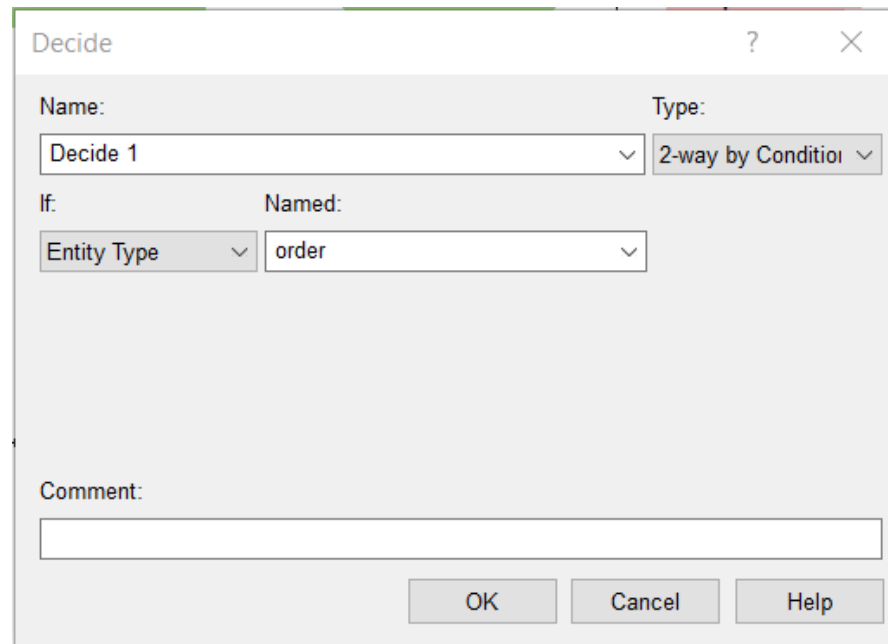
The screenshot shows a 'Separate' dialog box with the following settings:

- Name:** Separate Batch
- Type:** Split Existing Batch
- Member Attributes:** Retain Original Entity Values
- Comment:** (empty text box)

Buttons at the bottom: OK, Cancel, Help.

## 4. Experiment Procedure (1: push case)

- **Step 1-7. Decide module settings (Double-click Decide module)**
  - Decide module divides the order entity and product entity
  - As a result, order waiting time, product cycle time, system WIP information will be shown in the report for each entity



The screenshot shows a 'Decide' dialog box with the following fields and options:

- Name:** A dropdown menu showing 'Decide 1'.
- Type:** A dropdown menu showing '2-way by Condition'.
- If:** A dropdown menu showing 'Entity Type'.
- Named:** A dropdown menu showing 'order'.
- Comment:** An empty text input field.
- Buttons:** 'OK', 'Cancel', and 'Help' buttons at the bottom right.

## 4. Experiment Procedure (1: push case)

### ■ Step 1-8. Run Setup

- 100 minutes of Warm-up Period for system stabilization, 1000 minutes of actual simulation time, total of 1100 minutes of the run time. (Run Tab → Setup → Replication parameters)

Run Setup

Establish replication-related options for the current model. Settings include the number of simulation replications to be run, the length of the replication, the start date and time of the simulation, warm-up time length, time units, and the type of initialization to be performed between replications.

**Replication Parameters**

Number of Replications: 1

Start Date and Time: ☐ Saturday, June 10, 2023 5:43:49 PM

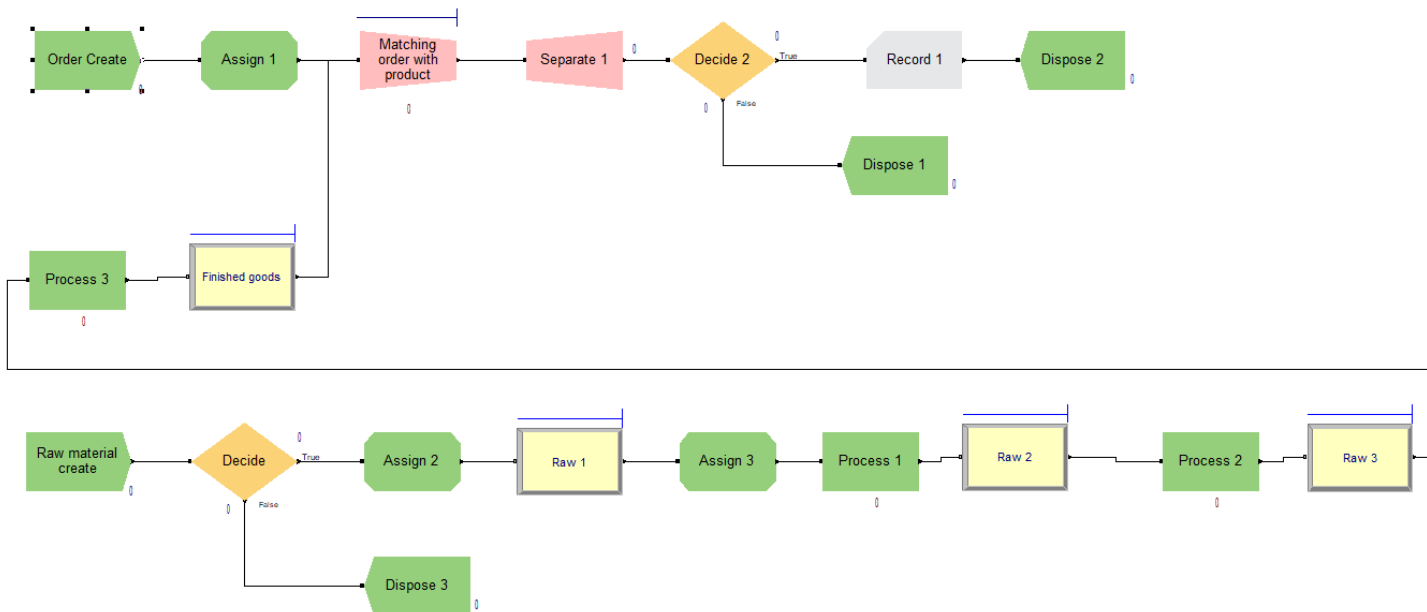
Warm-up Period: 100 Minutes

Replication Length: 1100 Minutes

Hours Per Day: 24

## 4. Experiment Procedure (2: pull case)

- **Step 2-1. Creating a simulation model and resources setting**
  - Basic simulation model is as the picture shown below (Raw 1~3 & Finished goods module = Hold module)
  - The system is divided into two parts where **generating an order** and **actual production**.



## 4. Experiment Procedure (2: pull case)

- **Step 2-2. Create module settings (Double-click Create module)**
  - Create module has a setting similar to the PUSH case.
  - Time between arrivals of the raw material is changed to 1 minute.  
(1st Create: Order release, 2nd Create: Raw material create)

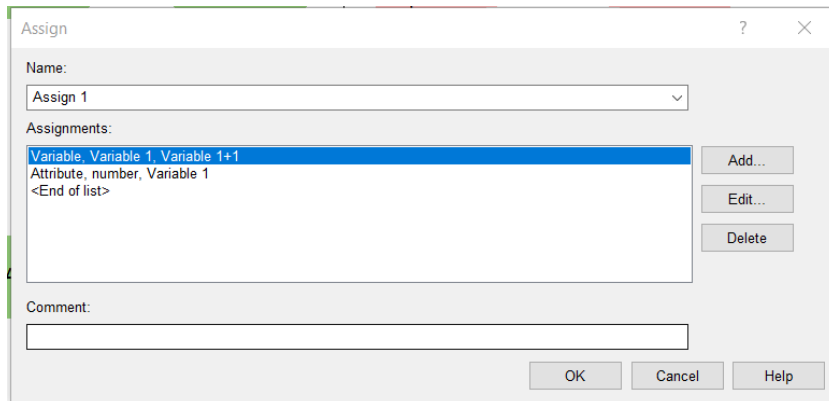
The screenshot shows the 'Create' dialog box for the 'Order Create' module. The 'Name' field is set to 'Order Create' and the 'Entity Type' is 'order'. Under 'Time Between Arrivals', the 'Type' is 'Random (Expo)', the 'Value' is '5' (highlighted with a red box), and the 'Units' are 'Minutes'. The 'Entities per Arrival' is '1', 'Max Arrivals' is 'Infinite', and 'First Creation' is '0.0'. There is a 'Comment' field at the bottom and 'OK', 'Cancel', and 'Help' buttons.

The screenshot shows the 'Create' dialog box for the 'Raw material create' module. The 'Name' field is set to 'Raw material create' and the 'Entity Type' is 'Raw material'. Under 'Time Between Arrivals', the 'Type' is 'Constant', the 'Value' is '1' (highlighted with a red box), and the 'Units' are 'Minutes'. The 'Entities per Arrival' is '1', 'Max Arrivals' is 'Infinite', and 'First Creation' is '0.0'. There is a 'Comment' field at the bottom and 'OK', 'Cancel', and 'Help' buttons.

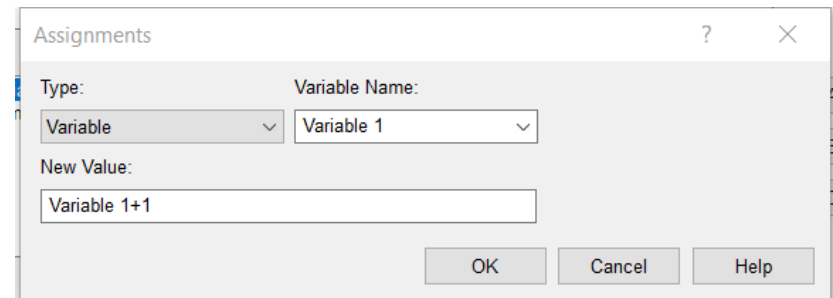


## 4. Experiment Procedure (2: pull case)

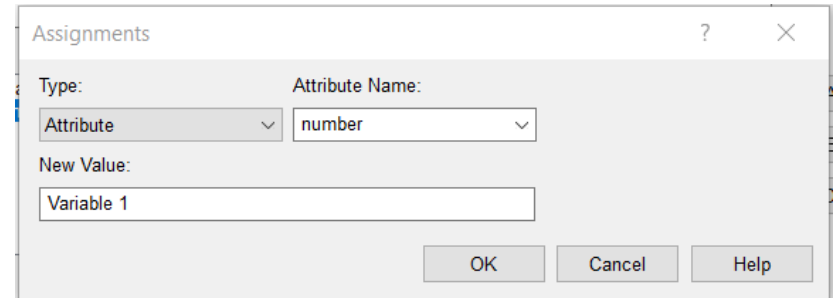
- **Step 2-3. Assign module settings for order**
  - Assign the attribute “number” to the order entity.
  - Once again! Remember that this is the process to match the order number and the product number.



The 'Assign' dialog box is shown. It has a title bar with a question mark and a close button. The 'Name' field contains 'Assign 1'. Below it, the 'Assignments' list contains 'Variable, Variable 1, Variable 1+1', 'Attribute, number, Variable 1', and '<End of list>'. To the right of the list are 'Add...', 'Edit...', and 'Delete' buttons. At the bottom, there is a 'Comment' text area and 'OK', 'Cancel', and 'Help' buttons.



The 'Assignments' dialog box is shown. It has a title bar with a question mark and a close button. The 'Type' dropdown is set to 'Variable' and the 'Variable Name' dropdown is set to 'Variable 1'. The 'New Value' text field contains 'Variable 1+1'. At the bottom right are 'OK', 'Cancel', and 'Help' buttons.



The 'Assignments' dialog box is shown. It has a title bar with a question mark and a close button. The 'Type' dropdown is set to 'Attribute' and the 'Attribute Name' dropdown is set to 'number'. The 'New Value' text field contains 'Variable 1'. At the bottom right are 'OK', 'Cancel', and 'Help' buttons.

## 4. Experiment Procedure (2: pull case)

- **Step 2-4. Decide module settings (process of actual PULL production)**
  - Arena is time-based simulation which cannot produce an entity with signal or specific condition, so modeling of the PULL system is implemented in front of the actual production.
  - Raw material entity is moving to the buffer in front of the first process, assume that first buffer(Raw 1) to arrive can only have **less than 30 of the raw material**.
  - Type in the constraint for Raw 1.Queue in Decide module.
  - Buffer in front of each process will be presented using Hold module (advanced process).

The screenshot shows the 'Decide' module configuration window. The 'Name' field is set to 'Decide' and the 'Type' is '2-way by Condition'. Under the 'If:' section, the 'Expression' field contains the text 'NQ(Raw 1.Queue)<30'. There is a 'Value:' field which is currently empty. At the bottom, there is a 'Comment:' field and three buttons: 'OK', 'Cancel', and 'Help'.

## 4. Experiment Procedure (2: pull case)

### ■ Step 2-5. Assign module settings for raw material

- If queue of Raw 1 is less than 30, raw material entity is assigned with the attribute value.
- Variable and attribute is defined and added to Assign 2 module just like Assign 1 module.

Assign

Name: Assign 2

Assignments:

- Variable, Variable 2, Variable 2+1
- Attribute, number, Variable 2
- <End of list>

Buttons: Add..., Edit..., Delete

Comment:

Buttons: OK, Cancel, Help

Assignments

Type: Variable Variable Name: Variable 2

New Value: Variable 2+1

Buttons: OK, Cancel, Help

Assignments

Type: Attribute Attribute Name: number

New Value: Variable 2

Buttons: OK, Cancel, Help

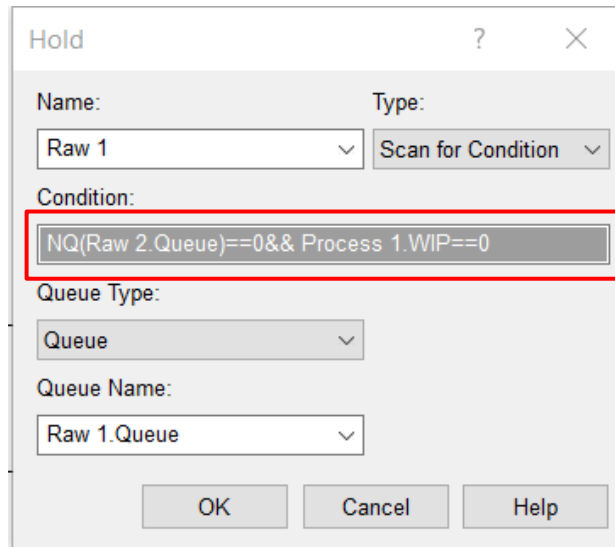
## 4. Experiment Procedure (2: pull case)

### ■ Step 2-6. Hold module settings

- Buffer of each station is represented with the **Hold** module.

→ Due to the nature of the PULL production to transfer the entity in the buffer by the certain condition or the signal.

→ Hold module is set up as shown below, and proceed with this process when process 1 is idle and buffer(Raw 2) in front of the next process does not have any entity waiting.



Hold

Name: Raw 1 Type: Scan for Condition

Condition: NQ(Raw 2.Queue)==0&& Process 1.WIP==0

Queue Type: Queue

Queue Name: Raw 1.Queue

OK Cancel Help

## 4. Experiment Procedure (2: pull case)

- **Step 2-7. Assign module settings (Raw material → Product)**
  - Through Step 2-6 set up for the PULL system, CT and WIP of the actual production system needs to be measured from this point.
  - Using the settings shown below to replace the entity from the raw material to product, and assign TNOW value to measure the actual production time.

Assign

Name: Assign 3

Assignments:

- Entity Type, product
- Attribute, Product Time, TNOW
- <End of list>

Add... Edit... Delete

Comment:

OK Cancel Help

Assignments

Type: Entity Type Entity Type: product

OK Cancel Help

Assignments

Type: Attribute Attribute Name: Product Time

New Value: TNOW

OK Cancel Help

## 4. Experiment Procedure (2: pull case)

- **Step 2-8. Process module settings**
  - Define 3 Process, and use simply Delay as action.

Process

Name: Process 1 Type: Standard

Logic:  
Action: Delay

Delay Type: Expression Units: Minutes Allocation: Value Added

Expression: EXPO( 4 )

☒ Report Statistics

Comment:

OK Cancel Help

Process

Name: Process 2 Type: Standard

Logic:  
Action: Delay

Delay Type: Expression Units: Minutes Allocation: Value Added

Expression: EXPO( 3 )

☒ Report Statistics

Comment:

OK Cancel Help

Process

Name: Process 3 Type: Standard

Logic:  
Action: Delay

Delay Type: Expression Units: Minutes Allocation: Value Added

Expression: EXPO( 4 )

☒ Report Statistics

Comment:

OK Cancel Help

## 4. Experiment Procedure (2: pull case)

### ■ Step 2-9. Hold module settings

- After Process 1, entity waits at Raw 2, and move on when process 2 is idle and buffer(Raw 3) in front of the next process is empty.
- After Process 2, entity waits at Raw 3, and move on when process 3 is idle and inventory of the finished product is less than or equal to 5.
- Completed entity waits at the Hold module “Finished goods” for an order, and it is processed when an order entity arrives at the Batch module.

Hold

Name: Raw 2 Type: Scan for Condition

Condition: NQ(Raw 3.Queue)==0&& Process 2.WIP==0

Queue Type: Queue

Queue Name: Raw 2.Queue

OK Cancel Help

Hold

Name: Raw 3 Type: Scan for Condition

Condition: Process 2.WIP==0&& NQ(Finished goods.Queue)<=5

Queue Type: Queue

Queue Name: Raw 3.Queue

OK Cancel Help

Hold

Name: Finished goods Type: Scan for Condition

Condition: NQ(Matching order with product.Queue)>=1

Queue Type: Queue

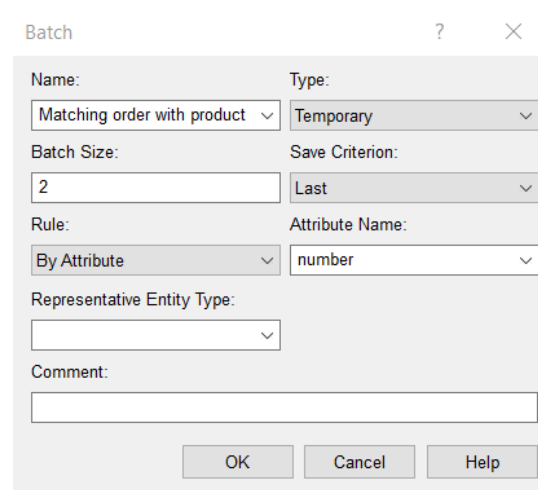
Queue Name: Finished goods.Queue

OK Cancel Help

## 4. Experiment Procedure (2: pull case)

### ■ Step 2-10. Batch module settings

- Order with an attribute assigned is sent to the Batch module, and it is processed right away if there is a finished product, otherwise it waits at Batch module's queue for a product to be finished.
- Batch module is set up as shown below, and Batch size is 2.
- It is to match a produced good with its order number at the moment of the order, and an order and a product is bundled into one batch.



The screenshot shows a dialog box titled "Batch" with a question mark icon and a close button (X). The dialog contains the following fields and options:

- Name:** A dropdown menu with "Matching order with product" selected.
- Type:** A dropdown menu with "Temporary" selected.
- Batch Size:** A text input field containing the number "2".
- Save Criterion:** A dropdown menu with "Last" selected.
- Rule:** A dropdown menu with "By Attribute" selected.
- Attribute Name:** A dropdown menu with "number" selected.
- Representative Entity Type:** A dropdown menu that is currently empty.
- Comment:** A text input field that is currently empty.

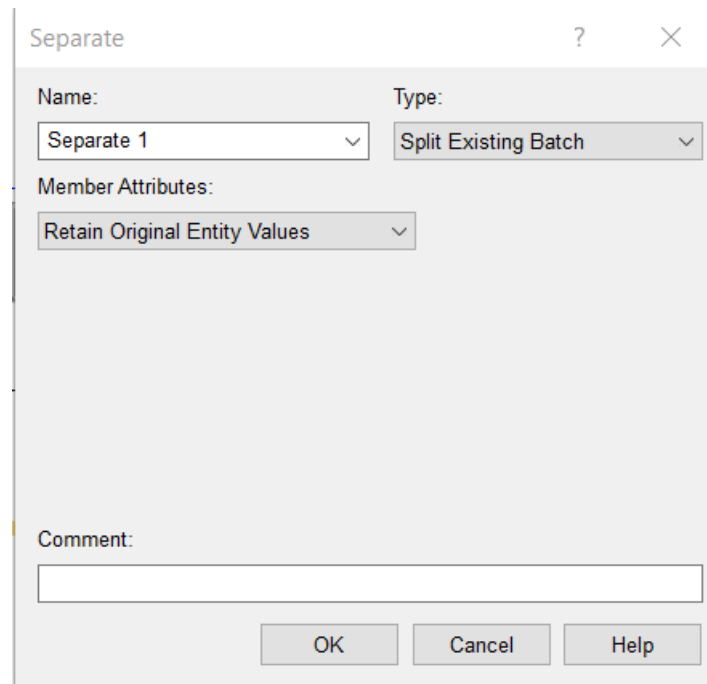
At the bottom of the dialog are three buttons: "OK", "Cancel", and "Help".



## 4. Experiment Procedure (2: pull case)

### ■ Step 2-11. Separate module settings

- Separate module separates the bundle of an order and a product formed in Batch module.
- It is a technical step to calculate the number of the order and products, and settings are shown below.



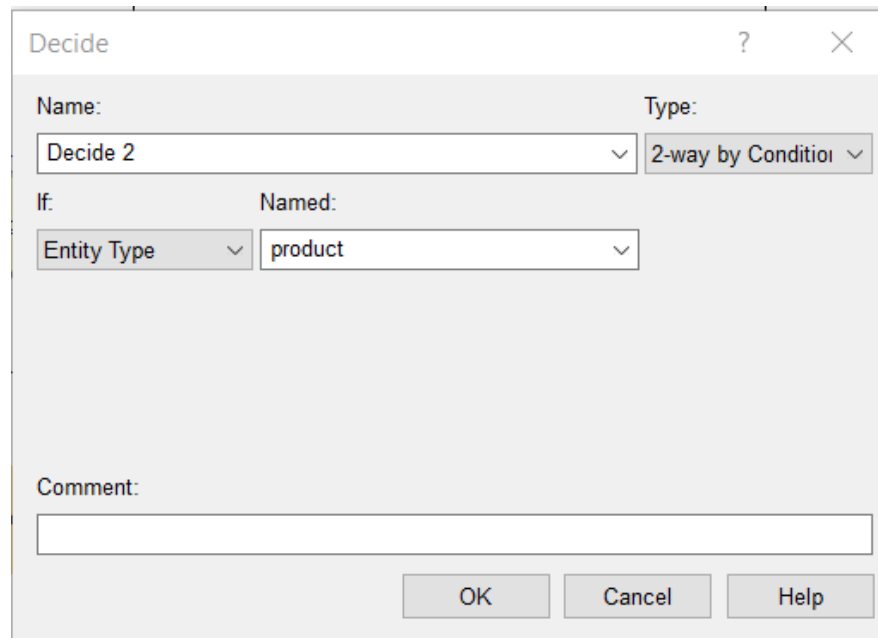
The screenshot shows a dialog box titled "Separate" with a question mark icon and a close button (X). The dialog contains the following fields:

- Name:** A dropdown menu with "Separate 1" selected.
- Type:** A dropdown menu with "Split Existing Batch" selected.
- Member Attributes:** A dropdown menu with "Retain Original Entity Values" selected.
- Comment:** A text input field.

At the bottom of the dialog are three buttons: "OK", "Cancel", and "Help".

## 4. Experiment Procedure (2: pull case)

- **Step 2-12. Decide module settings**
  - To measure the CT of a product from inputting into the actual production until order is processed, use the Decide module to separate the entity with entity type as product.



The screenshot shows a 'Decide' dialog box with the following fields and options:

- Name:** A dropdown menu with 'Decide 2' selected.
- Type:** A dropdown menu with '2-way by Condition' selected.
- If:** A dropdown menu with 'Entity Type' selected.
- Named:** A dropdown menu with 'product' selected.
- Comment:** An empty text input field.
- Buttons:** 'OK', 'Cancel', and 'Help' buttons at the bottom right.

## 4. Experiment Procedure (2: pull case)

### ■ Step 2-13. Record module settings

- TNOW for each entity assigned before passing Process 1 is used to calculate the Time interval and record the Total product time.
- Entity finished with recording time is disposed.

**Record**

Name: Record 1

Statistic Definitions:

- Time Interval, Product Time, No, Total product time
- <End of list>

Buttons: Add..., Edit..., Delete

Comment:

Buttons: OK, Cancel, Help

**Statistic Definition**

Type: Time Interval

Type NOTE: Records the difference between the current simulation time and the time-stamped value stored in Attribute Name for the Tally Name specified

Attribute Name: Product Time

Tally Name: Total product time

☐ Record into Set

Buttons: OK, Cancel, Help

## 4. Experiment Procedure (2: pull case)

### ■ Step 2-14. Run Setup

- 100 minutes of Warm-up Period for system stabilization, 1000 minutes of actual simulation time, total of 1100 minutes of the run time. (Run Tab → Setup → Replication parameters)

Run Setup

Establish replication-related options for the current model. Settings include the number of simulation replications to be run, the length of the replication, the start date and time of the simulation, warm-up time length, time units, and the type of initialization to be performed between replications.

**Replication Parameters**

Number of Replications: 1

Start Date and Time: ☐ Saturday, June 10, 2023 5:43:49 PM

Warm-up Period: 100 Minutes

Replication Length: 1100 Minutes

Hours Per Day: 24

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***Q & A***

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