

# Manufacturing System Analysis Experiment

---

Batching

# 1. Experiment Overview

- Title

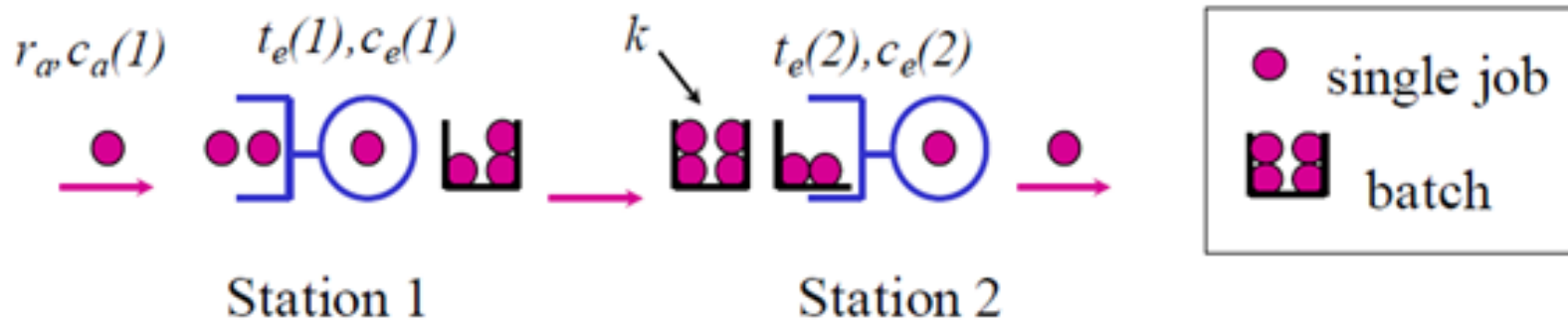
**Effects of batching on production system**

- Objective

- Model move batching and process batching, which are seen a lot in the industry, using the simulation
- Consider how changes in batch size within a given variation affects each batching system

## 2. Theoretical Background

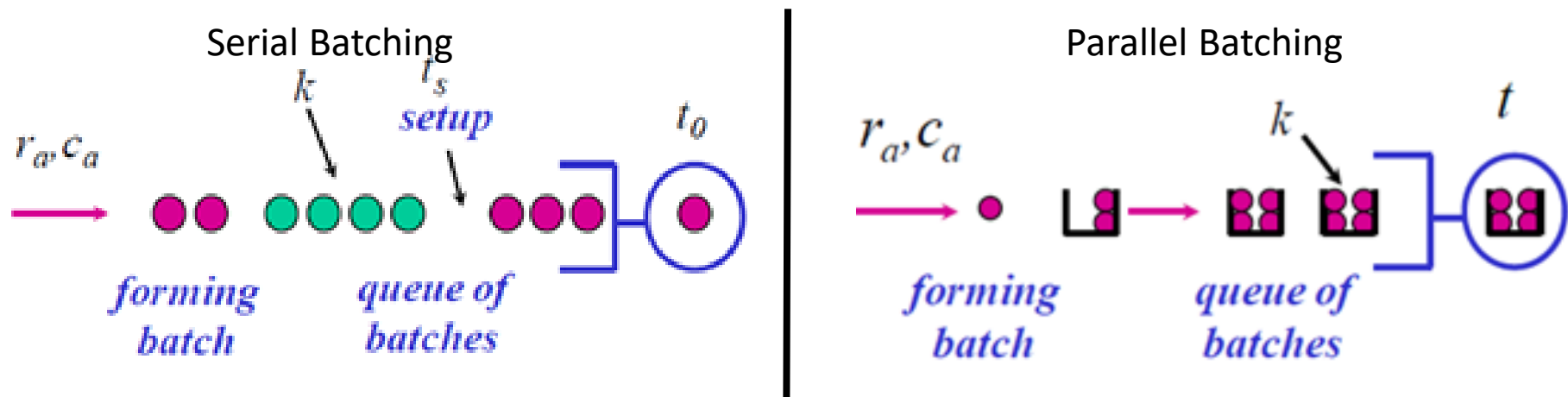
- Move (transfer) Batches



$$\begin{aligned}
 \bullet \quad CT(batching) &= CT(batching) \frac{k-1}{2u(1)} t_e + \frac{k-1}{2} t_e(2) = CT(batching) + \frac{k-1}{2} \left( \frac{t_e(1)}{u(1)} + \right. \\
 &\quad \left. t_e(2) \right)
 \end{aligned}$$

## 2. Theoretical Background

### Process Batches (Parallel Batching)



- $CT = WTBT$  (Wait To Batch Time, Batch forming time) +  $CT_q$  (waiting time) +

$$t(\text{working time}) = \frac{k-1}{2r_a} + \left(\frac{\frac{c_a^2}{k} + c_e^2}{2}\right) \left(\frac{u}{u-1}\right) t + 1 = \frac{k-1}{2ku} t + \left(\frac{\frac{c_a^2}{k} + c_e^2}{2}\right) \left(\frac{u}{1-u}\right) t + t$$

- Batching reduces the variability of the production system

# 3. Experiment Design

Yonsei Electronics has two production lines using batching:

- 1) Move batching
- 2) Process batching

Decide the appropriate batch size by calculating the cycle time and variability with the machine performance given below.

	Entity Create	Process time
Move Batching	15 min/unit	Expo (15 min)
Process Batching	15 min/unit	Expo (15 * batch size)

## 4. Experiment Procedure

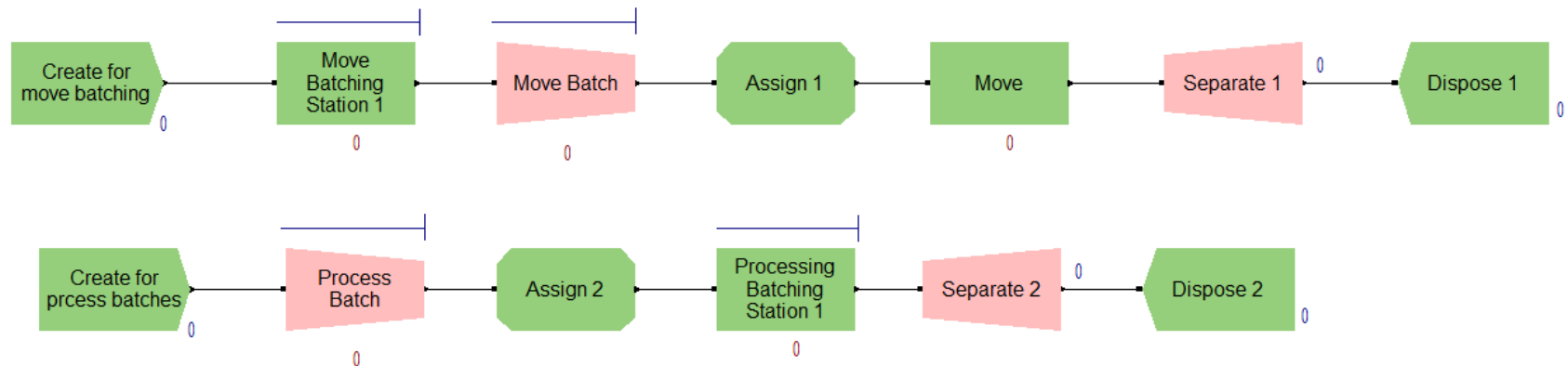
### ▪ Step 1-1. Simulation summary

- Simulation consists of two batch methods:
  - 1) move (transfer) batch
  - 2) process batch
- Each model is a simple system: create, batch, process, and dispose
- Simulation runs for one day (24 hrs) and is repeated 10 times (Run Setup settings)

# 4. Experiment Procedure

## ■ Step 1-2. Creating the model

- Basic simulation model is as the picture shown below
- Modules used: Create, Process, Batch, Separate, Dispose, Assign



<Picture 1> Models window with simulation modules

# 4. Experiment Procedure

- Step 1-2. Creating the model (cont.)
  - Create one resource each for move batching and process batching

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
1 ▶	MB station 1 mc	Fixed Capacity	1	0.0	0.0	0.0		0 rows	<input checked="" type="checkbox"/>
2	PB station 1 mc	Fixed Capacity	1	0.0	0.0	0.0		0 rows	<input checked="" type="checkbox"/>



# 4. Experiment Procedure

- **Step 1-2. Creating the model (cont.)**
  - Set ‘Initial Picture’ for each product to see the product moving through the line during simulation

Activity Area

Entity

Failure

Resource

Sequence

StateSet

Variable

Attribute

Expression

Queue

Schedule

Set

Station Data

	Entity Type	Initial Picture	Holding Cost / Hour	Initial VA Cost	Initial NVA Cost	Initial Waiting Cost	Initial Tran Cost	Initial Other Cost	Report Statistics
1 ▶	MB product	Picture.Green Ball	0.0	0.0	0.0	0.0	0.0	0.0	<input checked="" type="checkbox"/>
2	PB product	Picture.Green Ball	0.0	0.0	0.0	0.0	0.0	0.0	<input checked="" type="checkbox"/>

## 4. Experiment Procedure

- **Step 1-2. Creating the model (cont.)**
  - Set Create module
  - Move batching and process batching has the same constant arrival, as the objective is to see the effects of batch size

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

- Name:** Create for move batching
- Entity Type:** MB product
- Time Between Arrivals:**
  - Type:** Constant
  - Value:** 15
  - 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:** Create for process batches
- Entity Type:** PB product
- Time Between Arrivals:**
  - Type:** Constant
  - Value:** 15
  - Units:** Minutes
- Entities per Arrival:** 1
- Max Arrivals:** Infinite
- First Creation:** 0.0
- Comment:** (empty text box)
- Buttons:** OK, Cancel, Help

# 4. Experiment Procedure

- **Step 1-2. Creating the model (cont.)**
  - Define variables to set batch size
  - Useful when experimenting through changing batch size

Activity Area

Attribute

Entity

Expression

Failure

Queue

Resource

Schedule

Sequence

Set

StateSet

Station Data

**Variable**

Initial Values

10

	Name	Rows	Columns	Data Type	Clear Option	File Name	Initial Values	Report Statistics	Comment
1	move batching size			Real	System		1 rows	<input type="checkbox"/>	
2	process batching size			Real	System		1 rows	<input type="checkbox"/>	

## 4. Experiment Procedure

### ■ Step 1-2. Creating the model (cont.)

- Set Batch modules
- Use the name typed in Variable module for batch size

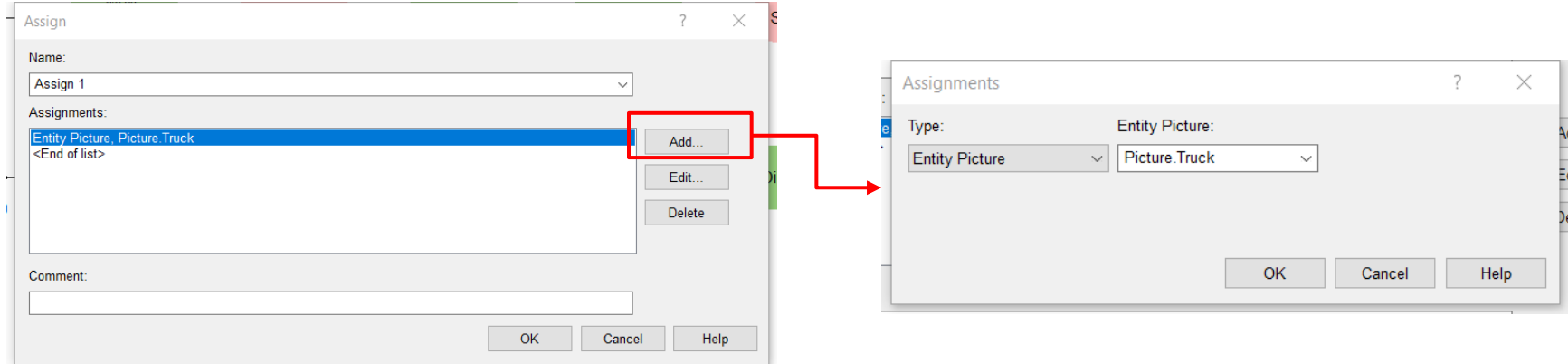
Variables representing  
the batch size

The screenshot shows the 'Batch' dialog box for the 'Move Batch' module. The 'Name' field is set to 'Move Batch' and the 'Type' is 'Temporary'. The 'Batch Size' field is highlighted with a red box and contains the text 'move batching size'. The 'Save Criterion' is set to 'Last'. The 'Rule' is 'Any Entity'. The 'Representative Entity Type' and 'Comment' fields are empty. The 'OK', 'Cancel', and 'Help' buttons are at the bottom.

The screenshot shows the 'Batch' dialog box for the 'Process Batch' module. The 'Name' field is set to 'Process Batch' and the 'Type' is 'Temporary'. The 'Batch Size' field is highlighted with a red box and contains the text 'process batching size'. The 'Save Criterion' is set to 'Last'. The 'Rule' is 'Any Entity'. The 'Representative Entity Type' and 'Comment' fields are empty. The 'OK', 'Cancel', and 'Help' buttons are at the bottom.

## 4. Experiment Procedure

- **Step 1-2. Creating the model (cont.)**
  - Assign new pictures for entity to see products batching
  - Use the add button to select the picture



## 4. Experiment Procedure

- **Step 1-2. Creating the model (cont.)**
  - Set Separate module as shown for both system
  - Move Batching is separated by definition
  - Process Batching is separated for the experiment purpose

The screenshot shows a dialog box titled 'Separate' with a question mark icon and a close button. It 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:** An empty text box.

At the bottom are three buttons: 'OK', 'Cancel', and 'Help'.

The screenshot shows a dialog box titled 'Separate' with a question mark icon and a close button. It contains the following fields:

- Name:** A dropdown menu with 'Separate 2' selected.
- Type:** A dropdown menu with 'Split Existing Batch' selected.
- Member Attributes:** A dropdown menu with 'Retain Original Entity Values' selected.
- Comment:** An empty text box.

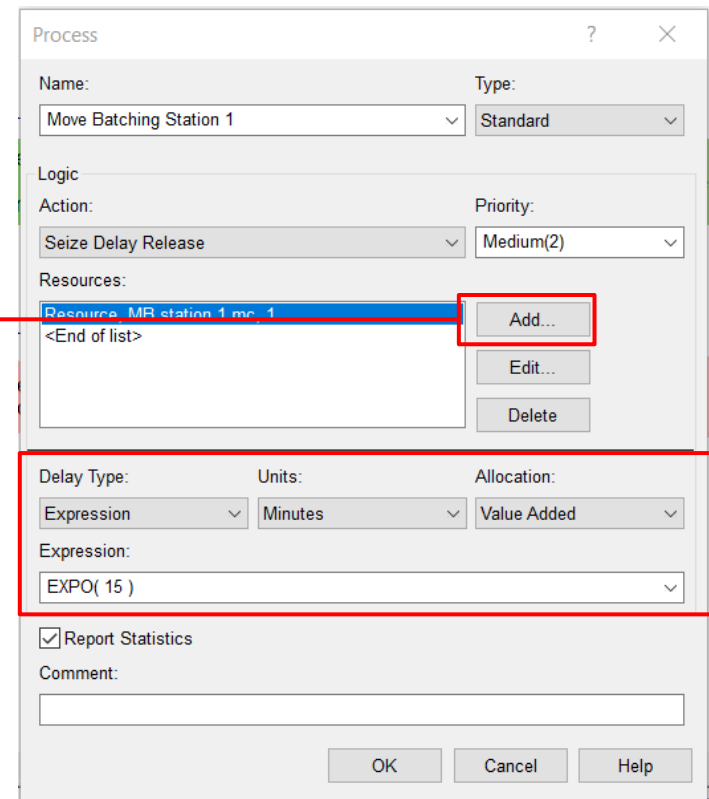
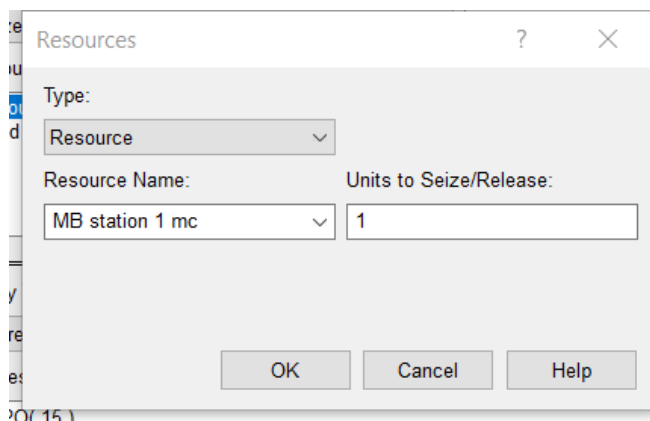
At the bottom are three buttons: 'OK', 'Cancel', and 'Help'.

# 4. Experiment Procedure

## ■ Step 1-2. Creating the model (cont.)

### 1. Move Batching

- Set action as 'Seize Delay Release'
- = Station seize, process, and return the resource
- Use Add button to assign resources
- Delay time = exponential (15)



# 4. Experiment Procedure

## ■ Step 1-2. Creating the model (cont.)

### 1. Move Batching

- Use a Process module to express the moving to the next process
- Set Action as Delay and Delay Type value to 0 as we do not consider the moving time

Process

Name: Move Type: Standard

Logic

Action: Delay

Delay Type: Constant Units: Minutes Allocation: Value Added

Value: 0

☒ Report Statistics

Comment:

OK Cancel Help



# 4. Experiment Procedure

## ■ Step 1-2. Creating the model (cont.)

### 2. Process Batching

- Set action as 'Seize Delay Release'
- Use Add button to assign resources
- Delay time = EXPO (150) or (15 \* batch size variable)
  - Describes the work arriving at the process after batching

## 4. Experiment Procedure

### ■ Step 2. Analyze the result report

- To analyze the variability of two machines, use [Waiting time /  $U \times t$ ]
  - Waiting time  $\approx V \times U \times t_e$
  - $V \approx \text{Waiting time} / U \times t$
  - $V$  = variability,  $U$  = utilization ( $u/(1-u)$ ),  $t_e$  = production time

### ■ Step 3. Change batch size & analyze the variability

- Change Batch size from 1 to 10 to analyze the performance

---

***Q & A***

---