# BU 610.615

# Simulation for Business Applications

## Homework 1

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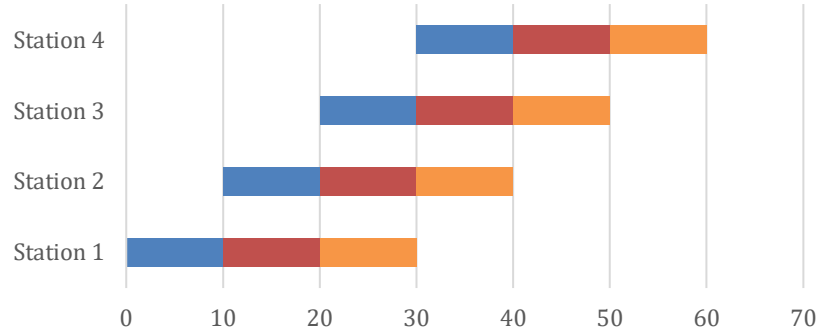
**Part 1: Assembly Line Simulation Exercise**

- **Question A**:
  Assume that the system is in steady-state
  Assume all stations have the same processing time

  - **Bottleneck**:
    MAX([10 mins, 10 mins, 10 mins, 10 mins]) = 10 mins
    VARIANCE([10 mins, 10 mins, 10 mins, 10 mins]) = 0
    All four stations are bottlenecks in this system

  - **Cycle time**:




    10 mins
  - **Throughput time**:
    10 mins + 10 mins + 10 mins + 10 mins = 40 mins
  - **WIP inventory**:
    6 units/hr * (40/60 hr) = 4 units
  - **Capacity utilization**:
    100 %
  - **5000 mins total output**:
    6 units/hr * (5000/60 hr) = 500 units

- **Question B**:
  - **Total output**:
    74 + 76 + 73 + 71 + 73 = 367
  -

| | % Utilization | % T Blocked | % T Starved |
|---|---|---|---|
| **Station 1** | 73.7 % | 26.3 % | 0.0 % |
| **Station 2** | 70.9 % | 21.4 % | 7.6 % |
| **Station 3** | 73.7 % | 13.0 % | 13.4 % |
| **Station 4** | 73.6 % | 0.0 % | 26.4 % |

  - **Throughput Time Avg.**:
    5000 / 367 = 13.624
  - **WIP Inventory Avg.**:
    3.525

- **Question C**:
  Due to the introduction of random variation of process time, blockages and starvations start to emerge within the system. As a result, stations aren't always running in full capacity (either waiting for the next station to be available or the previous station to finish), which leads to lower total output and % capacity utilization.
- **Question D**:
  The total output and % capacity utilization states slightly decreased comparing to the 4-station system. This could be caused by the uncertainty brought by the newly added station. In other words, the fifth station could cause blockage or starvation between station 4 and 5 that of which decreases the efficiency of the entire system.
- **Question E**:
  The total output and % capacity utilization states slightly decreased comparing to process time std. div. of 4. This could be caused by the increased uncertainty derived from a higher process time variance. Consequently, the probability of blockage or starvation between stations occurring increased.
- **Question F**:
  Comparing total output of three buffer inventory options (between 1 and 2, 2 and 3, and 3 and 4), placing the buffer between machine 2 and 3 yielded the highest average output. This could be explained by the phenomenon that buffer inventory eliminates wait time for both stations, which greatly reduced blockage and starvation rate in that part of the system.

**Part 2: Probability Warm-up Questions**

- **Question G**:
  - **Avg.**:
    (1 + 2 + 3 + 4 + 5 + 6) / 6 = 3.5
  - **Std. Div.**:
    $\frac{(1-3.5)^2+(2-3.5)^2+(3-3.5)^2+(4-3.5)^2+(5-3.5)^2+(6-3.5)^2}{6} = \frac{17.5}{6} = 2.91666666667$
- **Question H**:
  - Binomial Distribution
- **Question I**:
  - 5000 * 0.001 = 5
- **Question J**:
  - 5000 * 0.001 * (1 - 0.001) = 4.995
- **Question K**:
  - (1 - 0.001) ^ 5000 = 0.6721 %