BU 610.615

Simulation for Business Applications

Homework 1

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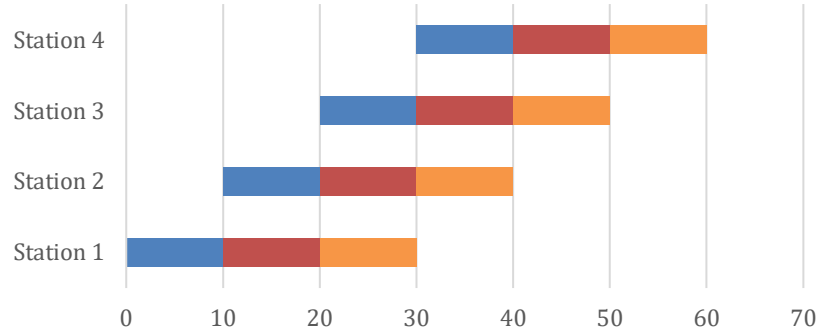
Part 1: Assembly Line Simulation Exercise

- **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 * 4 = 54.496
  - **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. (total output: 367 -> 361, % utilization: 73% -> 71%) 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. (total output: 367 -> 342, % utilization: 73% -> 68%) 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 output. (1-2: 373, 2-3: 396, 3-4: 375) 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.**:
    $$\sqrt{\frac{(1-3.5)^2+(2-3.5)^2+(3-3.5)^2+(4-3.5)^2+(5-3.5)^2+(6-3.5)^2}{6}} = \sqrt{\frac{17.5}{6}} = 1.7078$$
- **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 %