

# MSBA 7004

## Operations Analytics

Class 2-1: Process Flow Analysis (I)  
Capacity Rate, Flow Time, Bottleneck  
2023

# Definition: Arrival Rate

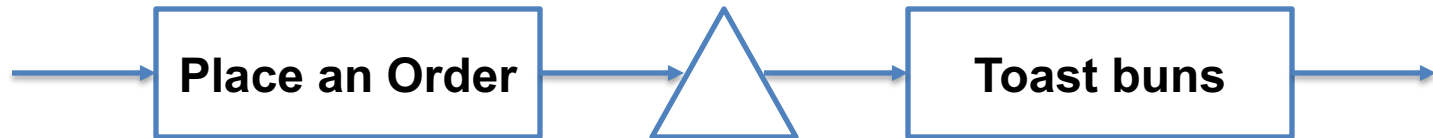
- Arrival Rate
  - The number of flow units (customers) that arrive in a unit of time
  - unit: # of customers/ unit time, e.g., 2 orders per hour
  - If *Arrival Rate*  $\geq$  Capacity,  
then the process cannot handle all the jobs, and hence the manager needs to find ways to increase capacity
    - Primary reason we see queues (waiting)

Match supply and demand

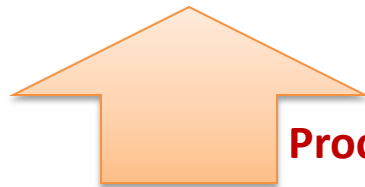
# Bottleneck Characteristics

- The bottleneck is fully utilized while other resources are not utilized
  - Always working (100% of the available time)
- Shortening tasks of non-bottleneck resources decreases flow time but does not affect capacity rate
  - Reducing flow time improves response time

# Processes may be *unbalanced*



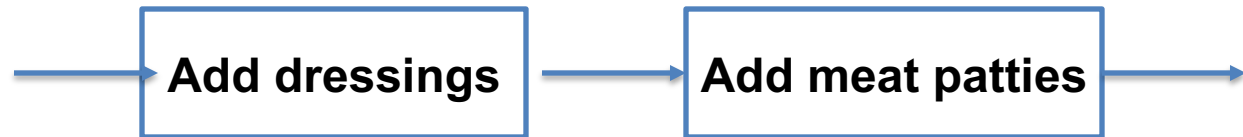
Flow Time	8 sec		10 sec
Capacity Rate	450/hour		360/hour



**Process is “Blocked”**

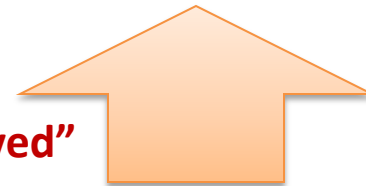
- When the next stage is busy, the order cannot be sent to the next stage after finishing the current stage, unless an inventory buffer is introduced

# Another example



Flow Time	8 sec		6 sec
Capacity Rate	450/hour		600/hour

Process is "starved"



# More Bottleneck Characteristics

- The bottleneck is fully utilized while other resources are not utilized
- Shortening tasks of non-bottleneck resources decreases flow time but does not affect capacity rate
  - Reducing flow time improves response time
- If a buffer is provided at some upstream stage to the bottleneck, inventory may build up at the buffer
- Inventory will not build up at the (immediately) downstream stages to the bottleneck even if buffers are provided

# Summary of Bottleneck Characteristics

- Increasing capacity rate of bottleneck resource(s) increases process capacity rate only when the bottleneck is unique
  - With multiple bottlenecks (same capacity rate), we need to increase capacity rate for all of them to increase process capacity rate
- Two ways of increasing capacity rate of bottleneck resources:
  1. Increase number of bottlenecks' resources
  2. Reduce unit load of bottlenecks' task
- Reducing unit load on a non-bottleneck resource **reduces flow time** but does **not affect cycle time (or capacity rate)**

# Process Analysis

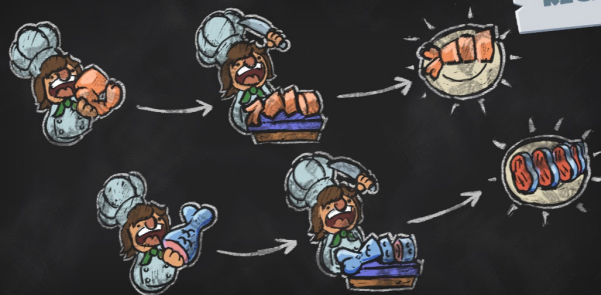
- **Improving a process**
  - Throughput (Capacity)
    - Bottleneck Analysis
    - Levers for Improvement

- Flow Time (Responsiveness)
  - Critical Path Analysis
  - Improvement Levers



## SASHIMI

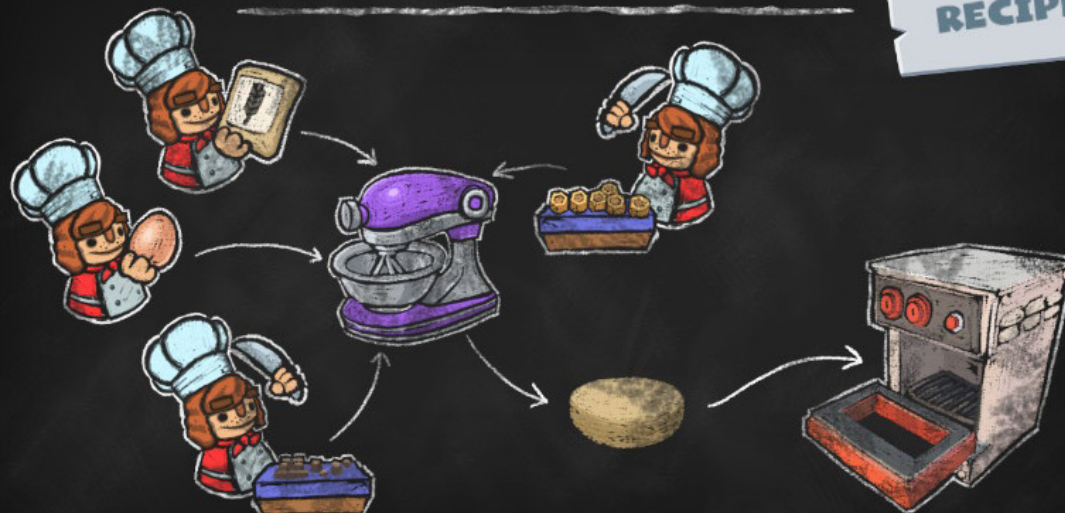
NEW  
RECIPE



HOW TO MAKE SASHIMI!

## CAKE

NEW  
RECIPE

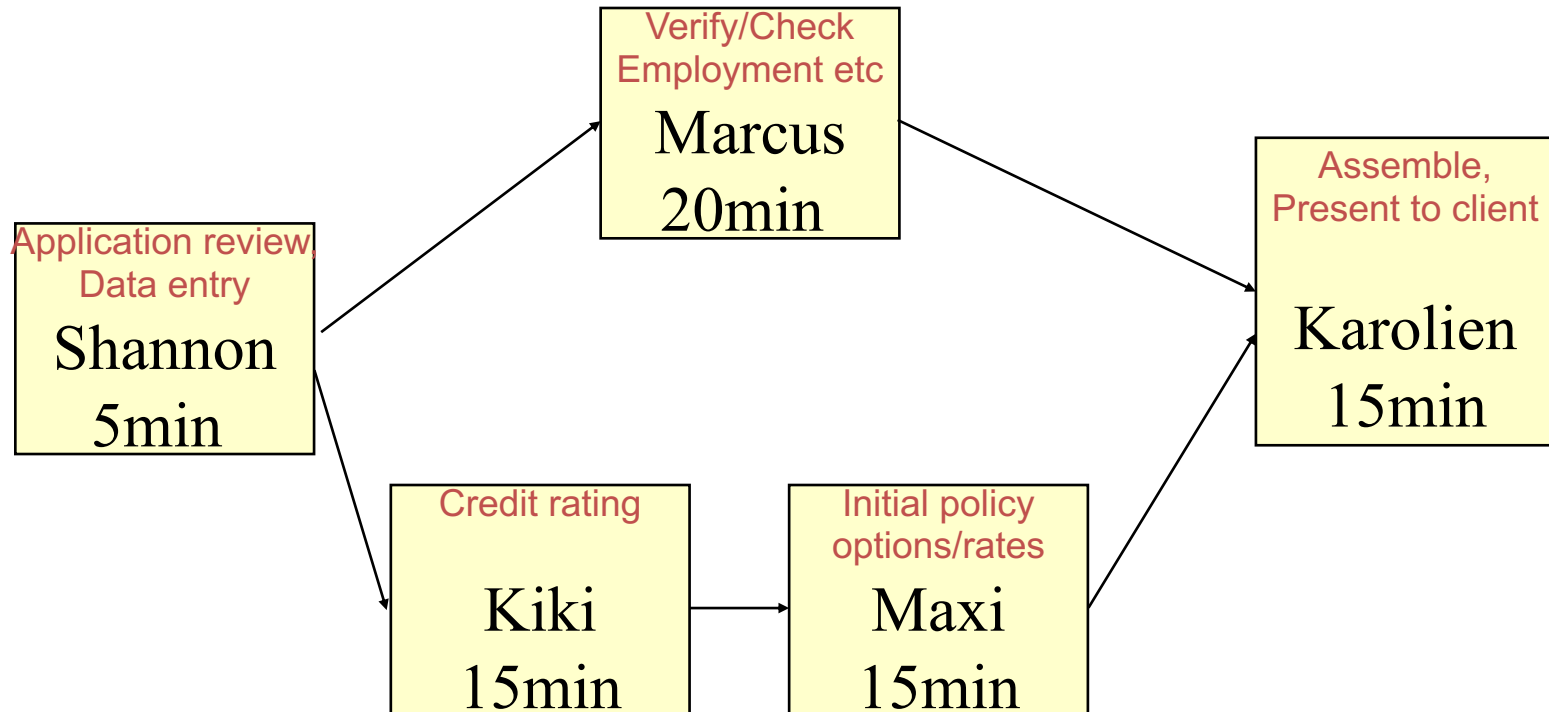


MIX FLOUR AND EGG WITH CHOPPED HONEY, CARROT OR CHOCOLATE AND  
BAKE THE LOT!

# Process Performance Characteristics: Capacity Rate and Flow Time

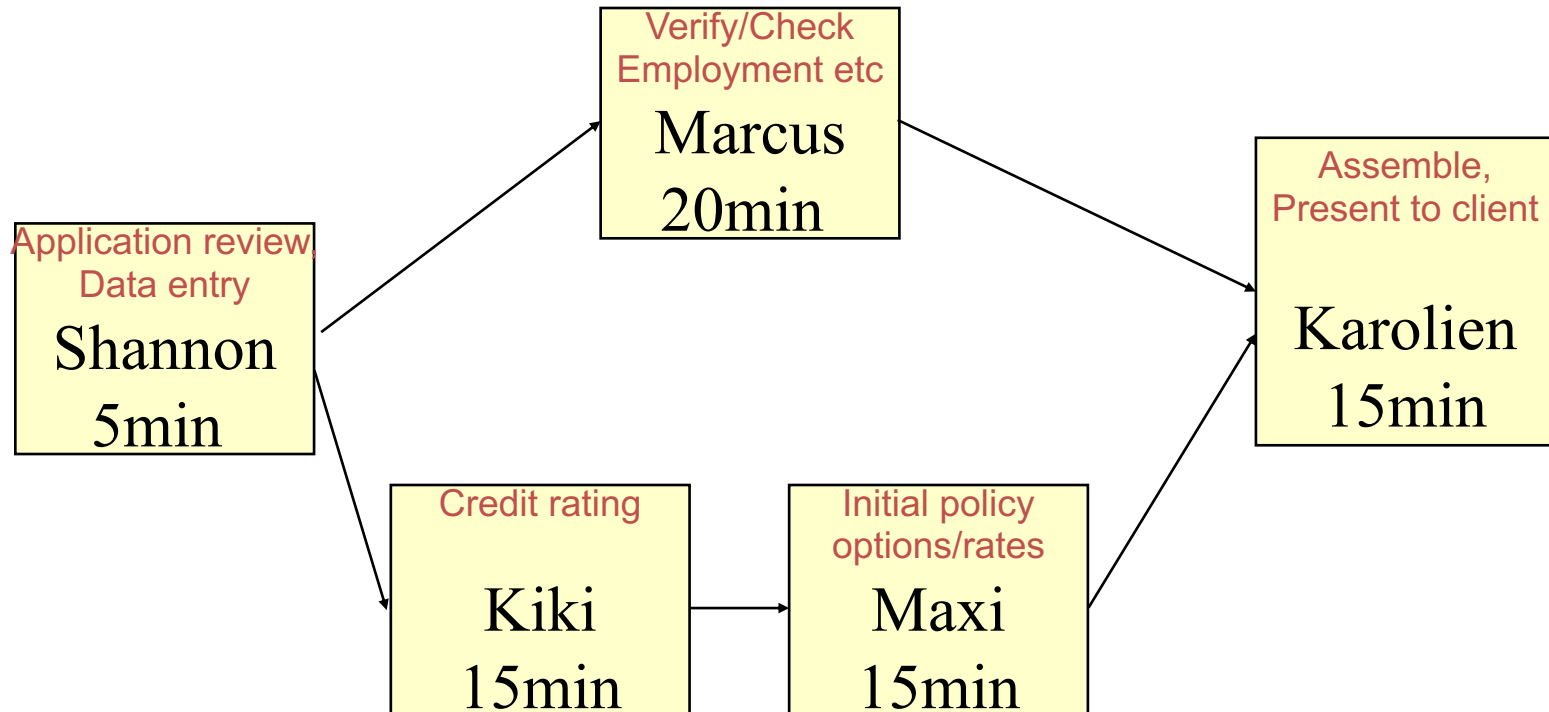
- *Capacity rate*: Maximum rate at which (flow) units can flow through the process
- ***(Theoretical) Flow time (or Throughput time)***: Total length of time a unit spends in the process
  - Shortest time (hence without waiting at all) for a flow unit to go through the entire process

# Analyzing Process Performance: Mortgage Application



- How to reduce flow time?
- Flow time: 50 mins

# Analyzing Process Performance: Mortgage Application



- How to reduce flow time?

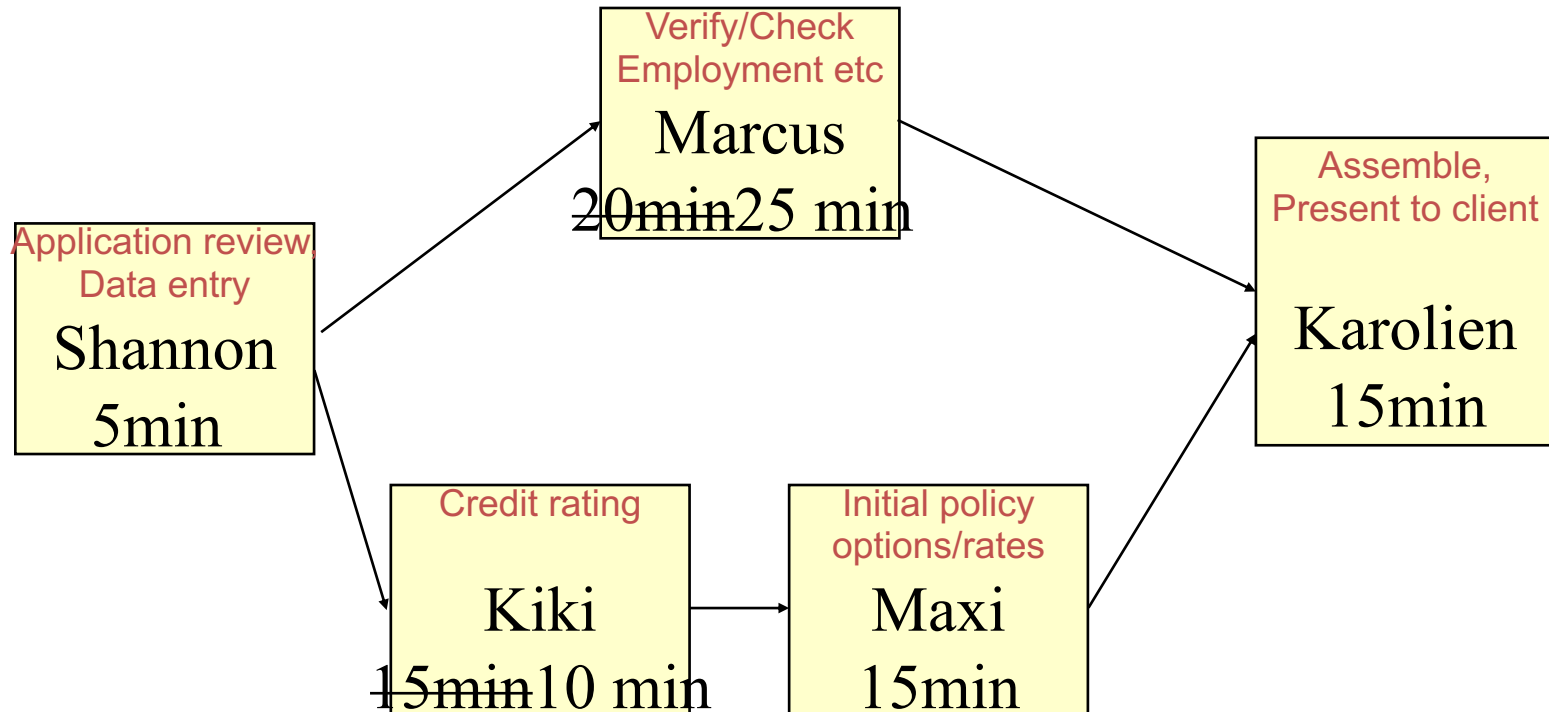
# Improving Flow Time

- **Critical path:** The longest path in the process flowchart.
- **Critical activities:** Activities on a critical path.
- Flow time = Activity time + Waiting (buffer) time
- Theoretical flow time = Value-adding flow time (on the critical path)

# Levers for Reducing Flow Time

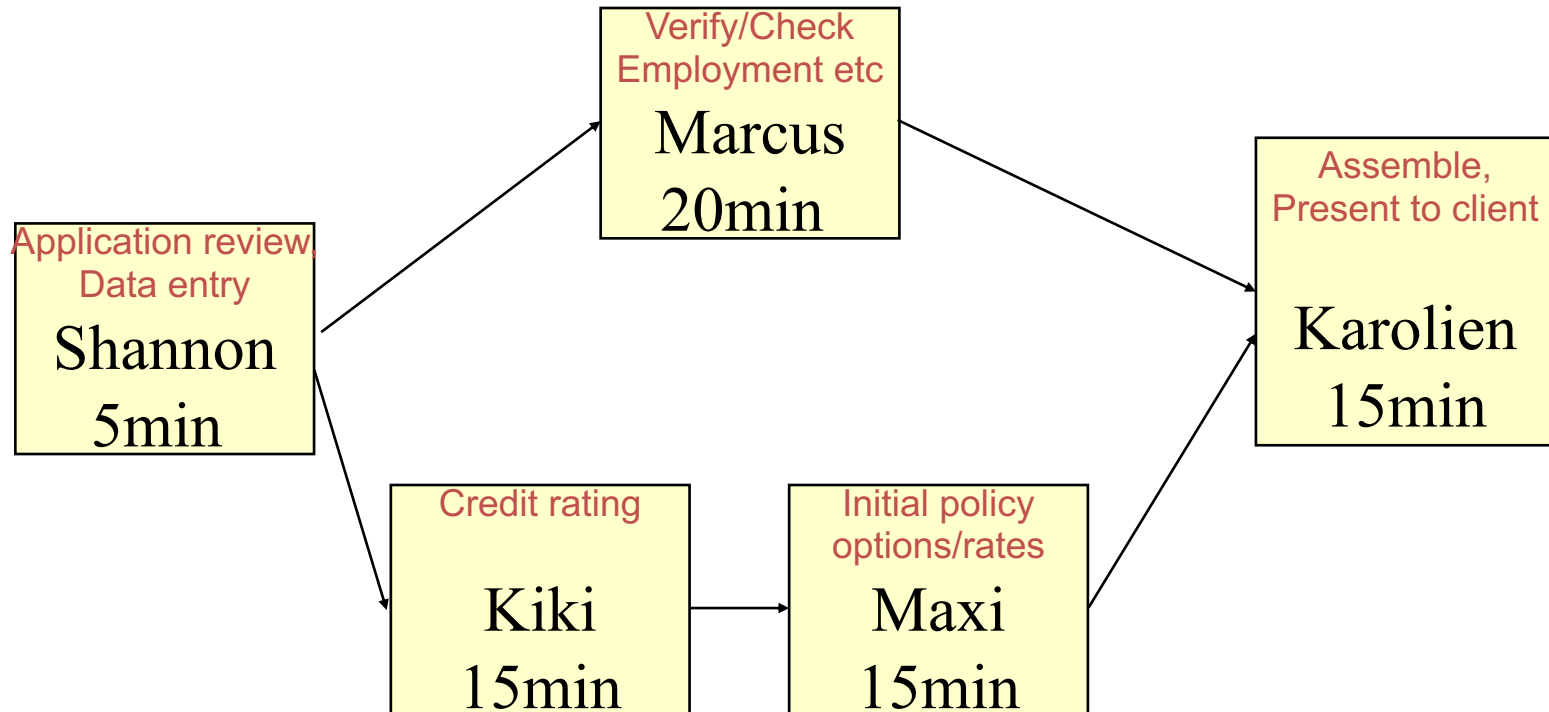
- Decrease the work content on the critical path (reducing activity time)
  - work faster (reduce flow time of critical activities)
  - move work content off the critical path
    - Rearrange the process
- Reduce waiting (buffer) time

# Analyzing Process Performance: Mortgage Application



- How to reduce flow time?

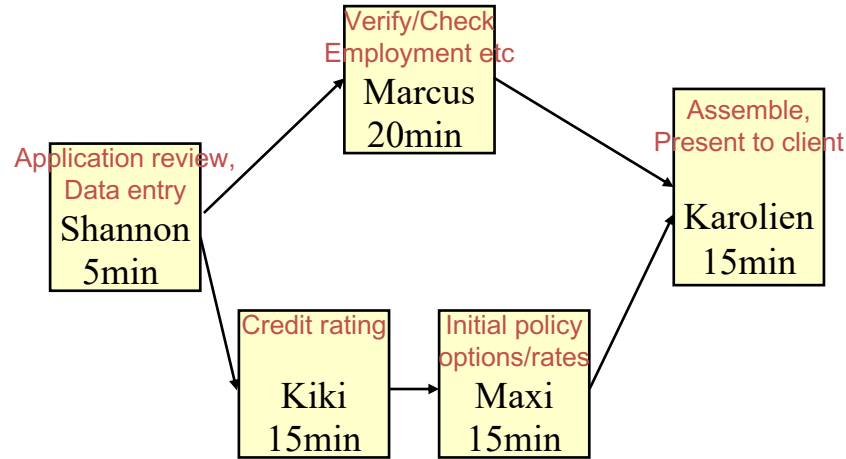
# Analyzing Process Performance: Mortgage Application



- How to increase capacity?



# Mortgage Application



Resource	Unit Load (time/job)	Resource Capacity			Process Capacity
		Unit Capacity	# of units	Total Capacity	
Shannon	5min	12/hr	1	12/hr	3/hr
Marcus	20min	3/hr	1	3/hr	3/hr
Kiki	15min	4/hr	1	4/hr	3/hr
Maxi	15min	4/hr	1	4/hr	3/hr
Karolien	15min	4/hr	1	4/hr	3/hr

The bottleneck doesn't have to be on the critical path