MSBA 7004
Operations Analytics

Class 2-1: Process Flow Analysis (I)
Capacity Rate, Flow Time, Bottleneck
2024

Assessment

Individual assignments	30%
Group assignment	10%
In-Class Participation + Attendance	10%
Final Exam	50%
Total	**100%**

- Objectives:
  - 1. Develop an Inventory policy for a simulation game (group assignment part 1)
  - 2. Participate in a simulation game (8th lecture)
  - 3. Reflect on the outcomes and effectiveness of your strategy (group assignment part 2)
- Group formation: 4-5 students
- Deliverables:
  - 1. Submit your strategy (inventory policy) at the beginning of the 8th lecture.
  - 2. After the game, submit a reflection analyzing your group's performance.
- Peer evaluation form

Assessment

Individual assignments	30%
Group assignment	10%
In-Class Participation + Attendance	10%
Final Exam	50%
Total	**100%**

- Take attendance (>=70% attendance rate = 5% final grade)
- In-Class Participation (5% = 2.5% (first half) + 2.5% (second half))
  - ***In-class practice problems will count. If you are able to submit all the in-class practice problems, you already get 70%*2.5%. For the rest 30%, you need to participate more during class.***
  - ***If you participate (ask or answer questions) during the class, I will distribute you a sticky note. Please write down your name and UID and return it to me. If I forget to distribute the note, please ask for it during the break.***
  - ***If you forget to do this, please send TA (cc me) an email (including what you asked or answered) at the end of every class (no later than 10:30 pm of the day).***

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* ≥ Capacity,

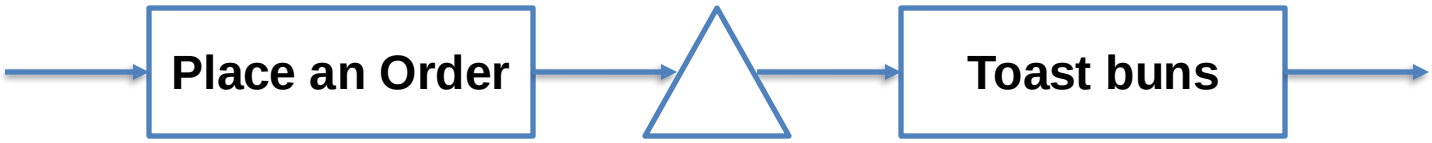
  then the process cannot handle all the jobs, and hence the manager needs to find ways to increase capacity
    - Primary reason we see queues (waiting)
    - Long waiting lines everywhere - HKQU

Match supply and demand

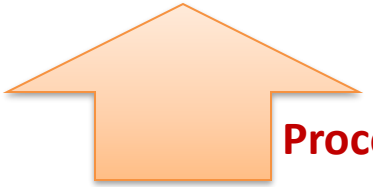
Bottleneck Characteristics

- 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*



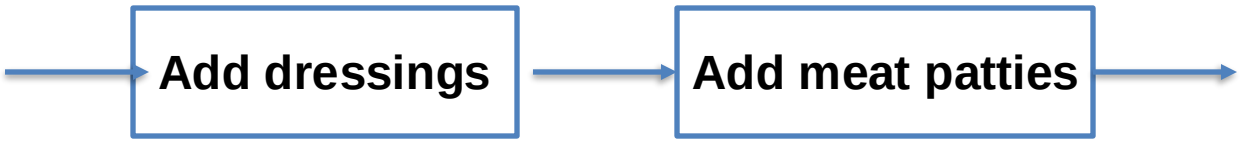
Flow Time	8 sec		10 sec
Capacity Rate	450/hour		360/hour



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

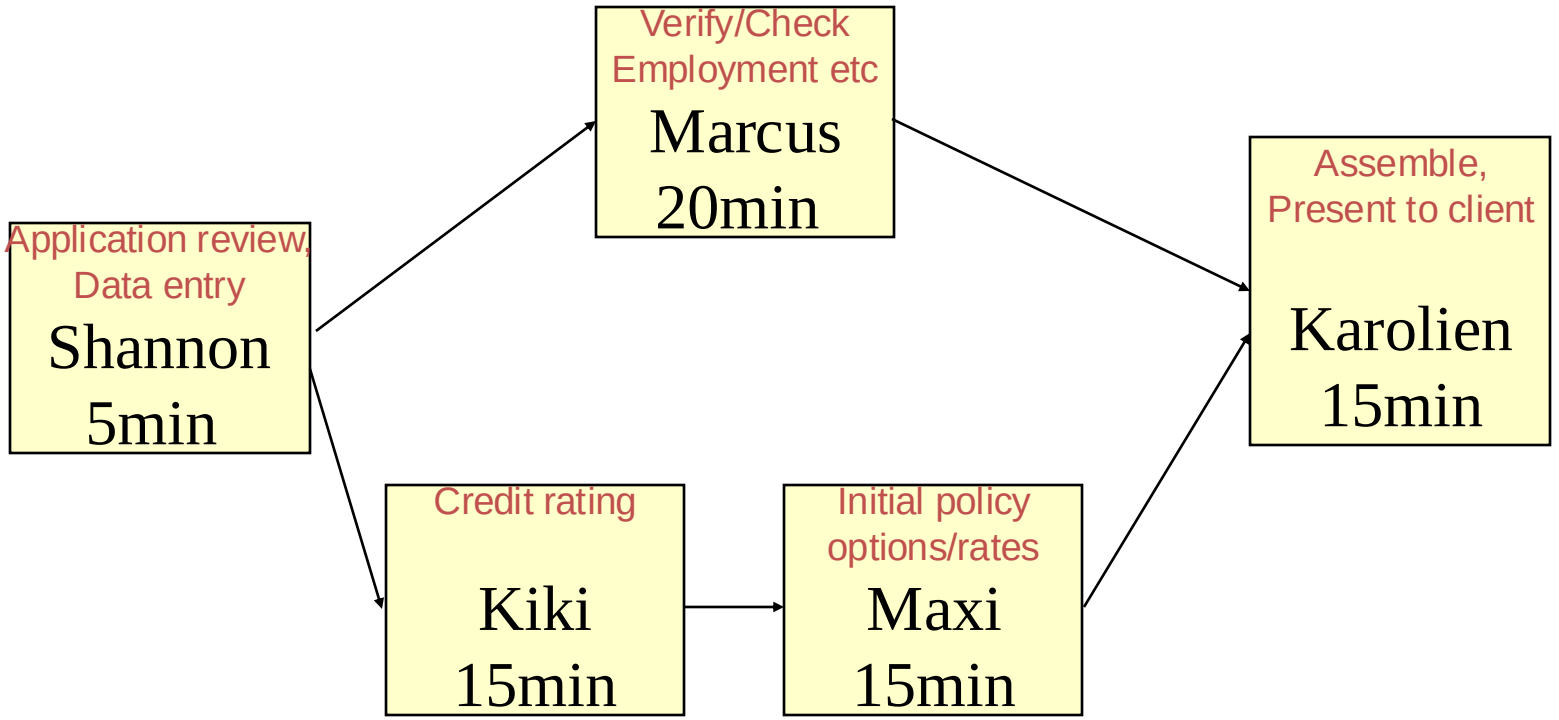

SASHIMI
NEW RECIPE
HOW TO MAKE SASHIMI!


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

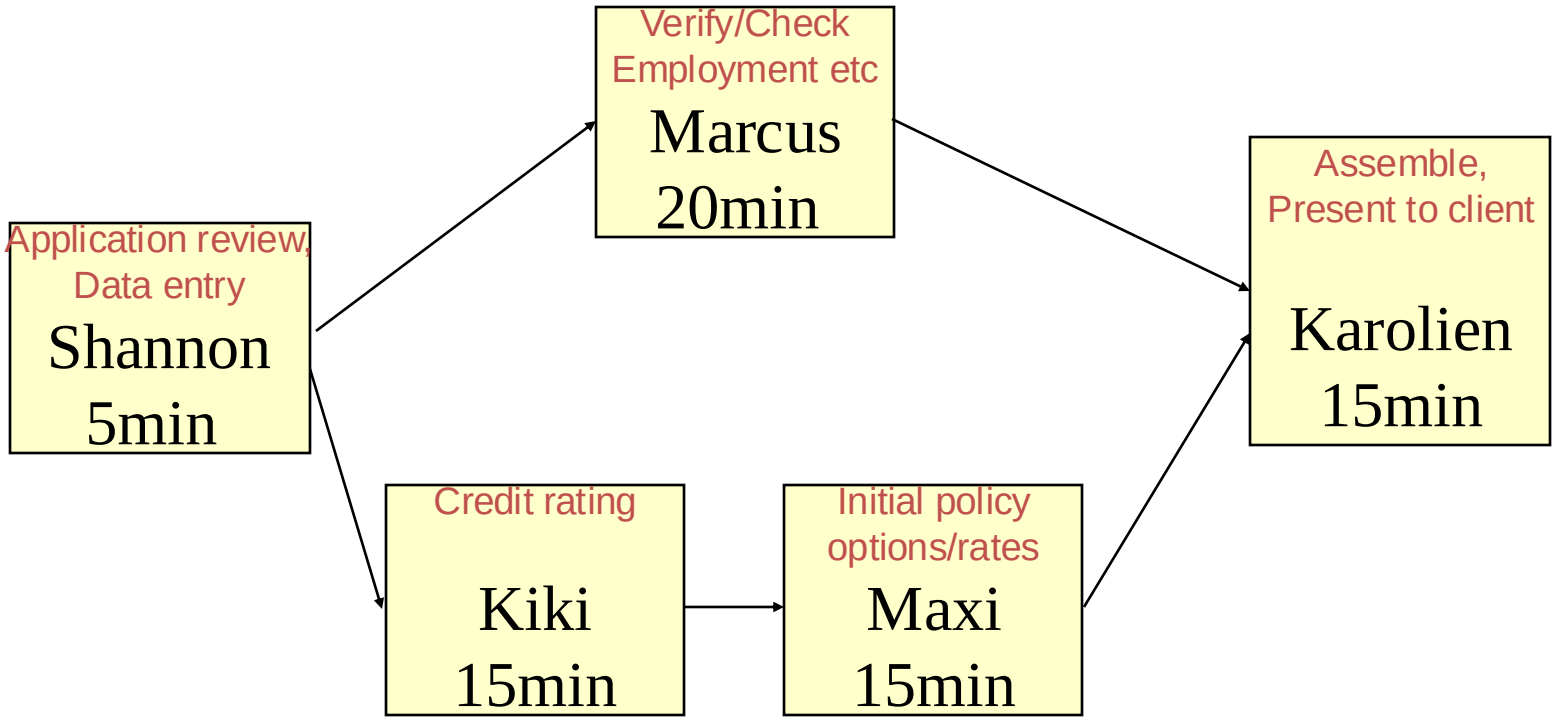
- *Capacity rate*: Maximum rate at which (flow) units can flow through the process
- ***(Theoretical) Flow time* (or *Throughput time*): Total length of time a unit spends in the process**
  - **Shortest time (hence without waiting at all) for a flow unit to go through the entire process**

Analyzing Process Performance: Mortgage Application



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

Analyzing Process Performance: Mortgage Application



- How to reduce flow time?

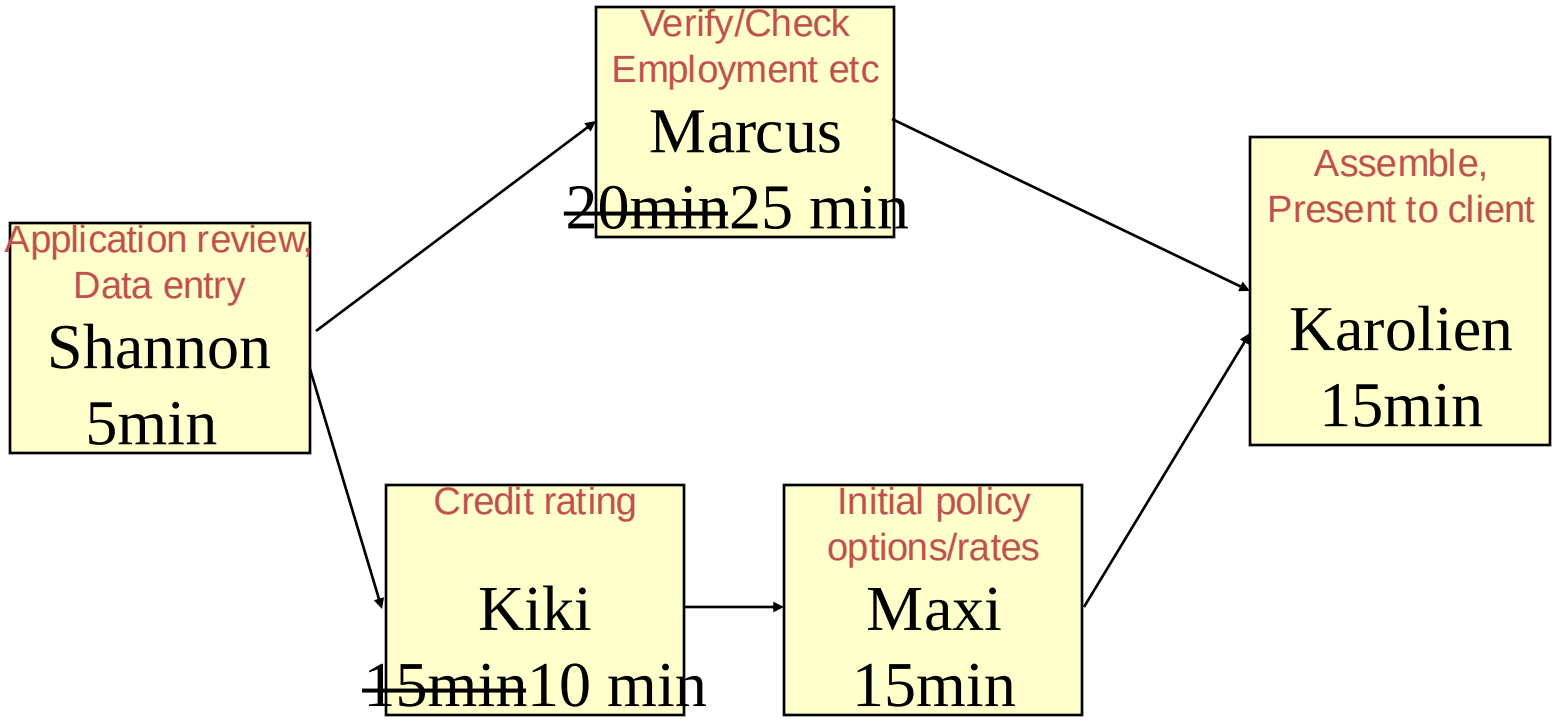
Improving Flow Time

- **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

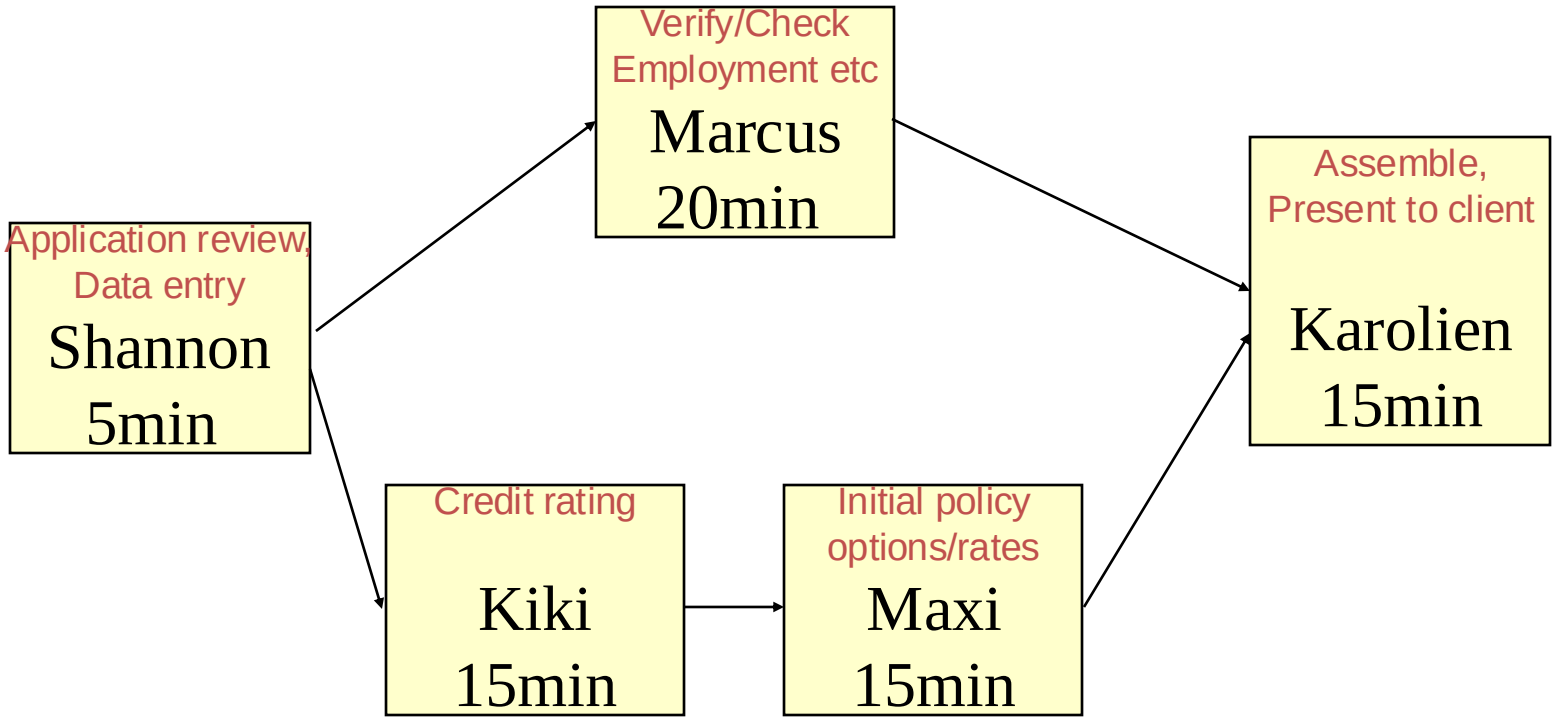
- Decrease the work content on the critical path (reducing activity time)
  - work faster (reduce flow time of critical activities)
  - move work content off the critical path
    - Rearrange the process
- Reduce waiting (buffer) time

Analyzing Process Performance: Mortgage Application



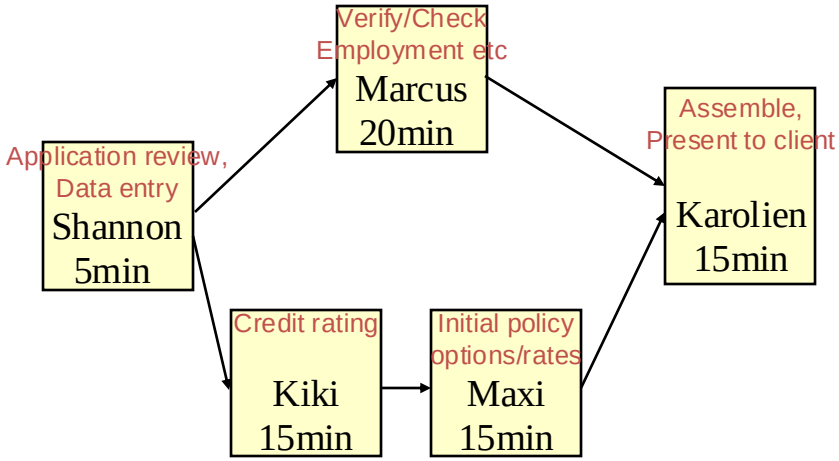
- How to reduce flow time?
- What is the consequence?

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