UCL
SCHOOL OF
MANAGEMENT

UCL

MSIN0095: Operations Analytics

Class 1: Introduction to OM and Process Analysis I

» OM as Managing Transformation Processes

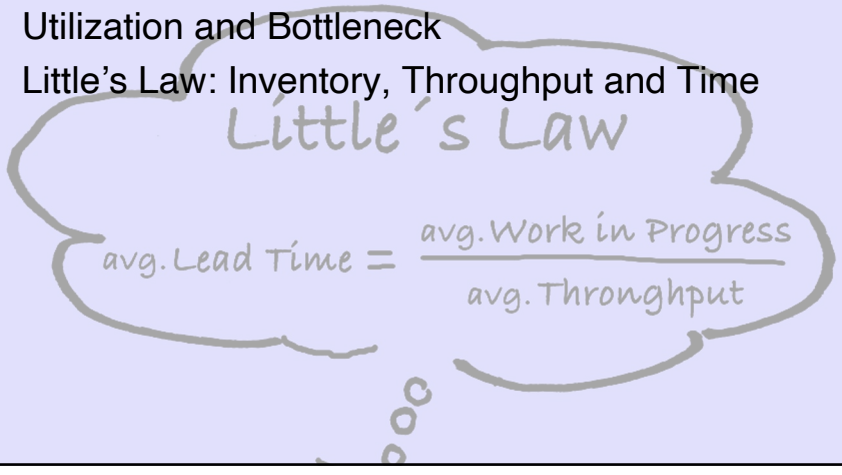
» Operations Strategy Meets Corporate Strategy

Class 2: Process Analysis I

» Introduction to Process Analysis I, Utilization, Little's Law

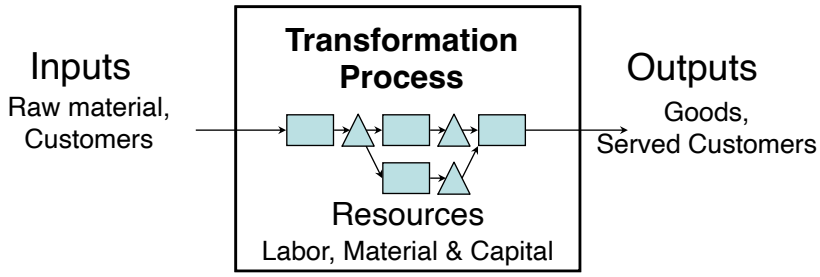
Learning Objectives: Class 2

- **Introduction to Process Analysis I**
- Utilization and Bottleneck
- Little's Law: Inventory, Throughput and Time



What is a process?

What is a process?

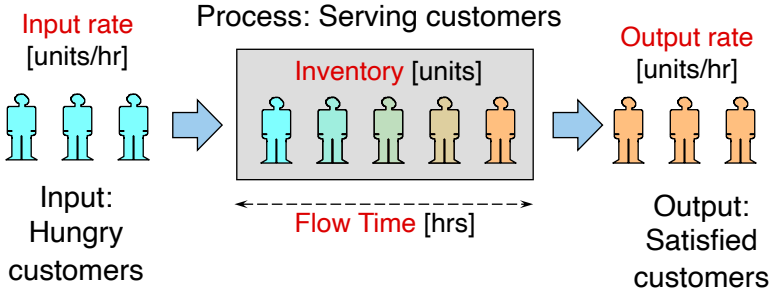


Examples of Processes

Organization	Inputs	Process	Outputs
Auto Factory	Auto parts, raw materials	Fabrication and assembly	Automobiles
Restaurant	Hungry customers (Raw food)	Serving customers (Cooking)	Satisfied customers (Prepared food)
MSIN0095	Students want to learn OM	Learning, teaching and practicing	Future [?] equipped with OM knowledge

Note: The process depends on the perspective you take

Basic Process Measures



Flow time is time a unit takes from entering to leaving the process

Cycle time is the time between consecutive units leaving process

Capacity is the maximum output rate when working at full speed

Warnings:

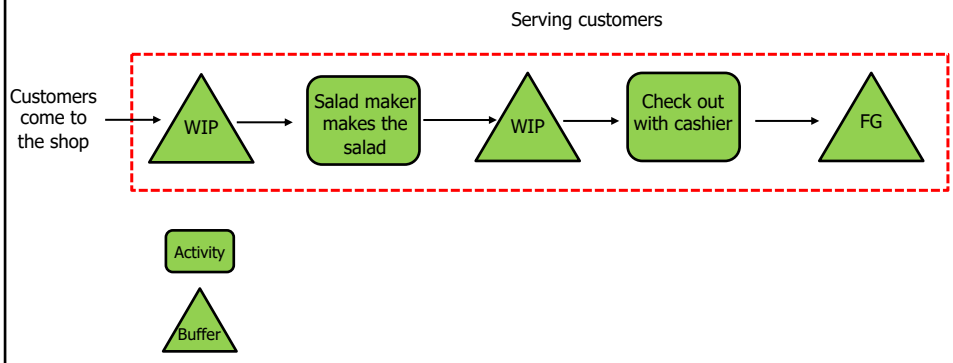
- Cycle time vs. flow time
- In process analysis, capacity is a rate not a number

Process Analysis Example

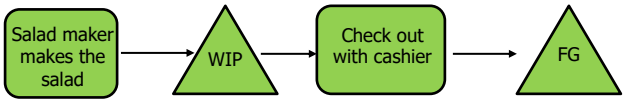
Salads Up

Process Analysis Example

- Ordering a salad from the Salads Up
- Process Flow Diagram:



Process Analysis

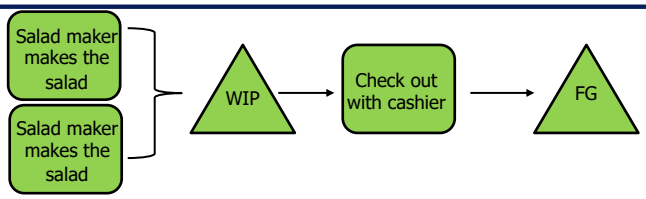


Individual stages			
Capacity:	15 orders / hr	20 orders / hr	Maximum efficiency
Cycle time:	4 min	3 min	Time between outputs
Flow time:	4 min	3 min	Time spent in an activity
The (whole) Process			
Flow time:	4 min + 3 min = 7 min		
Capacity:	15 orders / hr		
Cycle time: (assuming operated at full capacity)	4 min		

9

9

Process Analysis

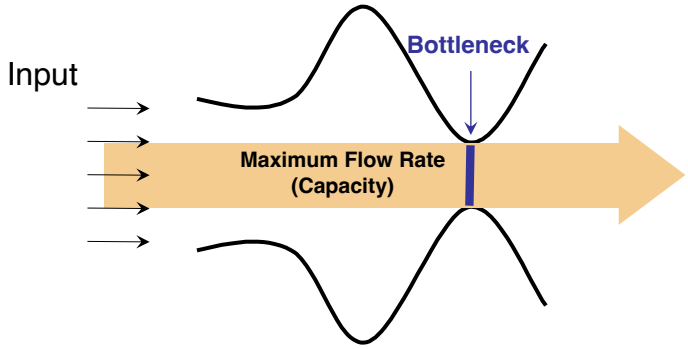


Individual stages			
Capacity rate:	15 orders / hr / chef or 30 orders / hr	20 orders / hr	Maximum efficiency
Cycle time:	2 min	3 min	Time between outputs
Flow time:	4 min	3 min	Time spent in an activity
The (whole) Process			
Flow time:	4 min + 3 min = 7 min		
Capacity rate:	20 orders / hr		
Cycle time: (assuming operated at full capacity)	3 min		

10

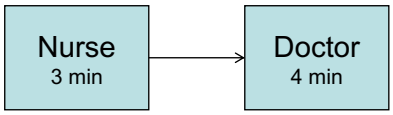
10

Bottleneck

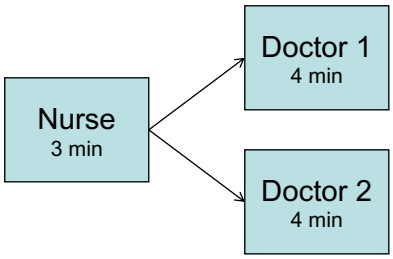


11

Bottleneck analysis and Gantt charts: Example 1



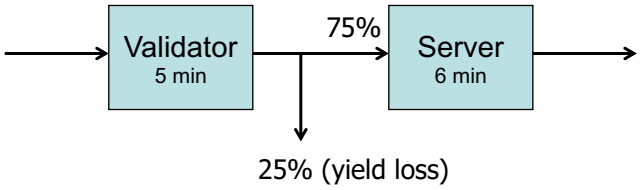
Which is the bottleneck?



Which is the bottleneck?

12

Identifying Bottleneck: Example 2



- Validator capacity = 12 units/hr
  Server capacity = 10 units/hr
- Max output from Validator = 12 units/hr
  Max output from Server = 12 x 75% = 9 units/hr < 10 units/hr
- Bottleneck is Validator
- Bottleneck is not necessarily the station with the smallest capacity.

13

13

14

14

Key steps in analyzing a process

- Step 1: Draw a process flow diagram (define the process)
  - Determine the process boundary and flow unit
  - Determine the activities, their sequence, and the resources required for each activity
  - Determine the buffers in the process
- Step 2: Bottleneck Analysis
  - Determine the capacity of each activity, of the resource, and of the process
  - Bottleneck is always a resource!

15

Practice: Zingerman's Aged Chelsea

- Mold ripened and aged for **4 weeks**, it has a thicker rind that gives the insides a hint of mushroom flavor.
- Smooth, creamy, intense without being "overly goaty." (www.zingermans.com)

16

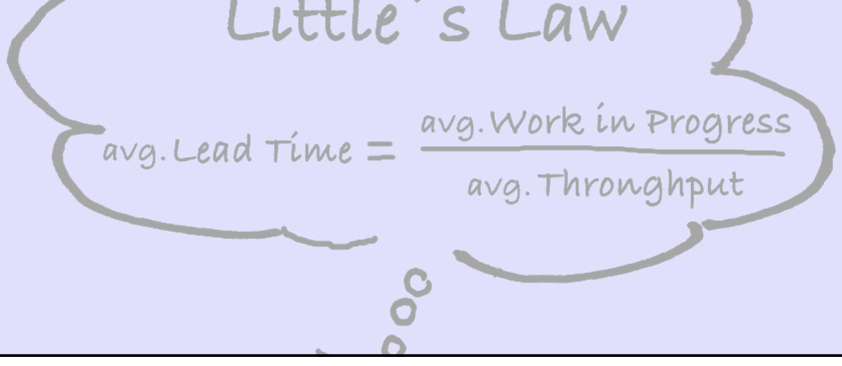
Practice: Zingerman's Aged Chelsea

- Scenario 1: Creamery starts 1 batch of cheese every day.
  - What is the cycle time of the cheese batch? **1 day**
  - What is the flow time of the cheese batch? **4 weeks**
- Scenario 2: Creamery starts 1 batch of cheese every 12 hours.
  - What is the cycle time of the cheese batch? **12 hrs**
  - What is the flow time of the cheese batch? **4 weeks**
- Scenario 3: Creamery starts 1 batch of cheese every day, but make Chelsea Select which requires 6 weeks aging.
  - What is the cycle time of the Chelsea Select cheese batch? **1 day**
  - What is the flow time of the Chelsea Select cheese batch? **6 weeks**

17

Learning Objectives: Class 2

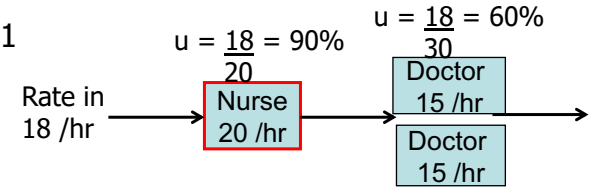
- Introduction to Process Analysis II
- **Utilization and Bottleneck**
- Little's Law: Inventory, Throughput and Time



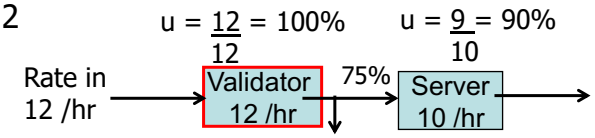
Utilization and Bottleneck

- Utilization = $\frac{\text{Throughput rate (how much does it produce)}}{\text{Capacity (how much it can produce)}}$
- Bottleneck is always station with highest utilization

Example 1



Example 2

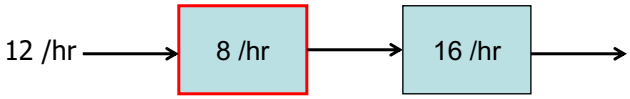


20

20

Actual vs. Implied Utilization

- Actual Utilization = Throughput rate / Capacity
- Implied Utilization = Demand rate / Capacity



Actual utilization	8/8 = 100%	8/16 = 50%
Implied utilization	12/8 = 150%	12/16 = 75%

Can this process keep up with demand? No!

What is the maximum rate the line can handle? 8/hr (rate of bottleneck)

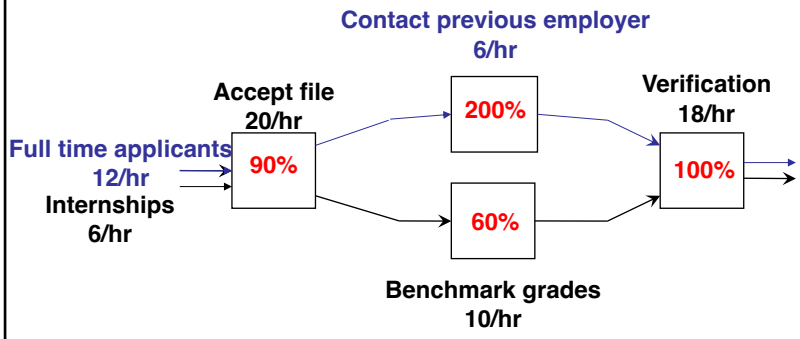
21

21

Identifying a bottleneck: Multi-flow Process

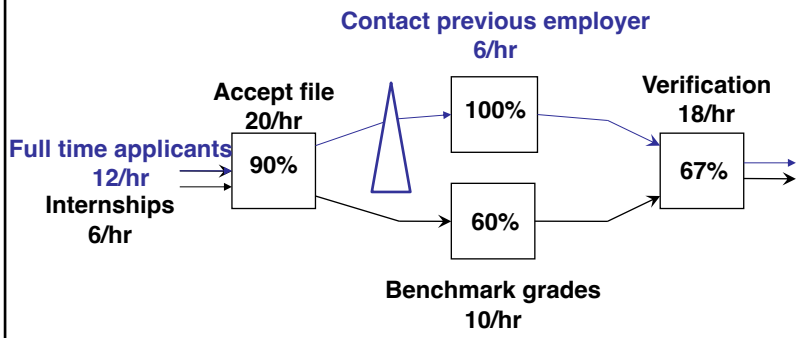
- Implied Utilization = Demand rate / Capacity rate, may>100%

Bottleneck is always resource with highest ***implied*** utilization



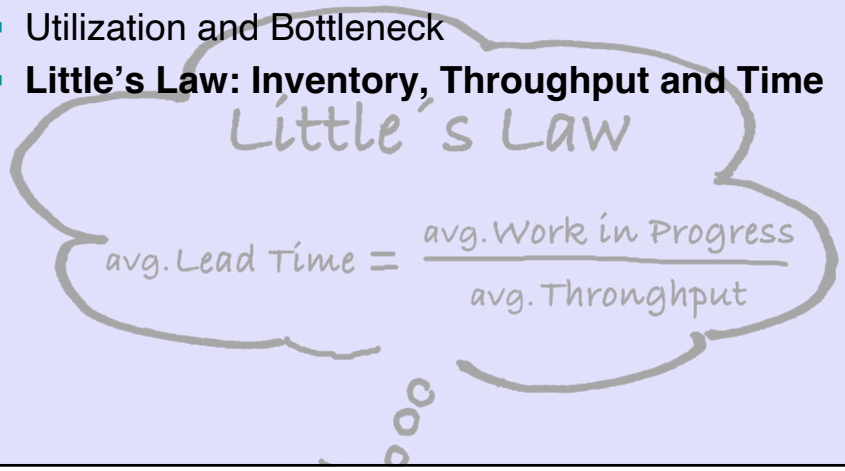
Identifying a bottleneck: Multi-flow Process

- Implied Utilization = Demand rate / Capacity rate, may>100%
- Actual Utilization = Throughput rate / Capacity rate, always ≤100%



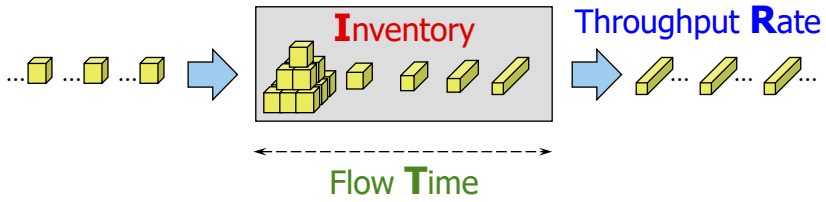
Learning Objectives: Class 2

- Introduction to Process Analysis II
- Utilization and Bottleneck
- **Little's Law: Inventory, Throughput and Time**



Little's Law

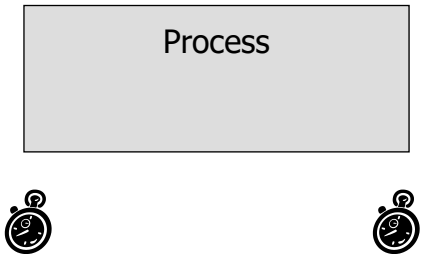
Inventory = Throughput **R**ate × Flow **T**ime



Little's Law: I = R × T

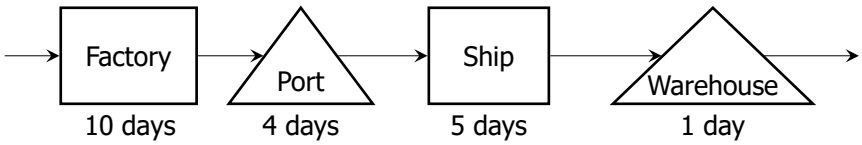
Inventory = Throughput Rate × Flow Time

Input rate: 2 customers per sec



Example 1: Walmart's Supply Chain

- Wal-Mart imports 3000 sweatshirts from an overseas supplier every month. The products go through several stages before arriving at Wal-Mart stores:



- How many sweatshirts in each stage, and in the entire supply chain?
- Little's Law can be applied to any part of the process.

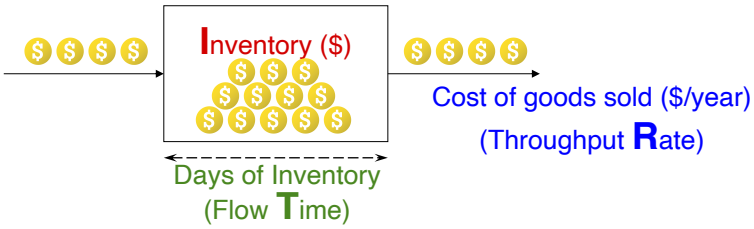
Example 2: Insurance Company

- An insurance company processes 10,000 claims per year. The average processing time is 3 weeks. How many claims are in the system on average? (Assuming 50 weeks in a year)
- R= 200 claims / week, T = 3 Weeks, I = 600 claims

- Now, the company reduces its processing time by 80%. How many claims are in the system on average?
- R= 200 claims / week, T = 0.6 Weeks, I = 120 claims

- A manager can influence any one of these measures by controlling the other two.

Example 3: Days of Inventory and Inventory Turnover



- By Little's Law,

$$\text{Days of Inventory} = \frac{\text{Inventory}}{\text{Cost of goods sold}} \times 365 \text{ days/yr}$$

$$\text{Inventory Turnover} = \frac{\text{Cost of goods sold}}{\text{Inventory}}$$

Example 3: PC Industry

	Dell	Lenovo	Apple	HP
Revenue (billion $)	$56.94	$33.87	$170.91	$111.85
Net income (billion $)	$2.37	$0.64	$37.04	$5.11
Inventory (billion $)	$1.38	$1.96	$1.76	$6.05
COGS (billion $)	$44.75	$29.80	$106.61	$85.79
Days of inventory				

Source: *finance.yahoo.com*

Example 3: PC Industry

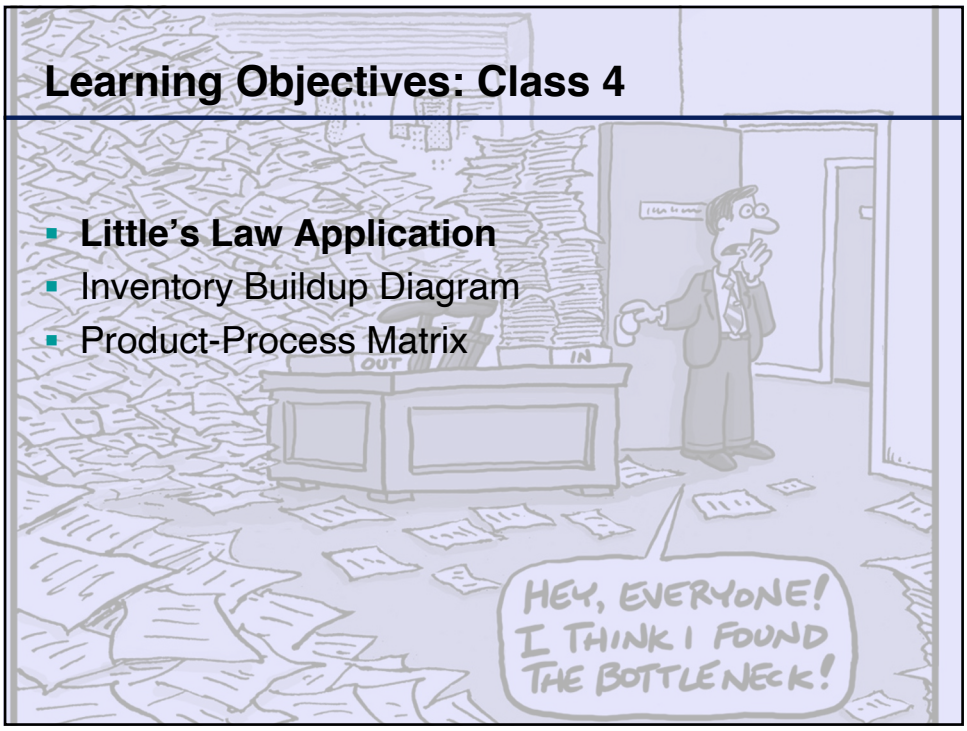
	Dell	Lenovo	Apple	HP
Revenue (billion $)	$56.94	$33.87	$170.91	$111.85
Net income (billion $)	$2.37	$0.64	$37.04	$5.11
Inventory (billion $)	$1.38	$1.96	$1.76	$6.05
COGS (billion $)	$44.75	$29.80	$106.61	$85.79
Days of inventory	**11.25**	**24.00**	**6.02**	**25.74**

Source: *finance.yahoo.com*

Practice Example 4: Days Sales Outstanding

- DSO measures how quickly a company collects revenue after a sale has been made.
- Samsung sells $300 million worth of cellular equipment per year. The average accounts receivable in the cellular group is $45 million. What is the average DSO?
- R = $300 million/year
  I = $45 million
  T = I / R = 0.15 year = 55 days

Learning Objectives: Class 4



- **Little's Law Application**
- Inventory Buildup Diagram
- Product-Process Matrix

Three Measures of Process Performance Example

	US Immigration	Champaign Industry	Masters of BA Program	Large PC Manufacturer
Flow Unit	Immigration applications	Bottle of champagne	Masters Student	Computer
Flow rate/throughput	6.3 million/year (approved or rejected cases)	260 million bottles/year	600 students/year	5000 units/day
Flow time	7.6 months (average processing time)	3.46 years	3 years	10 days
Inventory	4.0 million cases (pending)	900 million bottles	1800 students	50000 computers

- Decrease Flow time
- Increase Throughput rate (Capacity)
- Decrease Inventory

1. Increase Process Capacity Rate

- Be more productive, i.e., produce/serve more within a certain time period
- Why is it important?

  Nearly two years after the Wii's launch, U.S. consumers still can't walk into a retailer such as Best Buy or Wal-Mart and pick one up off the shelf. Online retailers haven't done much better, though secondary market sites like eBay have Wii consoles in stock—for a price jacked up from the $249.99 retail cost of the console. (Other sites, like Newegg, require customers to buy Wii "bundles," which can total nearly $500.)
- Among several speculative explanations of shortage:

  packaging problems

Practical Ways to Increase Capacity

	Labor	Machine
Long - term	Cross-train workers Hire or lay off workers	Invest in new equipment Outsourcing Develop the flexibility Improve the reliability
Medium - term	Subcontracting Flexible time	Reduce setup time Preventive maintenance Subcontracting
Short - term	Employ part-time workers Use overtime Add Shifts	Priority management

2. Reduce Process Flow Time

- **Be more responsive, i.e., produce/serve a unit within a short time period**

ZARA

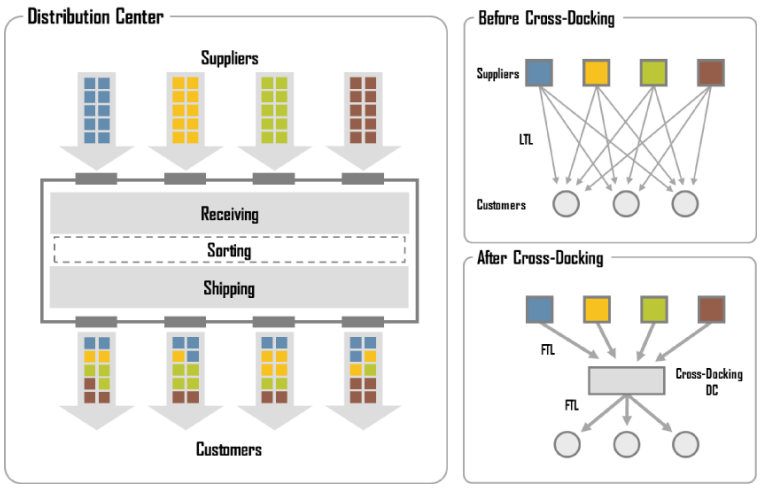
- **How responsiveness can contribute?**

Something (you might not know) about ZARA

- Zara was described by Louis Vuitton fashion director Daniel Piette as "possibly the most innovative and devastating retailer in the world."
- Zara can offer considerably more products than similar companies. It produces about 11,000 distinct items annually compared with **2,000 to 4,000** items for its key competitors
- The company can design a new product and have finished goods in its stores in four to five weeks; it can modify existing items in as little as two weeks, compared to a **six-month** industry average

3. Reduce Inventories

Example: Cross Docking at Walmart



Little's Law and Business Functions

	Performance Measures	Effects seen in
Inventory	Use of Working Capital	Balance Sheet
Throughput **R**ate	Rate of Revenue Generation	Income Statement
Flow **T**ime	Responsiveness Lead time	Operations Marketing