Data Analytics in Business

Operations Management

Bob Myers
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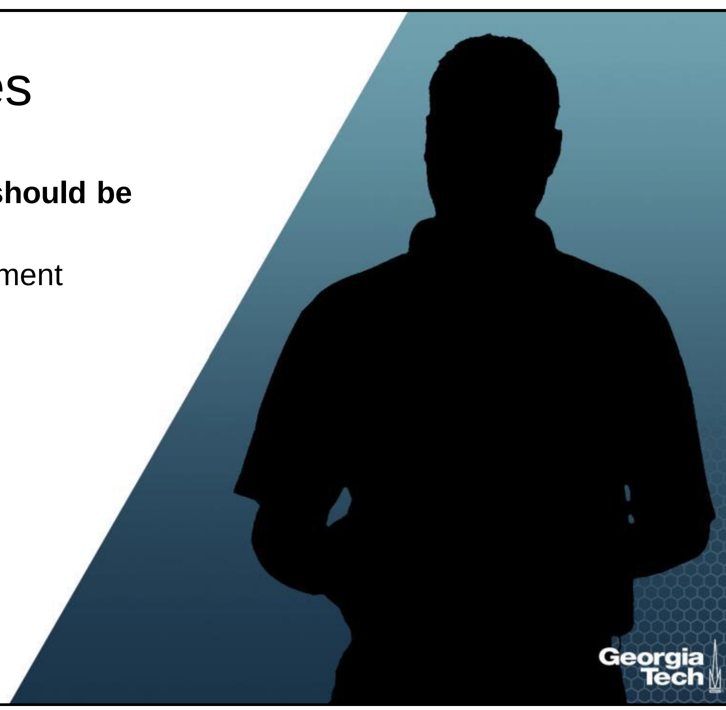
What is Operations Management?

Learning Objectives

At the end of this lesson, you should be able to:

- Describe Operations Management



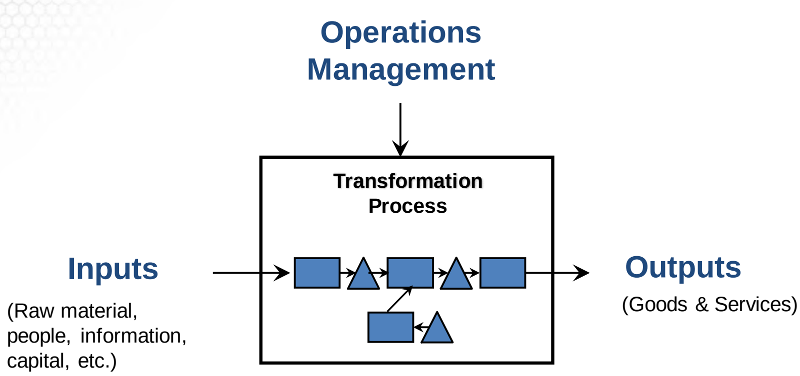
What is Operations Management?

OM = How to make stuff?

- Stuff = cars, gadgets, clothes, medicine, food, medical procedures, transportation services, education, online retailing, etc…
- How to make it **well**, **on time**, at **low cost**, & enough to **meet customer demand**

Operations management is the management (design, operation, and improvement) of the processes that transform material, labor, energy, and information into goods and services

What is Operations Management?



What Types of Decisions in OM?

Strategic Decisions (long-term impact)

- Product/Process Selection
- Location
- Capacity

Tactical Decisions (mid-term impact)

- Number of employees, number of hours worked
- Inventory levels
- Order quantity and frequency

Operational Decisions (short-term impact)

- Job scheduling
- Priorities

Strategic Decisions

Strategic questions that operations managers ask and respond to…

- How much capacity do we need? <u>Manufacturing</u>
- How should our staff be trained? <u>Services</u>
- Which projects should we invest in? <u>Prod. Dev.</u>

Tactical Decisions

Tactical questions that operations managers ask and respond to…

• Should we have finished goods inventory or should we make to order?	Manufacturing
• What types of queues should we employ at Hartsfield-Jackson International Airport?	Services
• Do we need to exchange preliminary design information with manufacturing?	Prod. Dev.

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Operational Decisions

Operational questions that operations managers ask and respond to…

• Which part should we make in machine A first?	Manufacturing
• Should the service system be first come first serve?	Services
• What is the critical path of this project?	Prod. Dev.

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Goal of Operations Management

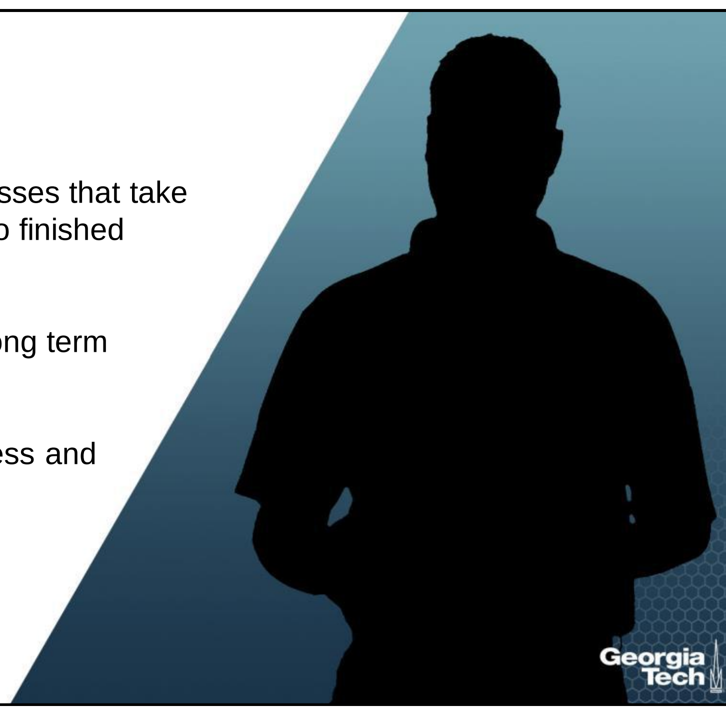
What is the goal of OM with respect to production and service systems?

1.	Improve Efficiency	Efficiency is doing something at the lowest possible cost
2.	Improve Effectiveness	Effectiveness is doing appropriate things to create value for an organization
3.	Increase Value	Value = “quality” / ”price”

Usually, these things require a tradeoff!

Summary

1. Direction and control of processes that take inputs and transform them into finished goods and services.
2. Involves short, medium and long term decisions.
3. Improve efficiency, effectiveness and value.



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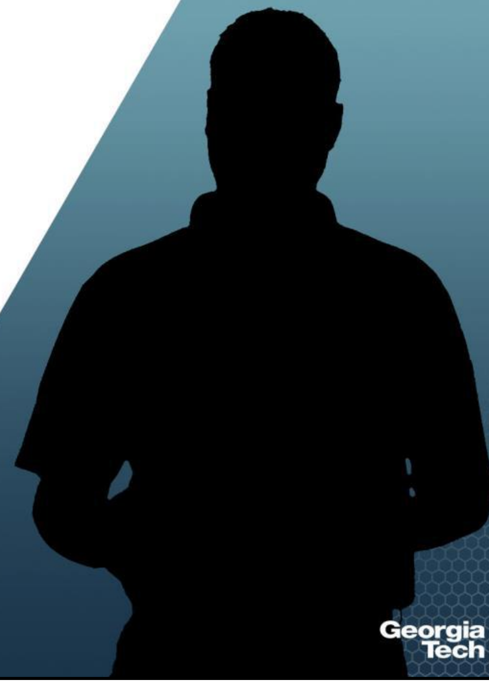
Importance of Operations Management



Learning Objectives

At the end of this lesson, you should be able to:

- Discuss the importance of Operations Management

Added Value of Operations Management

- 800 publicly traded firms studied over a 10 year period to examine impact of supply chain disruptions
  - 107% drop in operating income
  - 114% drop in return on sales
  - 93% drop in return on assets
  - 7 % lower sales growth
  - 11% increase in costs
  - 14% increase in inventory
- 33%-40% lower stock returns relative to industry
- 13.5% increase in stock price volatility

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Added Value of Operations Management

- Reasons for supply chain disruption
  - 31% internal (equipment breakdown, manufacturing problems, quality problems, inaccurate inventory records, poor forecasting, capacity or labor shortages)
  - 14.5% supplier failures
  - 12.8% customers
- Part Shortages
  - Underperformance by 25%
  - Median decrease in operating income of 31%

Hendricks and Singhal, "The Effect of Supply Chain Disruptions on Long-term Shareholder Value, Profitability, and Share Price Volatility

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Knowledge of OM is Essential to ALL Fields:

- **Accounting** – Cost Accounting
- **CIS** – Information Flows in Processes
- **Entrepreneurship** – Operations Feasibility
- **Finance** – NPV of New Projects
- **Law** – Pollution from Manufacturing
- **Marketing** – Pricing and Delivery Promises
- **OB/HR** – Job Design
- **Strategy** – Product Positioning and Operational Capability

Example 1

What the cluck? KFC runs out of chicken

By Ruth Brown February 19, 2018 | 12:29pm | Updated

"We've brought a new delivery partner on board, but they've had a couple of teething problems — getting fresh chicken out to 900 restaurants across the country is pretty complex!"

The company recently switched from a specialist food-delivery company to German shipping giant DHL, which promised in October to "set a new benchmark for delivering fresh products to KFC in a sustainable way."

Instead, DHL conceded that it has had "operational issues" in recent days, which resulted in "incomplete or delayed" bird deliveries.

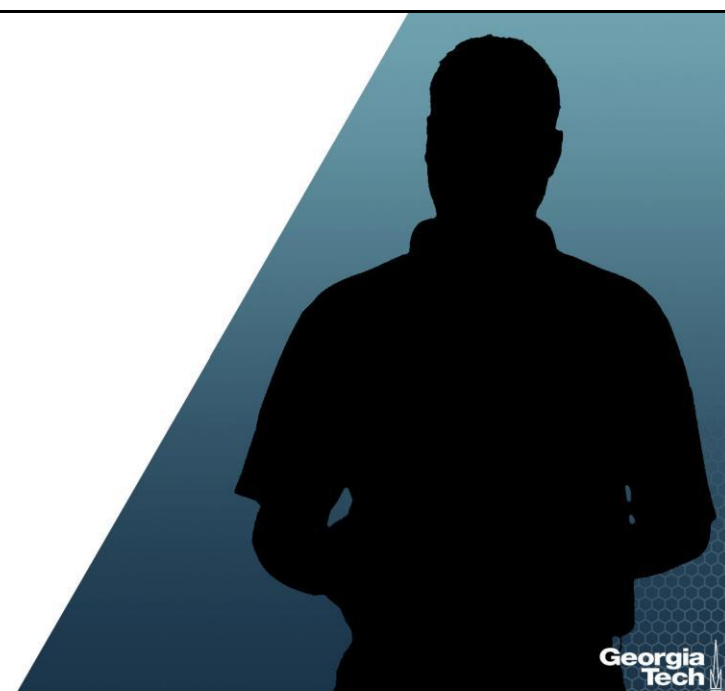
Example 2

By **REUTERS** April 17, 2016

Toyota, the world's biggest-selling automaker, said on Sunday it would suspend much of its production at plants across Japan this week after earthquakes in the country's south led to a shortage of parts, while some other manufacturers extended stoppages due to damage to factories.

Summary

1. Operations is essential to all Business fields



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Future of Operations Management

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Future of Operations Management

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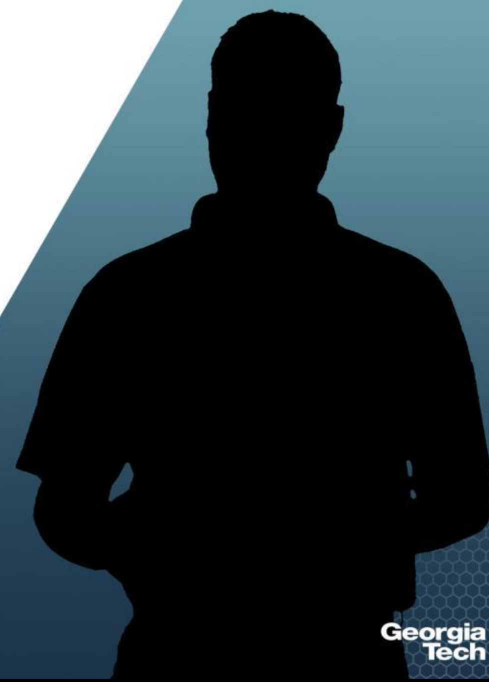
Learning Objectives

At the end of this lesson, you should be able to:

- Discuss technology trends that will impact operations management in the future



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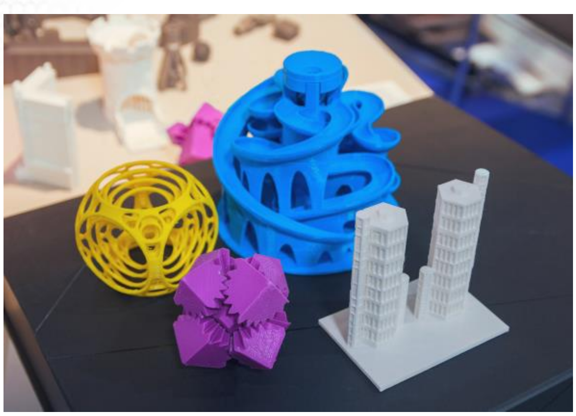
3D Printing



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Artificial Intelligence

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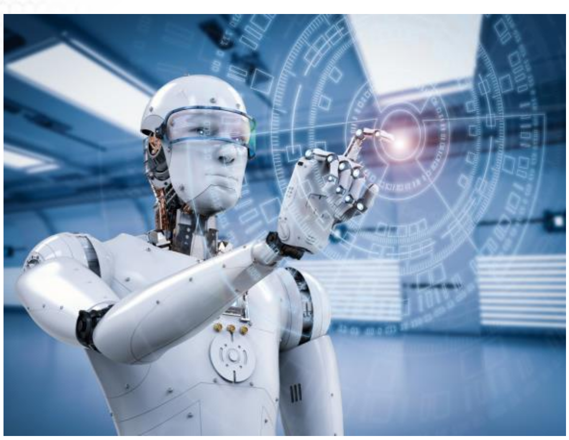
Robotics



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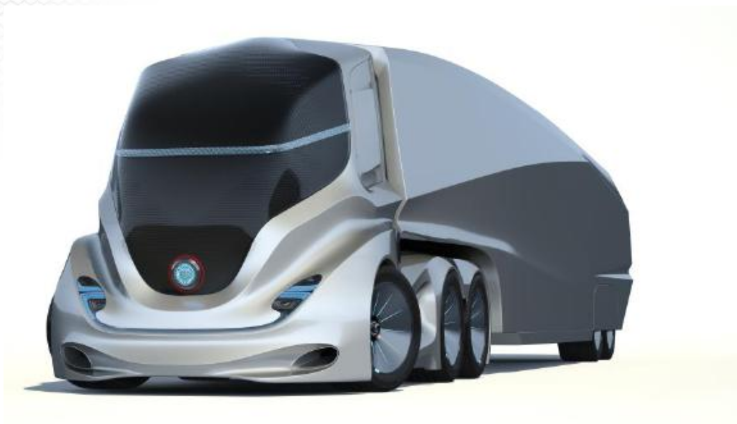
Autonomous Vehicles



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See Some Similarities?

- All of these have large amounts of data and calculations underlying them. Meaning the need for Analytics!

  These will fundamentally, radically change how companies do business.

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Summary

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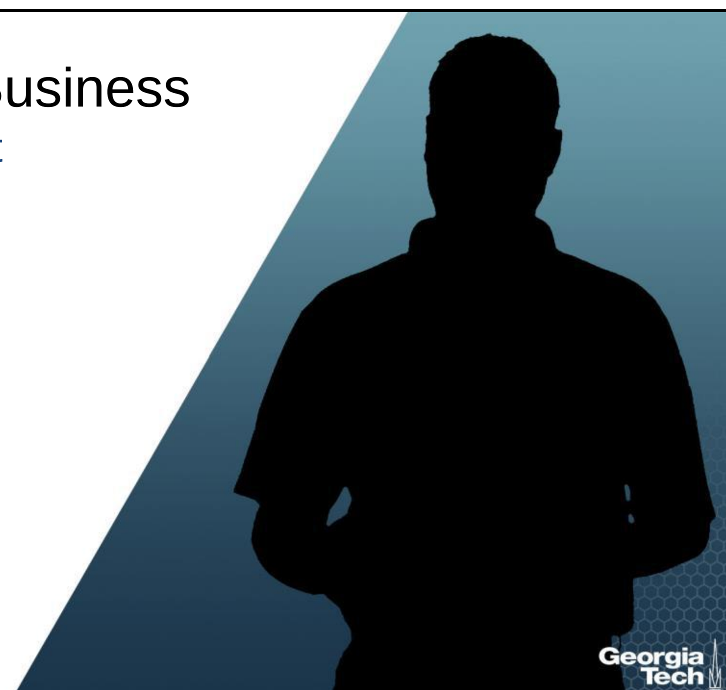
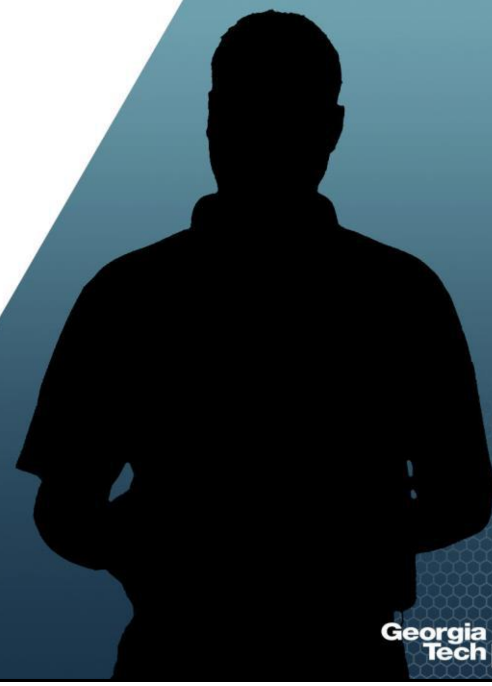
Queueing Theory Basics



Learning Objectives

At the end of this lesson, you should be able to:

- Illustrate the key parts of a waiting line/queue

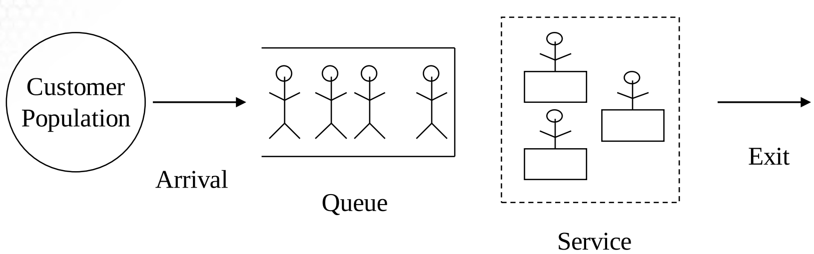


Queues (Lines)

Suggestions for Managing Queues

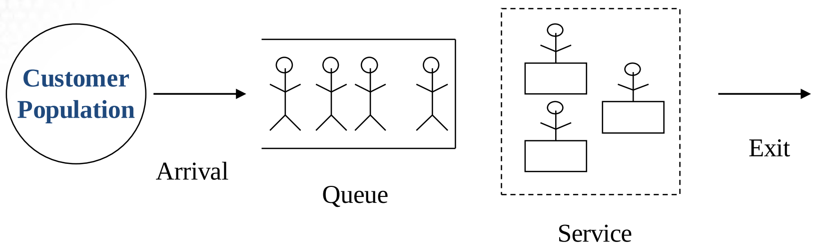
- Determine an acceptable waiting time for your customers
- Try to divert the customer's attention when waiting
- Inform the customer of what to expect
- Keep employees not serving the customers out of sight
- Segment the customers
- Train your employees to be friendly
- Encourage customers to come during off-peak times
- Take a long-term perspective towards minimizing queues

Queuing Systems: Key Concepts



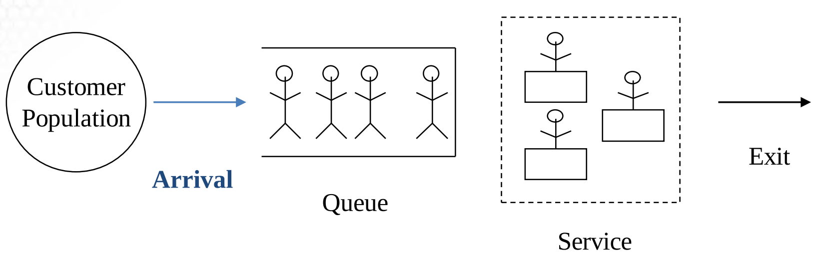
- Assume the system is running at steady state

Queuing Systems: Key Concepts



- **Customer Population**
  - Finite
  - Infinite

Queuing Systems: Key Concepts



- **Arrival Rate (λ)**
  - Constant
  - Variable
  - Example: 1 customer enters every 6 minutes

Modeling Variable Arrival Rates

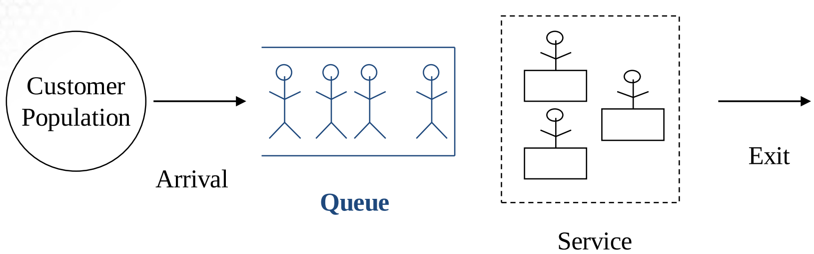
- Does the time between successive arrivals follow some statistical distribution?
  - Exponentially distributed interarrival time

$$f(t) = \lambda e^{-\lambda t}$$

- How many arrivals might enter the system within a time period T?
  - Poisson distributed arrivals per unit time

$$P_T(n) = \frac{(\lambda T)^n e^{-\lambda T}}{n!}$$

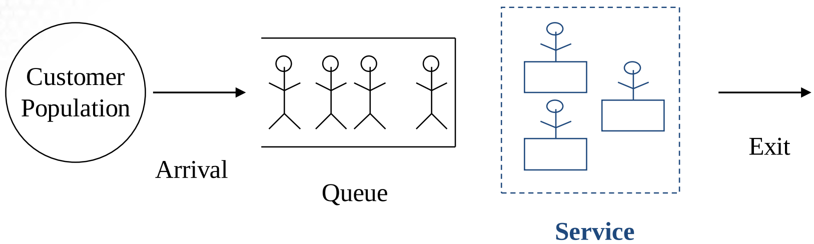
Queuing Systems: Key Concepts



- **Line Length**
  - Finite or Infinite
- **Number of Lines**

- **Queue Discipline**
  - FCFS
  - Reservations First
  - Highest Profit First

Queuing Systems: Key Concepts



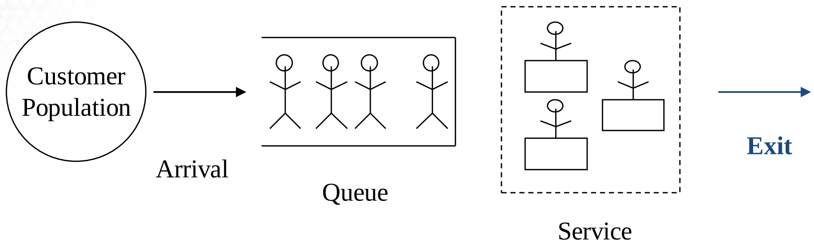
- **Service Rate** (μ)
  - Constant
  - Variable
  - Example: 12 customer served per hour
- **Number of Channels**
- **Number of Phases**

Modeling Variable Service Rates

- Does the service time follow some statistical distribution?
  - Exponentially distributed service time

$$f(t) = \mu e^{-\mu t}$$

Queuing Systems: Key Concepts



- **Probability of reservice**
  - Low
  - High

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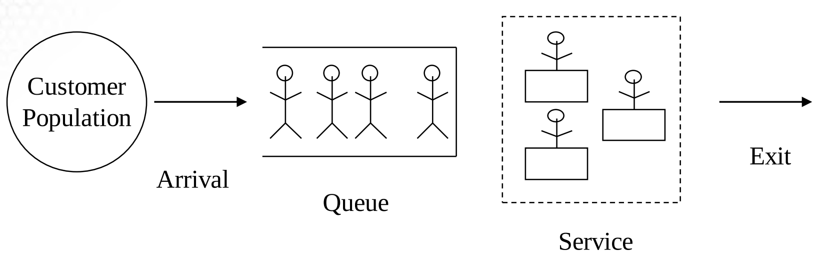
Queuing Systems: Key Concepts



- Assume the system is running at steady state

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Summary

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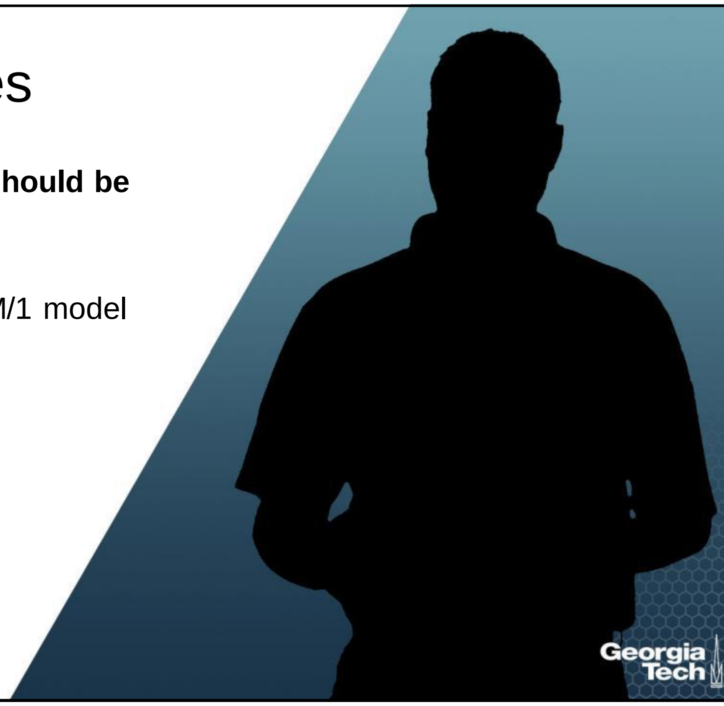
Queueing Theory M/M/1 Model

Learning Objectives

At the end of this lesson, you should be able to:

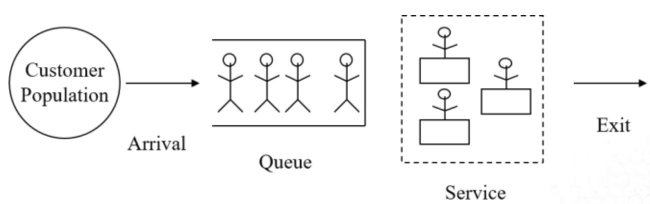
- Describe the M/M/1 model
- Solve a problem using the M/M/1 model



M/M/1 Model

- Assumptions:
  - Infinite Customer Population
  - Random Arrivals (Poisson)
  - Unlimited Queue Length
  - Single Line
  - FCFS
  - Single Channel (Exponential)
  - Single Phase

    Examples:
    - 1 lane toll bridge with manual pay
    - Drive Thru lane at McDonalds



M/M/1 Equations

Utilization

$$\rho = \frac{\lambda}{\mu}$$

Average # of customers in the system

$$L_s = \frac{\lambda}{\mu - \lambda}$$

Average # of customers in queue

$$L_q = \frac{\lambda^2}{\mu(\mu - \lambda)} = L_s * \rho$$

Average time a customer spends in the system

$$W_s = \frac{1}{\mu - \lambda} = \frac{L_s}{\lambda}$$

Average time a customer spends in the queue

$$W_q = \frac{\lambda}{\mu(\mu - \lambda)} = \frac{L_q}{\lambda}$$

Probability of n units in the system

$$P_n = (1 - \frac{\lambda}{\mu})(\frac{\lambda}{\mu})^n = (1-\rho)(\rho)^n$$

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Example Problem

10th Street Bank is considering opening a drive-through window for customer service. Management estimates that customers will arrive at the rate of 15 per hour. The teller who will staff the window can service customers at the rate of one every three minutes.

Assuming Poisson arrival and exponential service times, calculate performance metrics of this queue.

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Solution

Utilization

$\rho = \frac{\lambda}{\mu}$ = 15/20 = **75%**

Average # of customers in the system

$L_s = \frac{\lambda}{\mu - \lambda}$ = 15/(20-15) = **3 customers**

Average # of customers in queue

$L_q = \frac{\lambda^2}{\mu(\mu - \lambda)} = L_s * \rho$ = 3*.75 = **2.25 customers**

Average time a customer spends in the system

$W_s = \frac{1}{\mu - \lambda} = \frac{L_s}{\lambda}$ = 3/15 = .2 ➔**12 min**

Average time a customer spends in the queue

$W_q = \frac{\lambda}{\mu(\mu - \lambda)} = \frac{L_q}{\lambda}$ = 2.25/15 = .15 ➔ **9 min**

Example Problem - Continued

Because of limited space, the banker would like to ensure with a 95% confidence (or service level) that no more than 3 cars will be in the system at any time. What confidence exists currently for no more than 3 cars? What rate would the teller need to operate at in order to meet a 95% service level? What would be the utilization at this point?

Solution - Continued

Probability of n units in the system

$$P_n = (1-\frac{\lambda}{\mu})(\frac{\lambda}{\mu})^n = (1-\rho)(\rho)^n$$

r = 15/20 = .75

Probability of 0 cars in line:

$P_0 = (1-.75)(.75)^0 = .25$

Probability of 1 car in line:

$P_1 = (1-.75)(.75)^1 = .188$

Probability of 2 cars in line:

$P_2 = (1-.75)(.75)^2 = .141$

Probability of 3 cars in line:

$P_3 = (1-.75)(.75)^3 = .105$

Likelihood of 3 or fewer cars = $P_0+P_1+P_2+P_3$= .25+.188+.141+.105 = .684
➔ **68.4%**

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Solution - Continued

For a 95% service level, want:

$P_0+P_1+P_2+P_3$= .95

Writing out formulas for left side in terms of r will simplify to:

1- r^4 = .95 ➔ r = .47

Recall:

r = l/m ➔ .47 = 15/m ➔ **m= 32 people per hour**

Note a service rate of 32 people/hr equates to a 53% utilization rate

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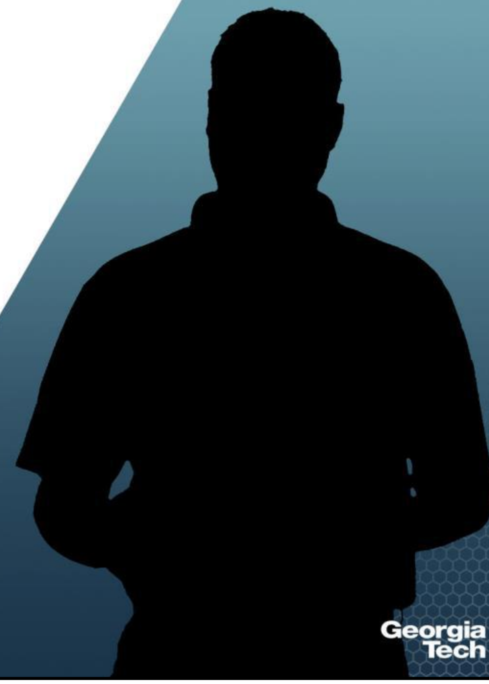
Summary



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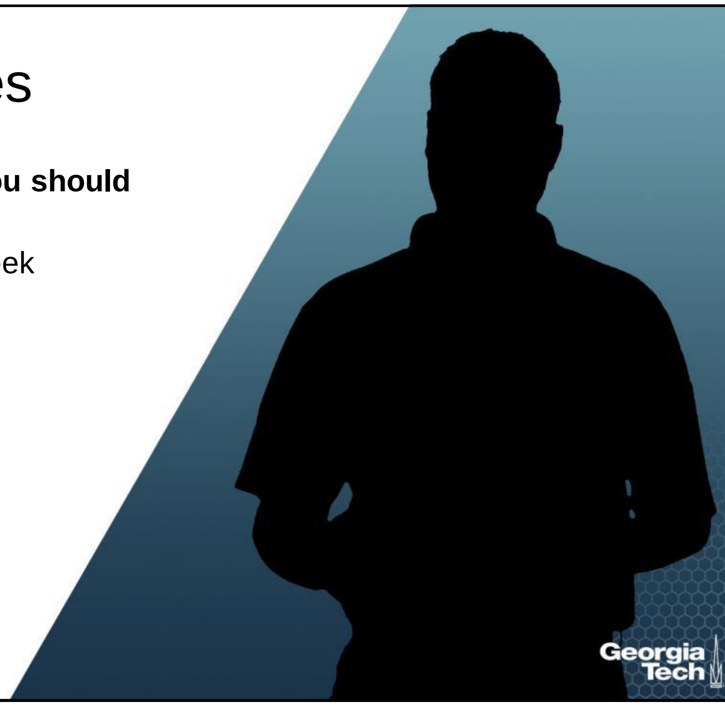
Recap

Learning Objectives

- **At the end of this lesson, you should be able to:**
- List the topics covered this week



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Recap

- Operations management is the direction and control of the processes that transform material, labor, energy, and information into finished goods and services.
- Operations management is at the core of every company.
- Several technologies maturing that promise to radically change how companies transform inputs. Analytics will be key here.
- Queuing theory can be used to analyze waiting lines.

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