Queuing Theory: An Introduction

"Delay is the enemy of efficiency" and "Waiting is the enemy of utilization"

CSE-3207:Mathematical Analysis for computer science.Credits: 3, ConHours: 3

Syllabus:

Stochastic processes, Discrete time Markov Chain and continuous time Markov chain, birth death process in queuing.

Queuing models: M/M/1, M/M/C, M/G/1, M/D/1, G/M/1 solution of network of queue-closed queuing models, approximate solution methods, Application of queuing models in Computer Science.

Books:

1. Kishor S. Trivedi: **Probability and Statistics with Reliability, Queuing and Computer Science Applications**. (Prentice-Hall)
2. Arnold O. Allen: **Probability, Statistics, and Queuing Theory with Computer Science Applications**. (2nd Edition, Academic Press Inc.)

Overview

- What is queuing theory?
- Examples of Real World Queuing Systems?
- Queuing problems arises because either
- Basic elements of Queuing System
- Queuing Models Calculate
- Queuing examples
- Applications of Queuing Theory

What is Queuing Theory?

- Queuing theory is the mathematics of waiting lines.
- It is extremely useful in predicting and evaluating system performance.
- Queuing theory has been used for operations research, manufacturing and systems analysis.
- Traditional queuing theory problems refer to customers visiting a store, analogous to requests arriving at a device.

Examples of Real World Queuing Systems?

- **Commercial Queuing Systems**
  - Commercial organizations serving external customers
  - Ex. Dentist, bank, ATM, gas stations, plumber, garage …
- **Transportation service systems**
  - Vehicles are customers or servers
  - Ex. Vehicles waiting at toll stations and traffic lights, trucks or ships waiting to be loaded, taxi cabs, fire engines, buses …
- **Business-internal service systems**
  - Customers receiving service are internal to the organization providing the service
  - Ex. Inspection stations, conveyor belts, computer support …
- **Social service systems**
  - Ex. Judicial process, hospital, waiting lists for organ transplants or student dorm rooms …

QUEUING PROBLEMS ARISES BECAUSE EITHER

There is too much demand on the facilities

(Much waiting time or inadequate number of service facilities)

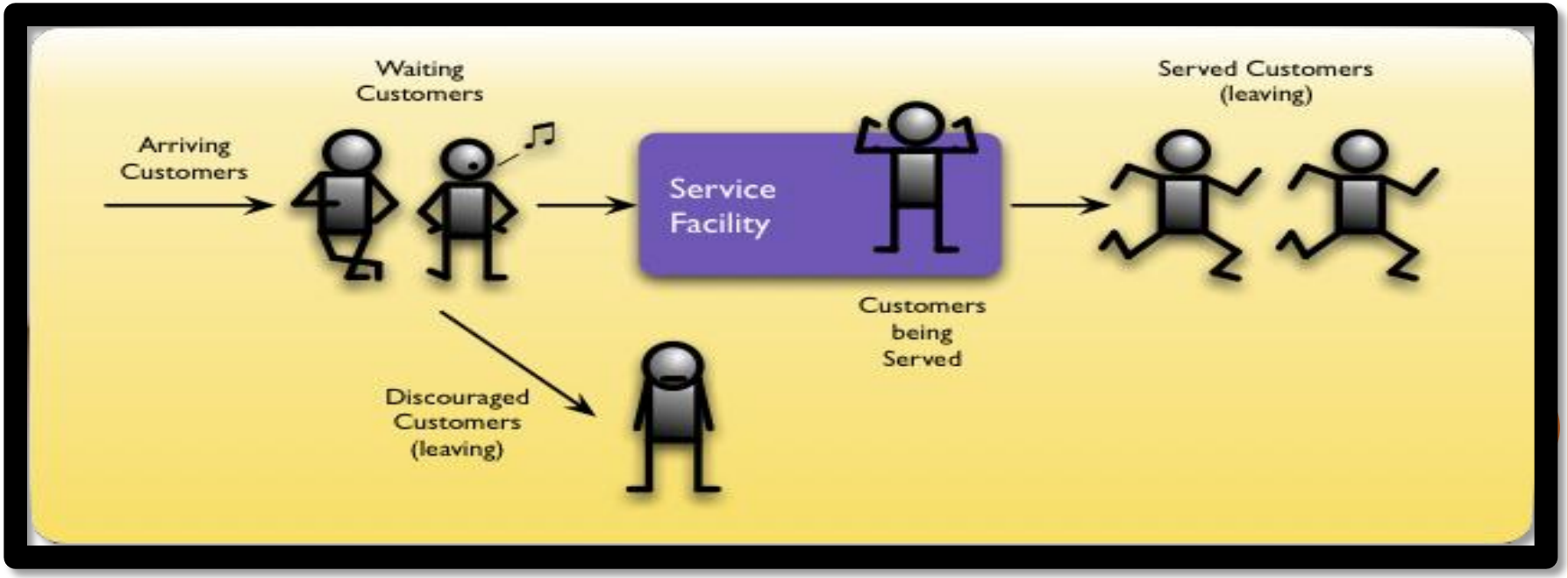
There is too less demand

(Much idle facility time or too many facilities)

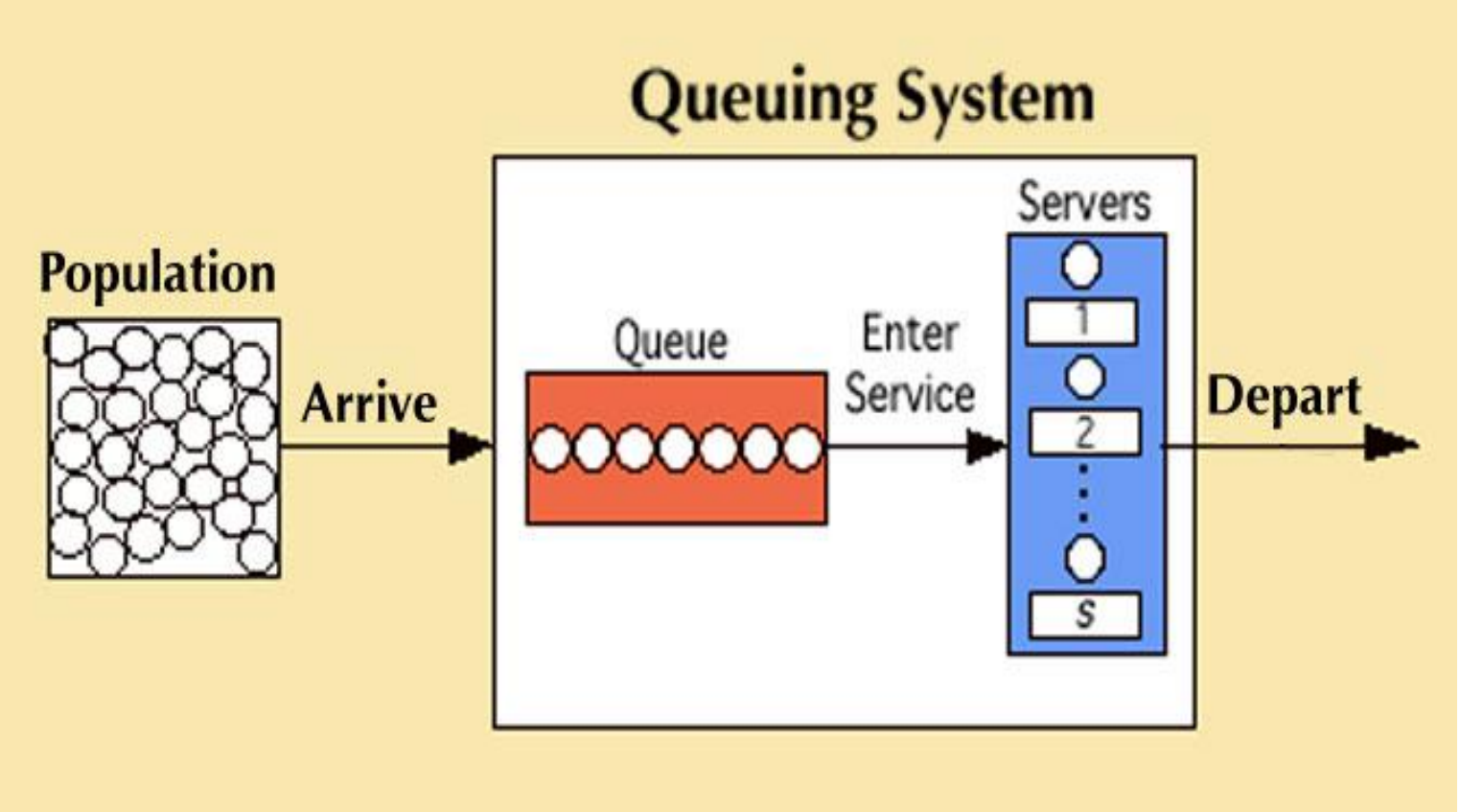
The problem is to either **schedule arrivals or provide extra facilities or both** so as to obtain an optimum balance between costs associated with waiting time and idle time .

Basic elements of Queuing System

- **Entries or Customers:** refers to anything that arrives at a facility and requires service, e.g., people, machines, trucks, e-mails, etc.
- **Queue:** waiting lines
- **Service Channels or Service Facility:** refers to any resource that provides the requested service, e.g., repairpersons, retrieval machines, runways at airport, etc.



Basic Structure



Assumptions

- Independent arrivals
- Exponential distributions
- Customers do not leave or change queues.
- Large queues do not discourage customers.

Many assumptions are not always true, but queuing theory gives good results anyway

Queuing Models Calculate

- Average number of customers in the system waiting and being served
- Average number of customers waiting in the line
- Average time a customer spends in the system waiting and being served
- Average time a customer spends waiting in the waiting line or queue.
- Probability of no customers in the system
- Probability of n customers in the system
- Utilization rate: The proportion of time the system is in use

QUEUING EXAMPLES

System	Customers	Server
Reception desk	People	Receptionist
Hospital	Patients	Nurses
Airport	Airplanes	Runway
Road network	Cars	Traffic light
Grocery	Shoppers	Checkout station
Computer	Jobs	CPU, disk, CD

Applications of Queuing Theory

- Telecommunications
- Traffic control
- Determining the sequence of computer operations
- Predicting computer performance
- Health services (e.g.. control of hospital bed assignments)
- Airport traffic, airline ticket sales
- Layout of manufacturing systems.


Thank You!