# 7. Service Systems [3] -- Demand/Capacity Management Models

**INFO 210 - 19 September 2007**
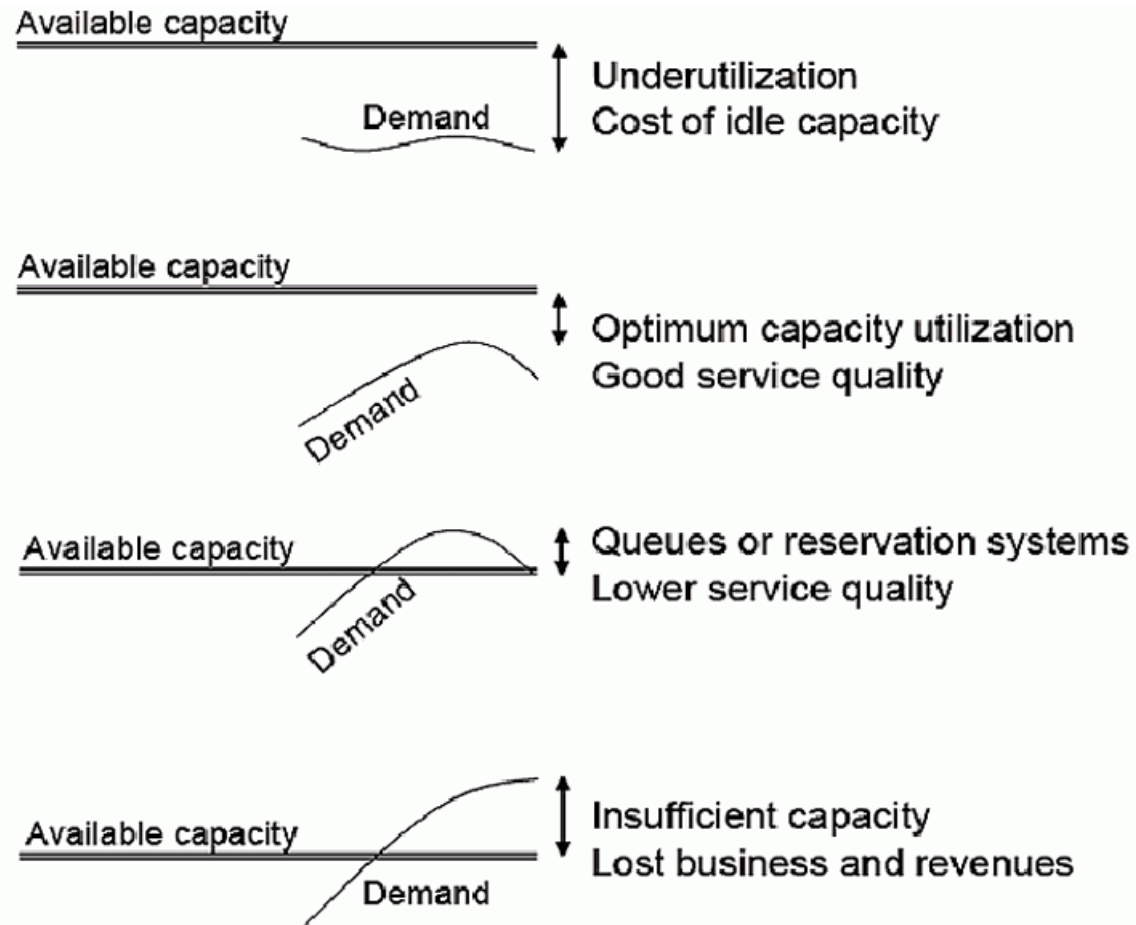
**Bob Glushko**

# Plan for Today's Lecture

Capacity Management

- Scheduling

Influencing and Managing Demand

- Managing Demand in Queues

- Call Centers

# Demand Vs Capacity - 4 Scenarios

# Capacity

Capacity in service operations is generally divided into *fixed (long-term)* and *variable (short-term)* components

Capacity is also categorized in terms of facilities, equipment, and labor

# Fixed Capacity

Fixed capacity is determined by physical resources like facilities, airplanes, beds, computers, classrooms...

These usually represent significant strategy choices and investments and take time to acquire and deploy

The fixed capacity investments largely determine the MAXIMUM CAPACITY of the service (hotel rooms, seats on airplane flights, checkout stations, call center telephone lines)

The OPTIMAL CAPACITY, the number of customers that can be served at a desired level of service, is always less than the MAXIMUM CAPACITY

# Strategy Considerations for Fixed Capacity Investments

Fixed capacity investments are often significant and irreversible

Fixed capacity is often added in large discrete units (airplanes, buildings,...) so it is impossible to match capacity with demand exactly

When to invest is a critical decision

Is it useful to distinguish fixed capacity for "back stage" operations from that for "front stage" operations?

# Variable Capacity for Fixed Investments?

Scheduling of equipment (airplanes, trains, buses) and deliveries (sequence, routing) is a critical issue in service design

If facilities and equipment can easily be reallocated, rescheduled, or reconfigured for different tasks or functions they can be viewed as variable capacity

Sharing of facilities or equipment increases the overall capacity of the service providers doing the sharing

Facilities, equipment, computing capacity can be rented/leased or obtained "on demand" from a service provider

# Labor Capacity

Labor is obviously the most variable resource of a service firm

Labor capacity is managed in many ways depending on the time horizon:

- Education, immigration policy, and other long-term factors shape labor capacity in the economy

- Hiring and internal training affect the long-term labor capacity of a firm

- Scheduling of service workers is the primary mechanism for adjusting variable capacity to address short-term variations in demand

- Queuing and routing of customers are mechanisms for managing capacity in real time

# The Vision of Scheduling



**THE WALL STREET JOURNAL. ONLINE**

**Wal-Mart Seeks
New Flexibility
In Worker Shifts**

By KRIS MAHER
*January 3, 2007*

The nation's biggest private employer is about to revamp the way it schedules its work force, in a move that could shake up many employees' lives.

Early this year, Wal-Mart Stores Inc., using a new computerized scheduling system, will start moving many of its 1.3 million workers from predictable shifts to a system based on the number of customers in stores at any given time. The move promises greater productivity and customer satisfaction for the huge retailer but could be a major headache for employees.

The change is made possible by a software system that can crunch an array of data, part of a shift toward computerized management tools that can help pare costs and boost companies' bottom lines. But it also could demand greater flexibility and availability from workers in place of reliable work shifts -- and predictable paychecks.

# The Reality of Scheduling

# Scheduling [1]

Short-term demand variability can be addressed via cross-training of workers

And by the use of part-time or temp workers, even in their own homes

Seasonable variation in demand for services that use low-skill / low-paid workers can also be met by hiring more of them

# Scheduling Challenges in Professional Services

Scheduling is less effective at handling variable demand for services that need highly-skilled and highly-paid professionals to deliver them

Professional services have significant variability in their resource requirements to begin with

There are also "non-linear effects in team formation, both super-additive and sub-additive"

Assignments are influenced not just by current needs, but by expected future requirement

# Influencing or Shifting Demand [1]

The most fundamental approach in managing demand is to shift it from periods when it exceeds service capacity (and quality is impaired) to periods of underutilized capacity (when quality can be much better)

PRICE DISCOUNTS for services provided at off-peak times or surcharges for peak times can significantly shift demand

Demand can also be shifted by offering a comparatively less attractive service package at peak times

BUNDLING -- offering a combination of several services at a reduced rate -- is another technique for increasing demand at off-peak times

# Influencing or Shifting Demand [2]

PROMOTION AND ADVERTISING can help by branding the idea that services at off-peak times are convenient and desirable (7/11 stores, 24-hour fitness, PSA "midnight flyer" )

RESERVATIONS enable a service provider to schedule or shift demand, and coupled with YIELD MANAGEMENT pricing mechanisms can either increase revenue or increase effective capacity

# Influencing or Shifting Demand [3]

SMOOTHING of demand is accomplished by moving any discretionary or schedulable services away from periods of high variable demand and toward periods of low variable demand

- Emergency calls and preventive action have different origins. Emergency calls are often highly uncertain and random, whereas preventive action can be planned

- But some "emergencies" are highly predictable

Demand can also be smoothed by RESOURCE POOLING, as in the case of a typing pool or a centralized call center that handles calls for numerous time zones or companies

LOYALTY PROGRAMS smooth demand by offering customers free or upgraded services that would otherwise go unused to increase their likelihood of buying services at other times

# Yield Management

For firms that provide services with high fixed costs and low variable costs (airlines, cruise ships, hotels, rental cars,amusement parks...) profitability is directly tied to their overall sales

So the firm wants to maximize its capacity utilization, even if it requires selling (or pre-selling) some of that capacity at reduced prices, as long as those prices exceed its variable costs
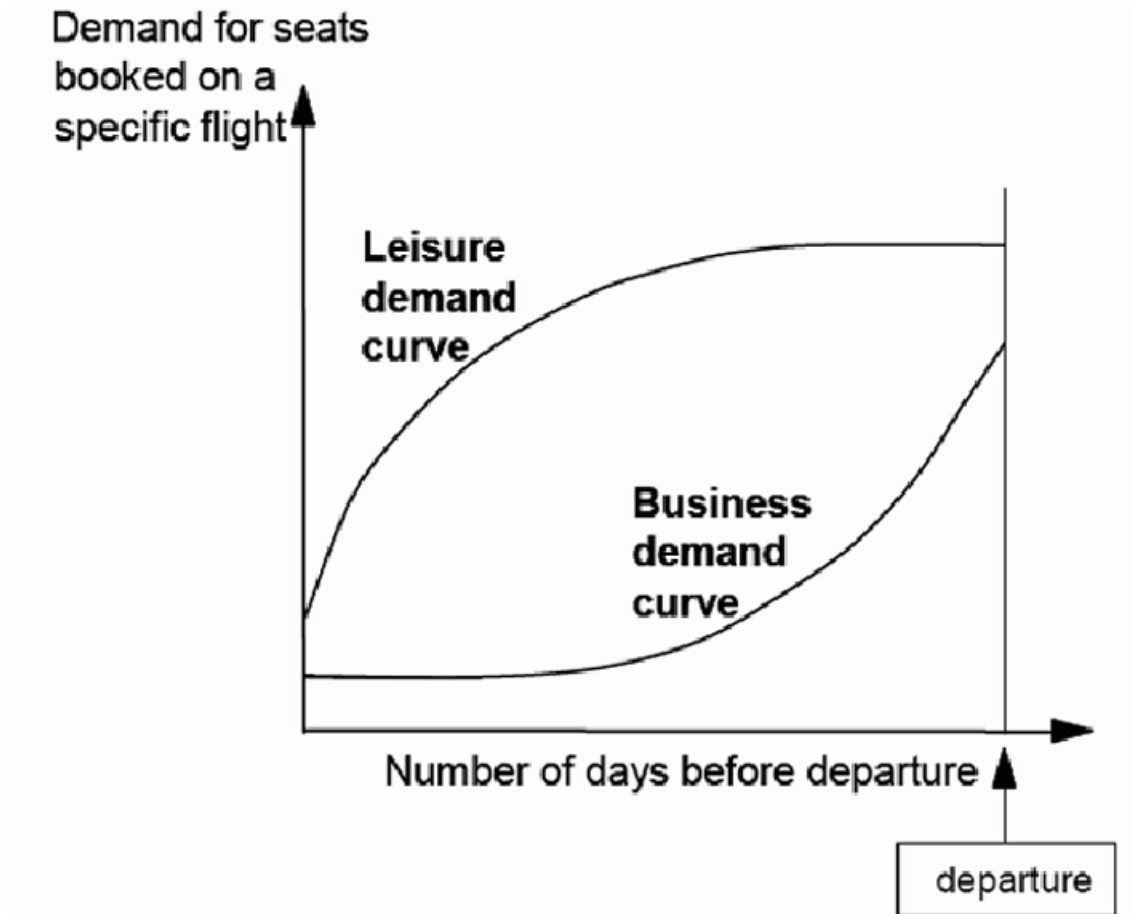
The essence of yield management is CUSTOMER SEGMENTATION

Yield management is simple in principle but requires substantial computing in practice
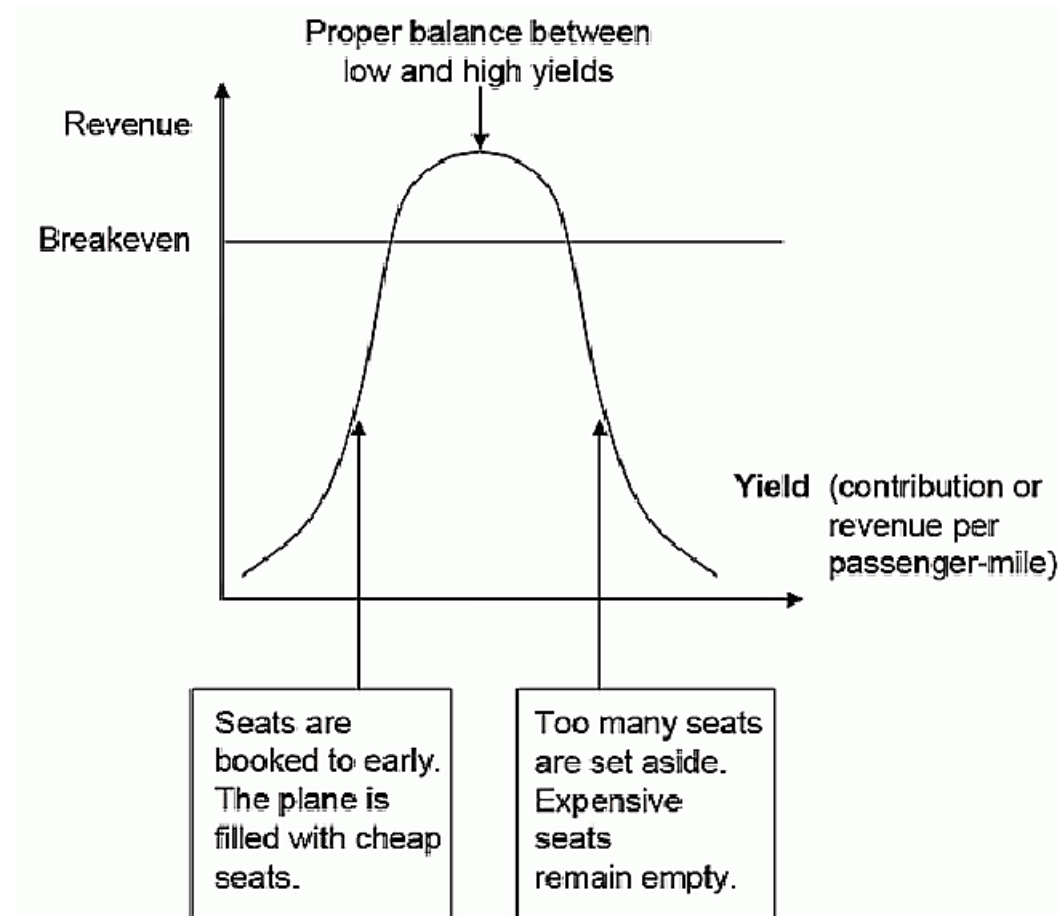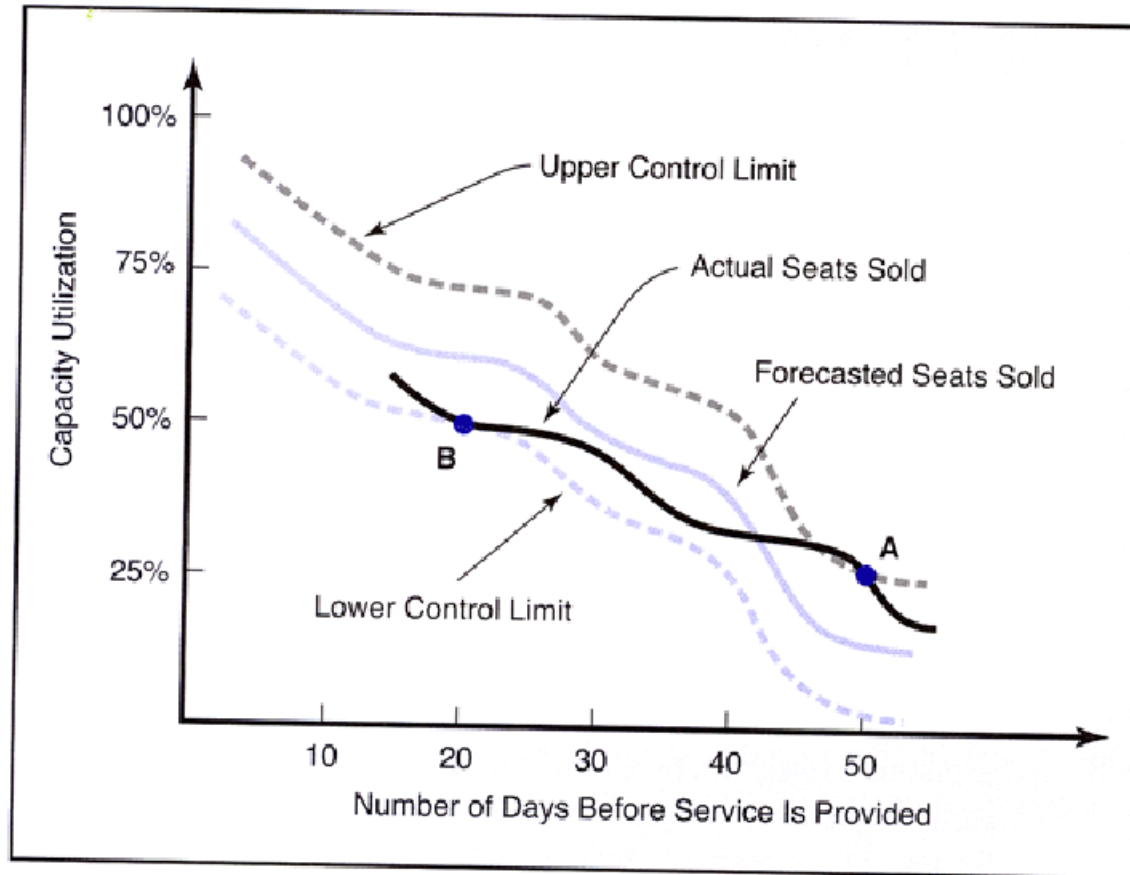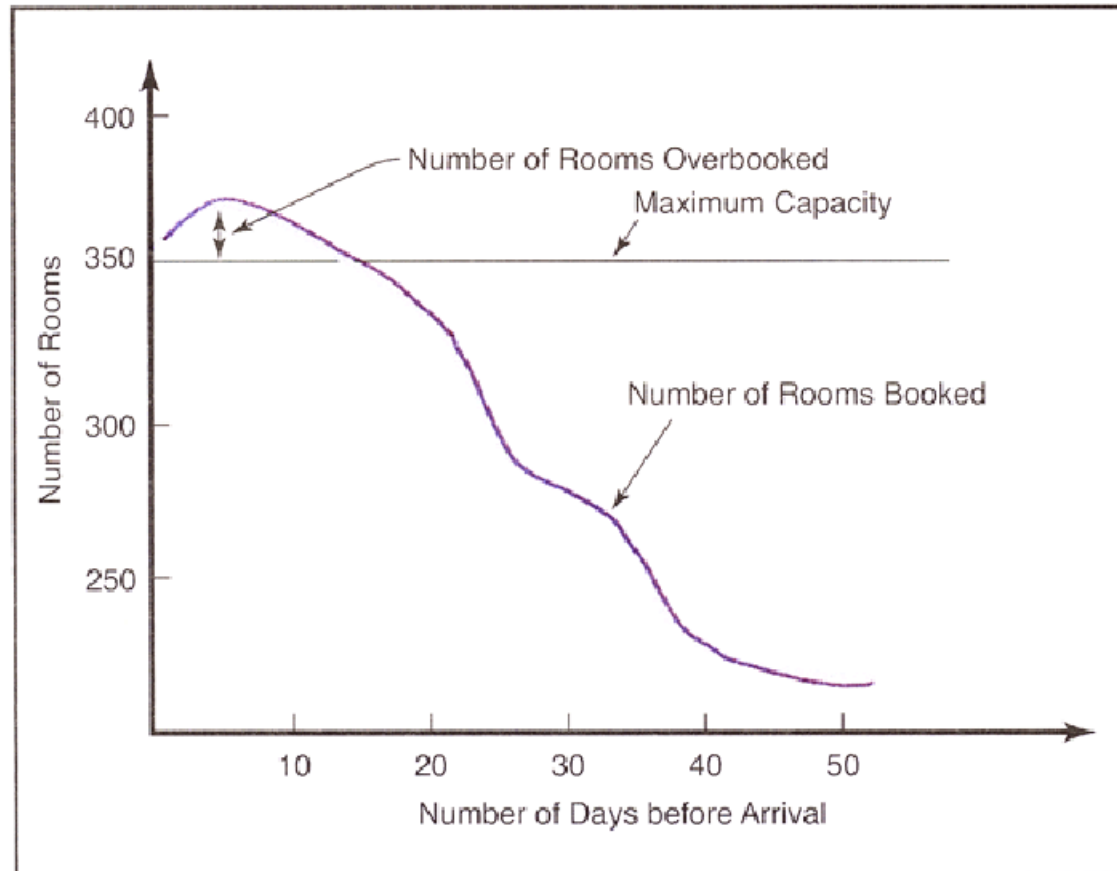
# Yield Management: Modeling the Customer

# Yield Management: Maximizing Profits

# Yield Management: The Booking Curve

# Yield Management: Overbooking

# Managing Demand in Queues

If demand and supply are still out of balance and there is no option to reserve in advance, customers have to wait in line, at the risk that some may leave and switch.

The advantage of queues for the service provider is that they keep personnel busy and facilities and equipment fully utilized.

As the rate of arrivals nears the service rate, the average length of the queue will quickly increase.

An imbalance of supply and demand has different impact on the front and back stages of a service system

# Toward Infinite Waiting
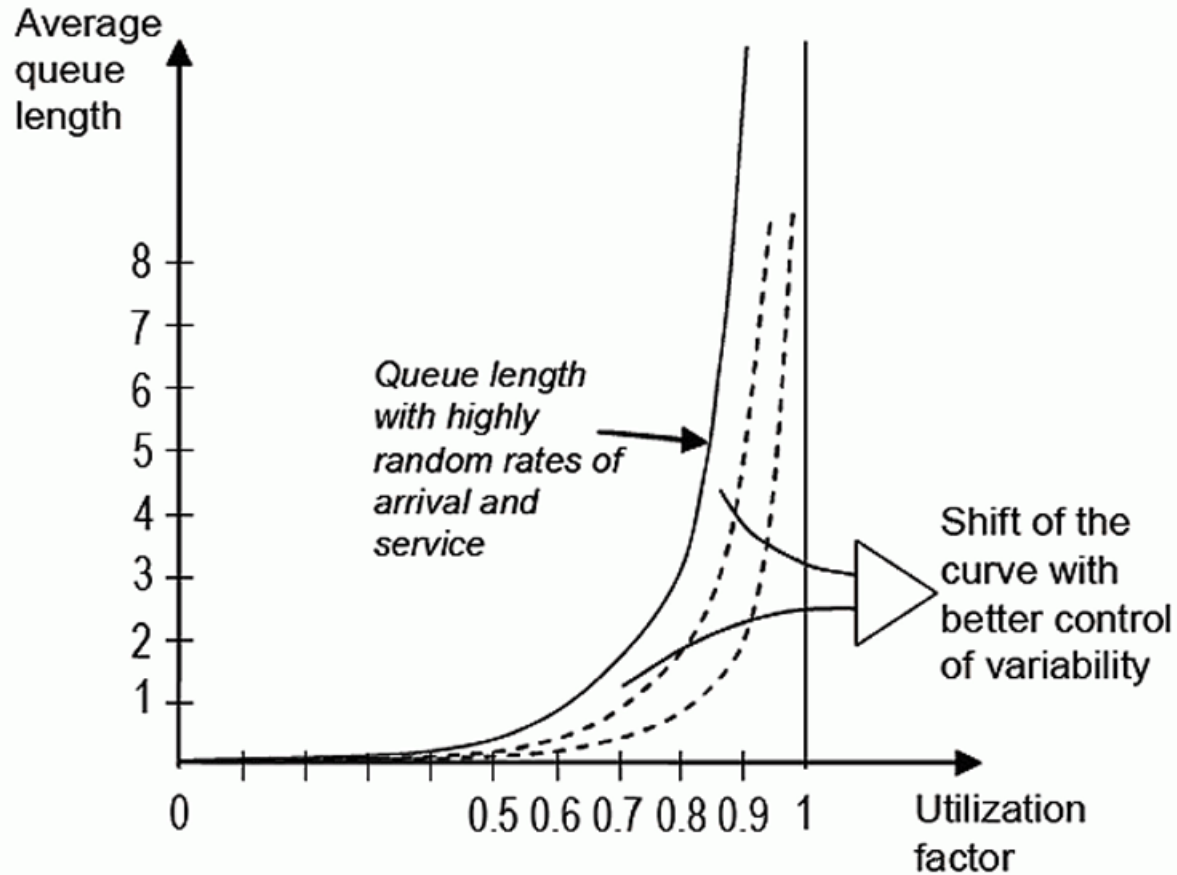
# Managing the Front Stage Queue: Configuration

The QUEUE CONFIGURATION refers to the number of queues, their locations and their layout (if spatial)

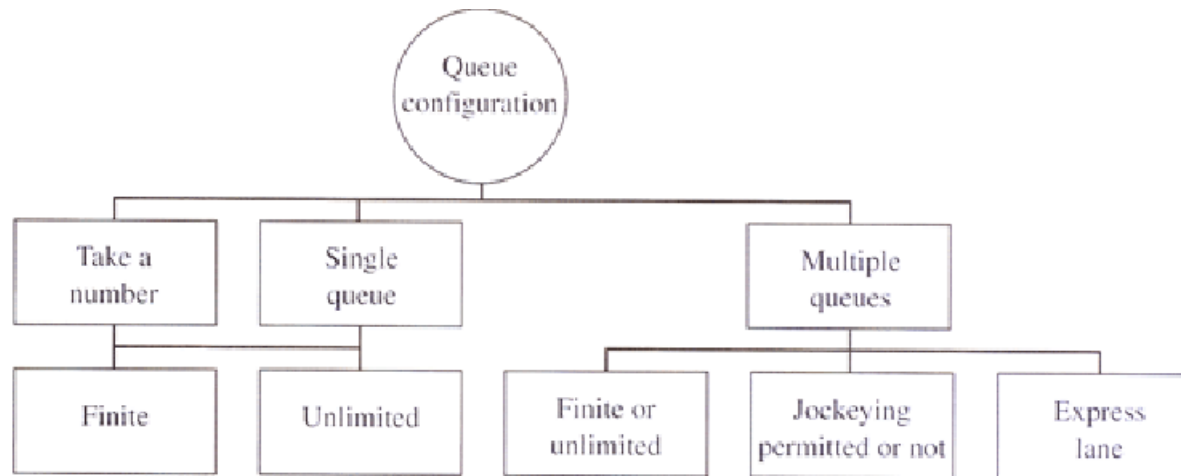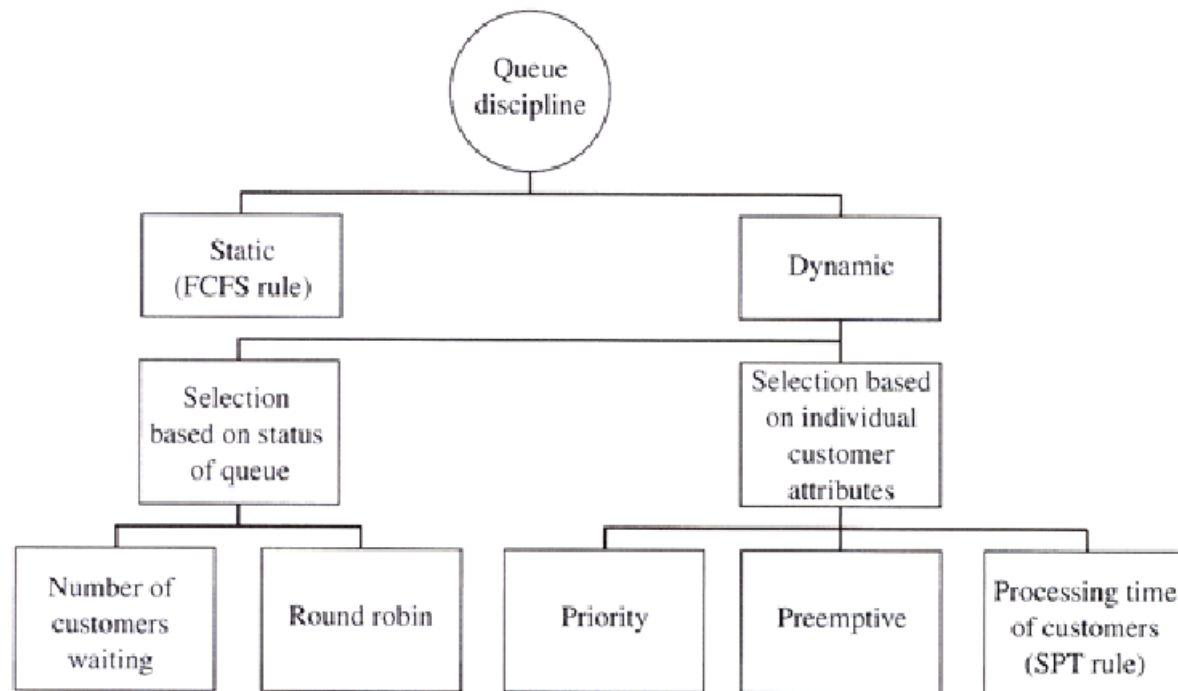The customer might have a choice of queue, and this choice may be irrevocable... but sometimes it isn't and people engage in *jockeying*

# Managing the Front Stage Queue: Discipline

The QUEUE DISCIPLINE is the policy for selecting the next customer from the queue

# Managing the Back Stage Queue

FCFS is often the policy for doing the back stage operations but other rules can be followed

Shortest processing time -- perform the service that will take the least amount of work to complete

Promised completion date or time -- perform the service that has the earliest due date

Start date -- perform the service that had the earliest start date

Slack time remaining -- perform the service on the job for which the amount of slack is the lowest (slack is the difference between the due date and the amount of work left to be done)

Managing to minimize the amount of idle capacity

# The Call/Contact Center

The call/contact center is classic example of a service system, where formal models and data collection dominate (queuing theory)

It is essential to model it as a service system because the quality of the "customer service" experience is not just determined when you talk to a person, but also whether you get through at all, wait times, and so on

Customers express preferences and opinions about a service by their waiting, abandonment, interactions and subsequent interactions

Most of the measures are also unbiased and quantitative, which are hard to come by in services

# Call Center Service System

The service provider -- the company running the call center

The agents/call takers

The schedulers / account managers

Company that has outsourced its customer service

# The Call Center State Model
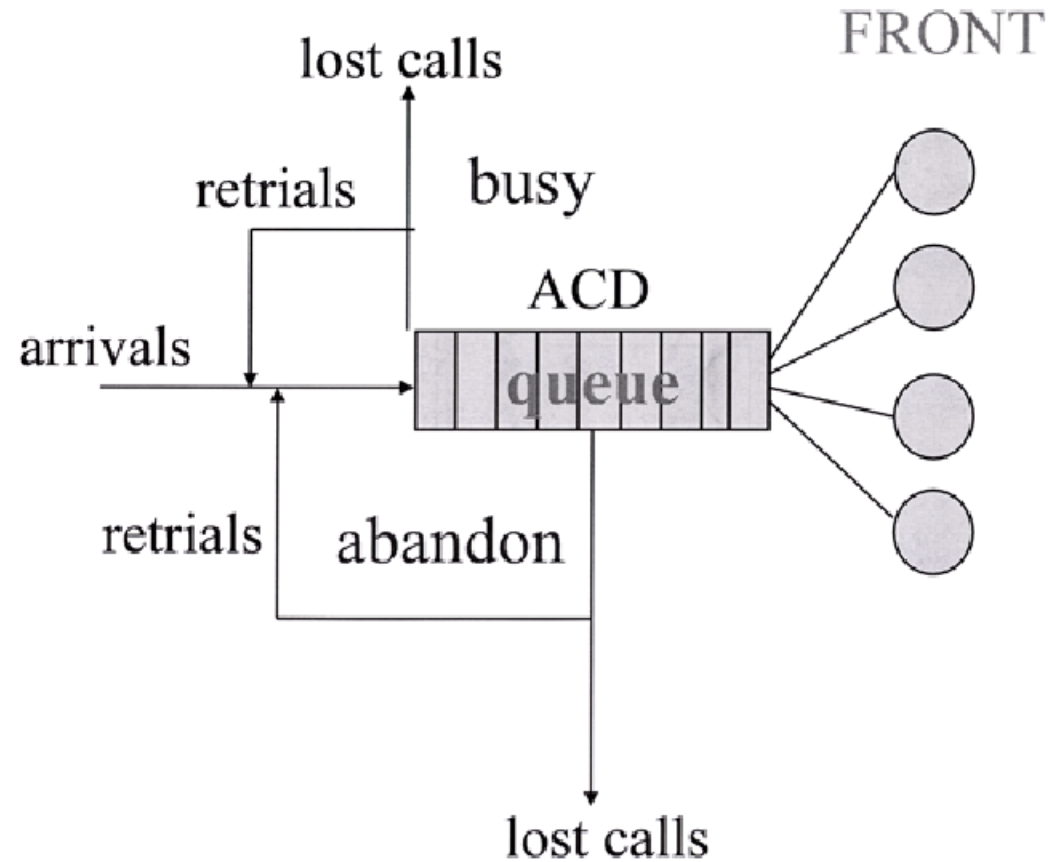
# The Call Center System Conceptual Model - Queuing Theory

## Simple Model: Palm/Erlang-A

agents

queue

arrivals
$\lambda$

abandonment $\theta$

(1)
(2)
...
(n)
$\mu$
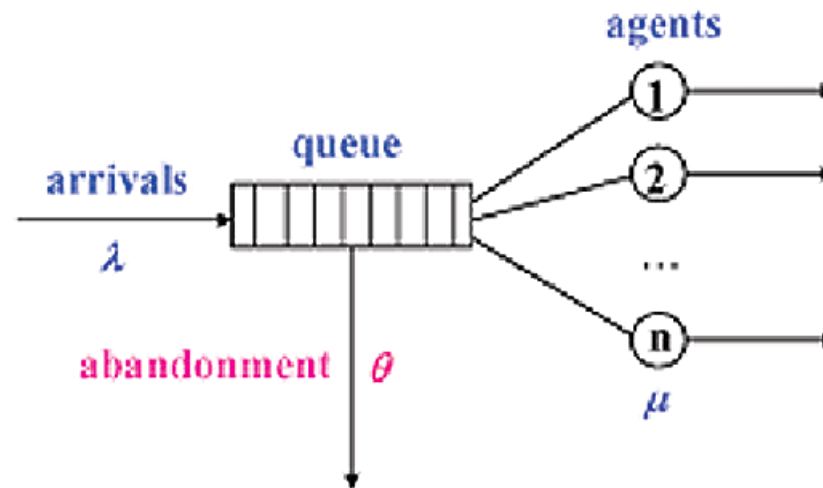
## Erlang-A Parameters (Math. Assumptions):

- ► $\lambda$ – **Arrival** rate (Poisson)
- ► $\mu$ – **Service** rate (Exponential)
- ► $\theta$ – **Impatience** rate (Exponential)
- ► $n$ – Number of **Service-Agents**.

# Call Center Call Log - Raw Data

| vru+line | call_id | customer_id | priority | type | date | vru_entry | vru_exit | vru_time | q_start | q_exit | q_time | outcome | ser_start | ser_exit | ser_time | server |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AA0101 | 44749 | 27644400 | 2 | PS | 990901 | 11:45:33 | 11:45:39 | 6 | 11:45:39 | 11:46:58 | 79 | AGENT | 11:46:57 | 11:51:00 | 243 | DORIT |
| AA0101 | 44750 | 12887816 | 1 | PS | 990905 | 14:49:00 | 14:49:06 | 6 | 14:49:06 | 14:53:00 | 234 | AGENT | 14:52:59 | 14:54:29 | 90 | ROTH |
| AA0101 | 44967 | 58660291 | 2 | PS | 990905 | 14:58:42 | 14:58:48 | 6 | 14:58:48 | 15:02:31 | 223 | AGENT | 15:02:31 | 15:04:10 | 99 | ROTH |
| AA0101 | 44968 | 0 | 0 | NW | 990905 | 15:10:17 | 15:10:26 | 9 | 15:10:26 | 15:13:19 | 173 | HANG | 00:00:00 | 00:00:00 | 0 | NO_SERVER |
| AA0101 | 44969 | 63193346 | 2 | PS | 990905 | 15:22:07 | 15:22:13 | 6 | 15:22:13 | 15:23:21 | 68 | AGENT | 15:23:20 | 15:25:25 | 125 | STEREN |
| AA0101 | 44970 | 0 | 0 | NW | 990905 | 15:31:33 | 15:31:47 | 14 | 00:00:00 | 00:00:00 | 0 | AGENT | 15:31:45 | 15:34:16 | 151 | STEREN |
| AA0101 | 44971 | 41630443 | 2 | PS | 990905 | 15:37:29 | 15:37:34 | 5 | 15:37:34 | 15:38:20 | 46 | AGENT | 15:38:18 | 15:40:56 | 158 | TOVA |
| AA0101 | 44972 | 64185333 | 2 | PS | 990905 | 15:44:32 | 15:44:37 | 5 | 15:44:37 | 15:47:57 | 200 | AGENT | 15:47:56 | 15:49:02 | 66 | TOVA |
| AA0101 | 44973 | 3.06E+08 | 1 | PS | 990905 | 15:53:05 | 15:53:11 | 6 | 15:53:11 | 15:56:39 | 208 | AGENT | 15:56:38 | 15:56:47 | 9 | MORIAH |
| AA0101 | 44974 | 74780917 | 2 | NE | 990905 | 15:59:34 | 15:59:40 | 6 | 15:59:40 | 16:02:33 | 173 | AGENT | 16:02:33 | 16:26:04 | 1411 | ELI |
| AA0101 | 44975 | 55920755 | 2 | PS | 990905 | 16:07:46 | 16:07:51 | 5 | 16:07:51 | 16:08:01 | 10 | HANG | 00:00:00 | 00:00:00 | 0 | NO_SERVER |
| AA0101 | 44976 | 0 | 0 | NW | 990905 | 16:11:38 | 16:11:48 | 10 | 16:11:48 | 16:11:50 | 2 | HANG | 00:00:00 | 00:00:00 | 0 | NO_SERVER |
| AA0101 | 44977 | 33689787 | 2 | PS | 990905 | 16:14:27 | 16:14:33 | 6 | 16:14:33 | 16:14:54 | 21 | HANG | 00:00:00 | 00:00:00 | 0 | NO_SERVER |
| AA0101 | 44978 | 23817067 | 2 | PS | 990905 | 16:19:11 | 16:19:17 | 6 | 16:19:17 | 16:19:39 | 22 | AGENT | 16:19:38 | 16:21:57 | 139 | TOVA |
| AA0101 | 44764 | 0 | 0 | PS | 990901 | 15:03:26 | 15:03:36 | 10 | 00:00:00 | 00:00:00 | 0 | AGENT | 15:03:35 | 15:06:36 | 181 | ZOHARI |
| AA0101 | 44765 | 25219700 | 2 | PS | 990901 | 15:14:46 | 15:14:51 | 5 | 15:14:51 | 15:15:10 | 19 | AGENT | 15:15:09 | 15:17:00 | 111 | SHARON |
| AA0101 | 44766 | 0 | 0 | PS | 990901 | 15:25:48 | 15:26:00 | 12 | 00:00:00 | 00:00:00 | 0 | AGENT | 15:25:59 | 15:28:15 | 136 | ANAT |
| AA0101 | 44767 | 58859752 | 2 | PS | 990901 | 15:34:57 | 15:35:03 | 6 | 15:35:03 | 15:35:14 | 11 | AGENT | 15:35:13 | 15:35:15 | 2 | MORIAH |
| AA0101 | 44768 | 0 | 0 | PS | 990901 | 15:46:30 | 15:46:39 | 9 | 00:00:00 | 00:00:00 | 0 | AGENT | 15:46:38 | 15:51:51 | 313 | ANAT |

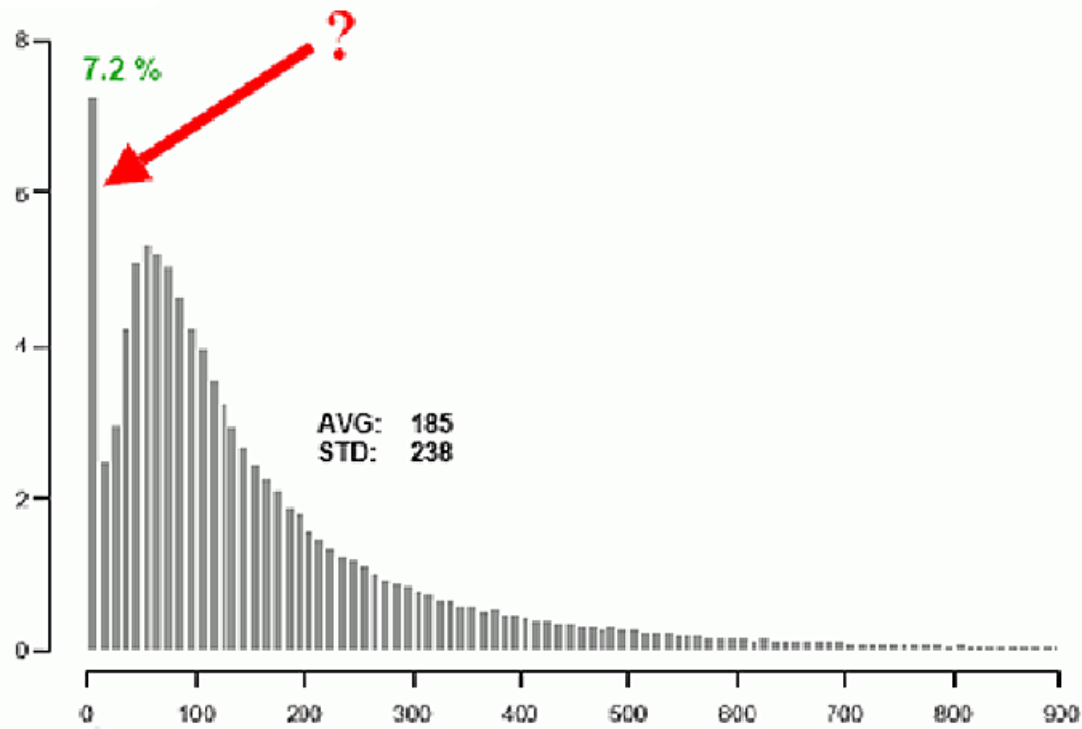# Call Center Daily Summary
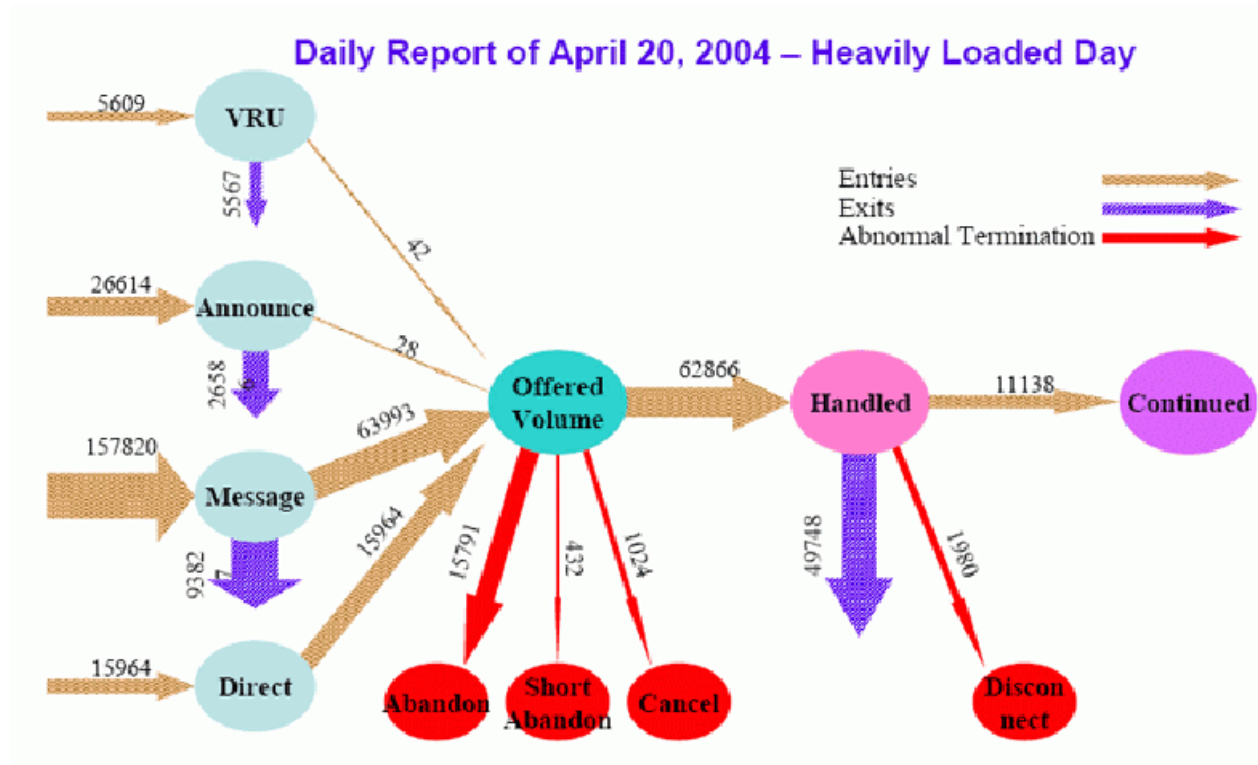
# Call Center Data Regularity



Arrival Rates on Tuesdays in a September – U.S. Bank
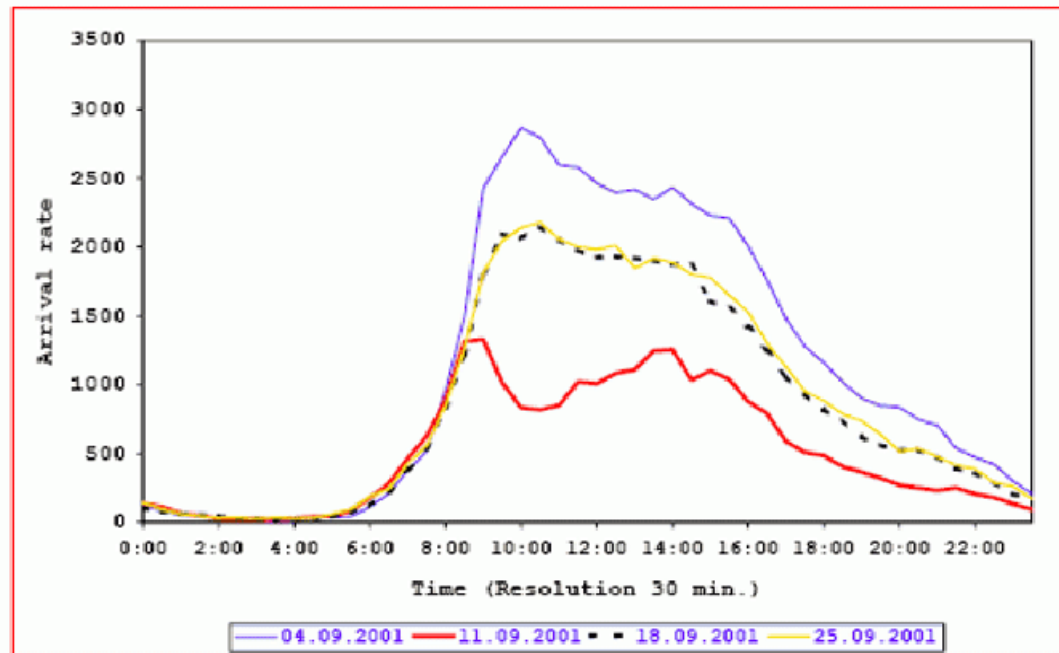
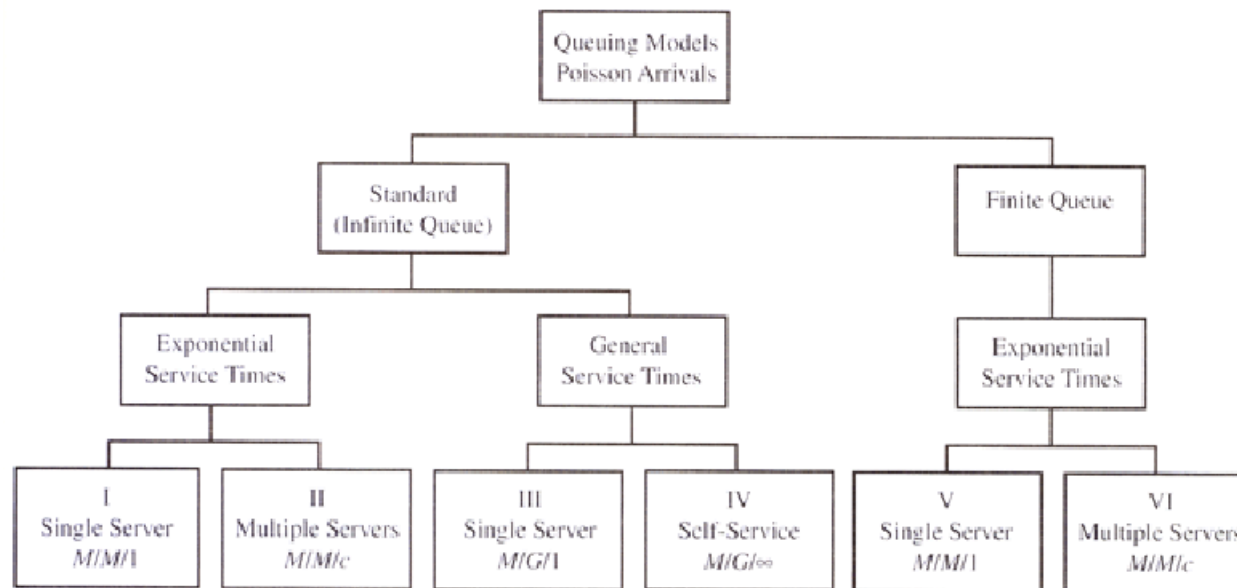# Call Center -- Never Look at Average Service Time

# Analytical Queuing Models

Queuing models can be used to predict the performance (waiting time) for different configurations and disciplines

They can be used to evaluate alternate approaches to capacity planning and demand management

# Readings for 24 September

Shapiro, Benson P., V. Kasturi Rangan, & John J. Sviokla. "Staple yourself to an order" Harvard Business Review (1992).

Adomavicius, G. & Tuzhulin, A. Personalization Technologies: A Process-Oriented Perspective. Communications of the ACM, 48(10), October 2005.