From Systems to Descriptive Models

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Modeling

- Abstraction of a real system.
- Should capture enough details to satisfy goals of the study.
- Types of models:
  - Simulation
  - Analytic
  - Hybrid

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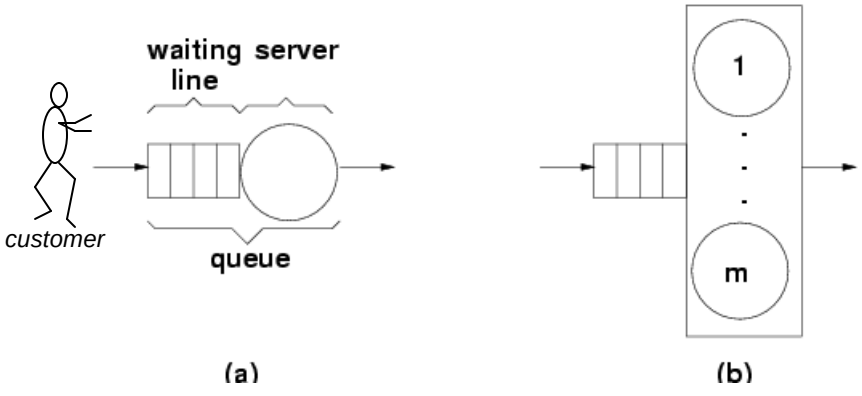
Graphical Notation for Queues



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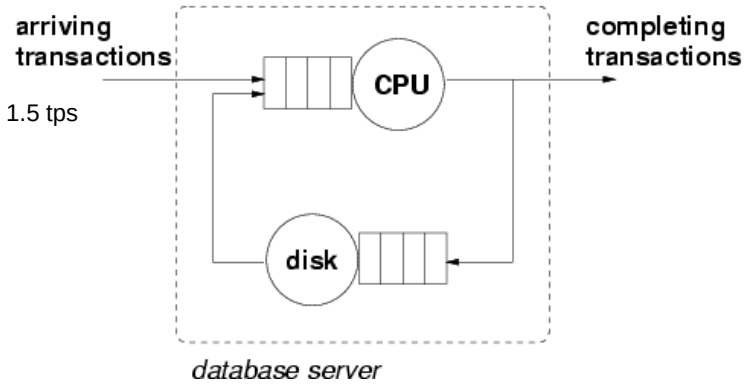
Simple Database Server Example: Open Workload



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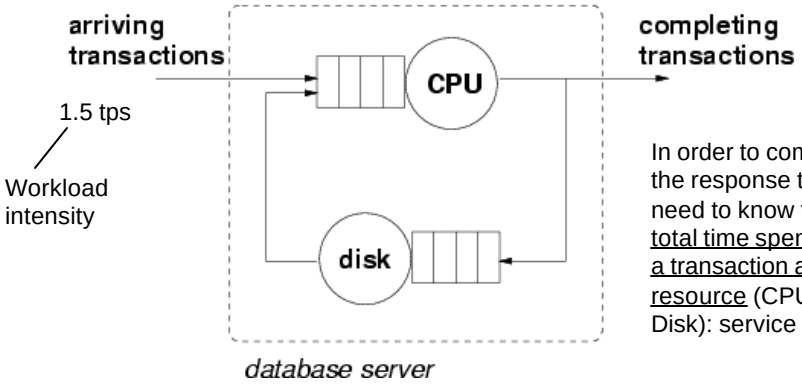
Simple Database Server Example: Open Workload

Queuing Network (QN)



Workload intensity

In order to compute the response time, we need to know the total time spent by a transaction at each resource (CPU and Disk): service demand.

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Multiclass DB Example

transaction group	percent of total	avg. CPU time (sec)	avg. no. I/Os
Trivial	45%	0.04	5.5
Medium	25%	0.18	28.9
Complex	30%	1.20	85

Each transaction group is assigned to a customer class in the Queuing Network.

When do we need multiple classes?

- Heterogeneous service demands.
- Different types of workloads.
- Different service level objectives.

Open Class

- Workload intensity specified by an arrival rate (usually independent of the system state).
- Unbounded number of customers in the system.
- Throughput is an input parameter, which is equal to the arrival rate in equilibrium.

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Closed Class

- Workload intensity specified by customer population (i.e., concurrency level)
- Bounded and known number of customers in the system.
- Throughput is an output parameter.

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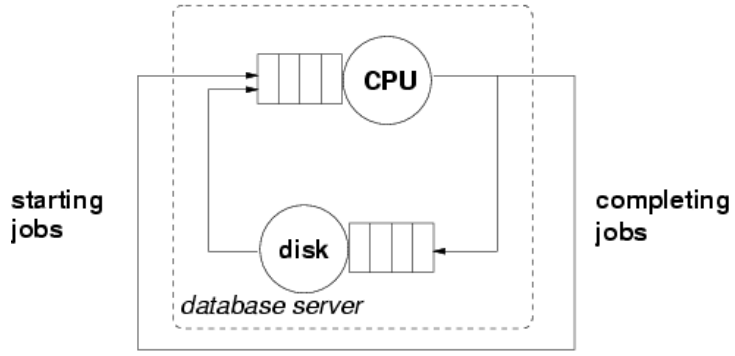
Closed Workload Example



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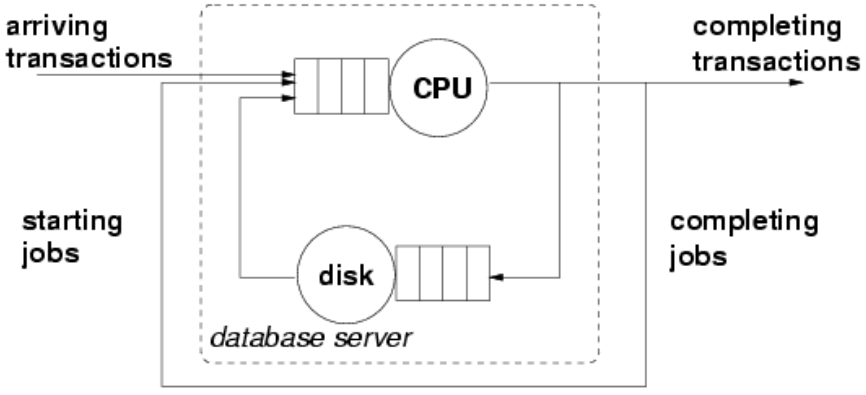
Mixed Workload Example



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Service Level Agreements (SLA)

- Agreement between users and providers of computing services on the levels of various performance metrics.
  - 99.99% availability during 8:00am-11:00pm period and 99.9% at other times
  - Less than 4 sec page download time for requests over non-secure connections less than 6 sec for requests over secure connections
  - Minimum throughput of 2,000 page downloads/sec.

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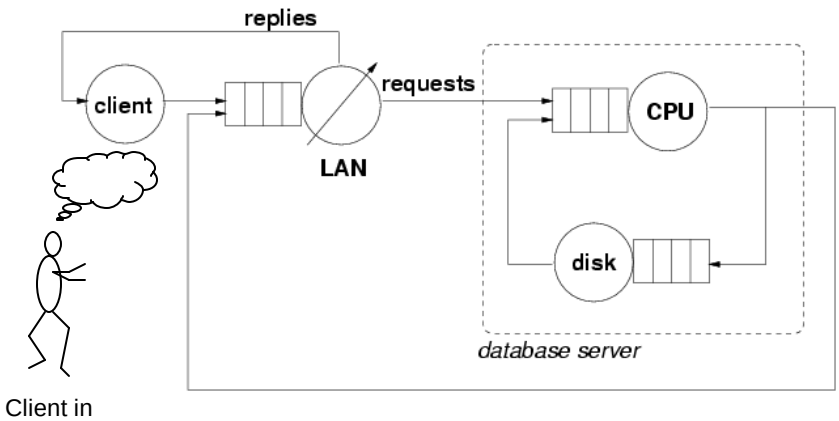
Different Types of Resources



Client in think mode

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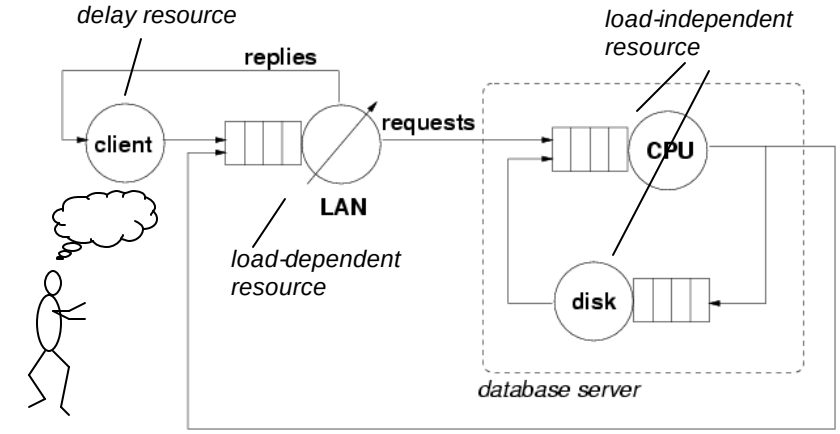
Different Types of Resources



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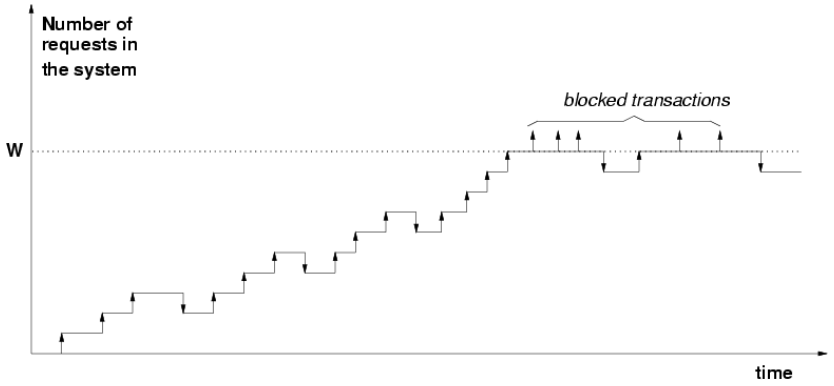
Blocking (Admission Control)



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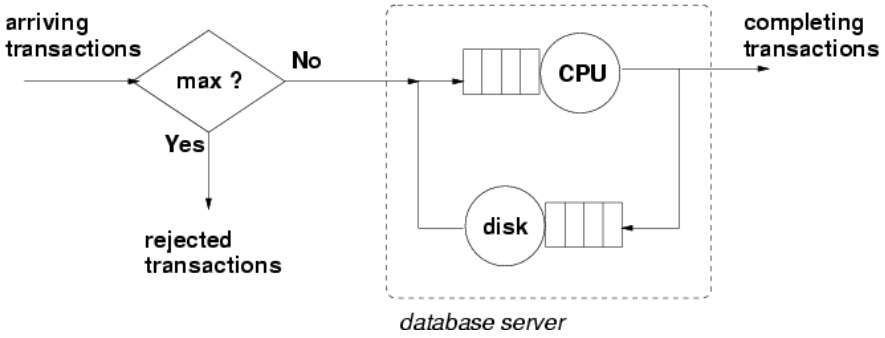
System with Admission Control



Throughput = Arrival Rate x (1 – Probability of Rejection)

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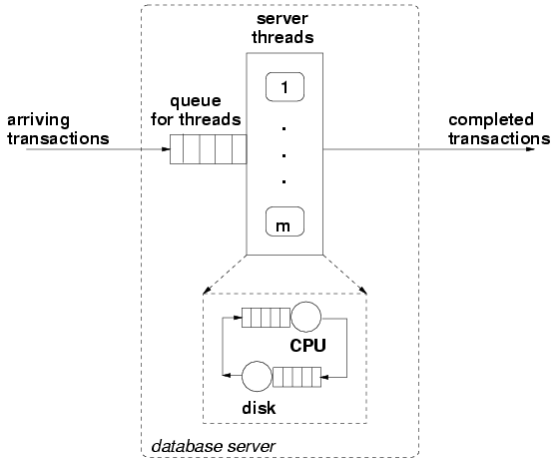
Database Server with Software Contention



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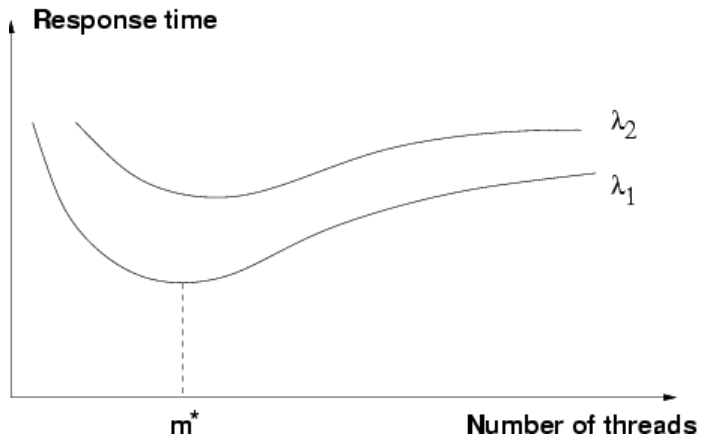
Effect of Software Contention



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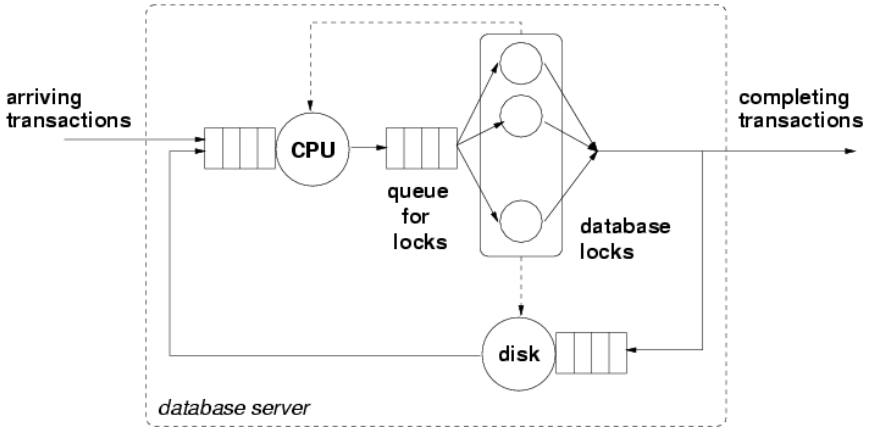
A DB Server with Lock Contention



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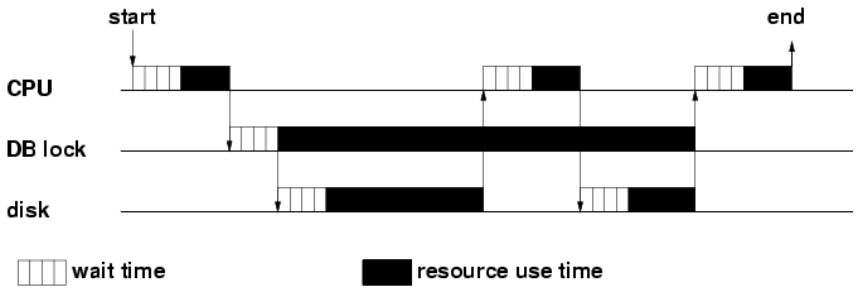
Simultaneous Resource Possession Time Axes



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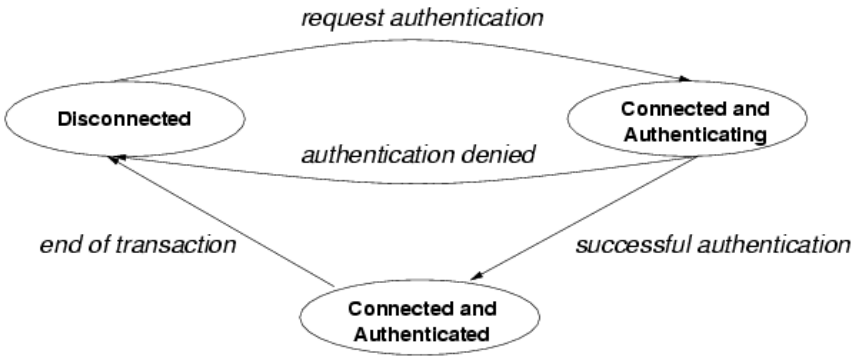
Class Switching



Authentication can be significantly more CPU-intensive than DB access.

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Queuing Disciplines

- First Come First Served (FCFS)
- Priority Queuing (FCFS breaks the tie):
  - Non-preemptive
  - Preemptive resume
  - Preemptive repeat.
- Round-Robin (RR)
- Processor Sharing (PS)
- Last Come First Served-Preemptive Resume (LCFS-PR)
- Shortest Job First (SJF)

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QN Models

- K queues (i = 1, …, K)
- R classes (r = 1, …, R)
- Input parameters:
  - Workload intensity

$$\vec{l} = (l_1, ..., l_r, ..., l_R)$$ for open classes

$$\vec{N} = (N_1, ..., N_r, ..., N_R)$$ for closed classes

  - Service demands (D_{ir})

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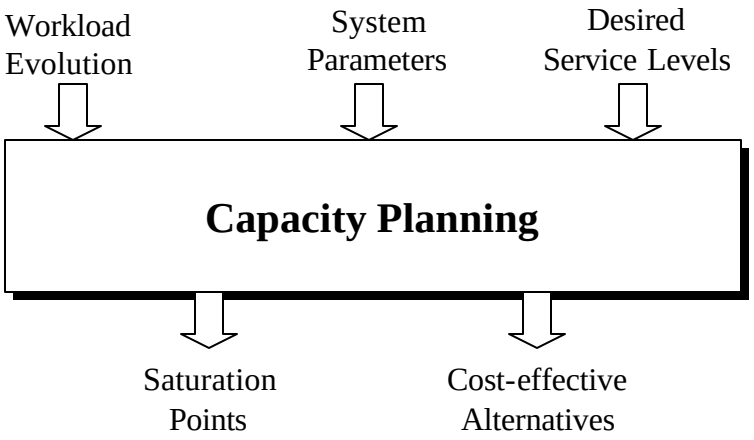
Capacity Planning Input and Output Variables



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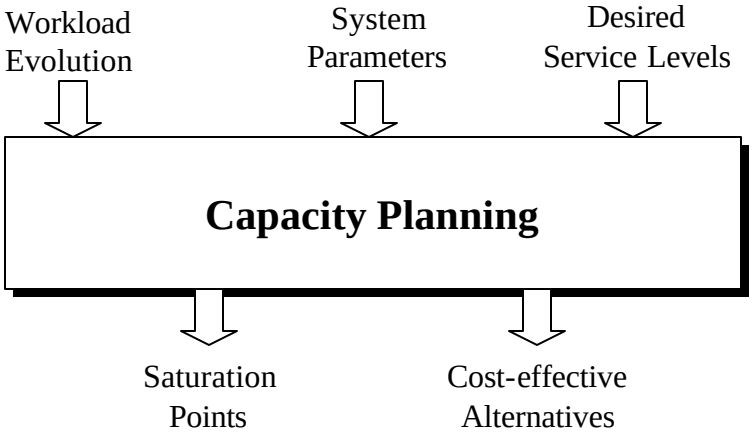
Capacity Planning Input and Output Variables

- *intensity*
- *nature*



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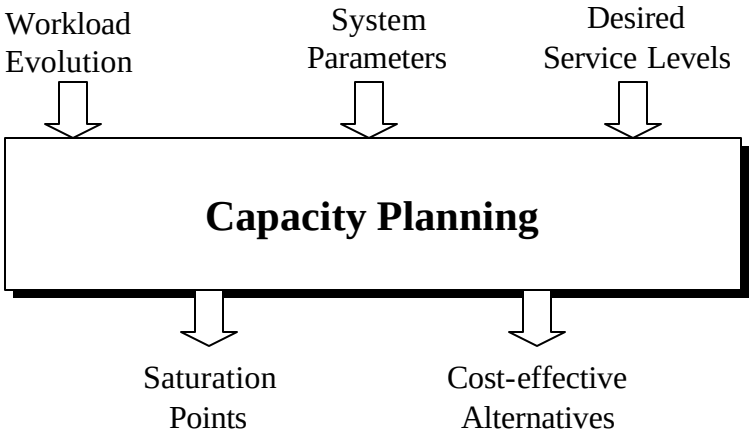
Capacity Planning Input and Output Variables

•*intensity* • *processors, disks, networks*
•*nature* • *max. no. connections*



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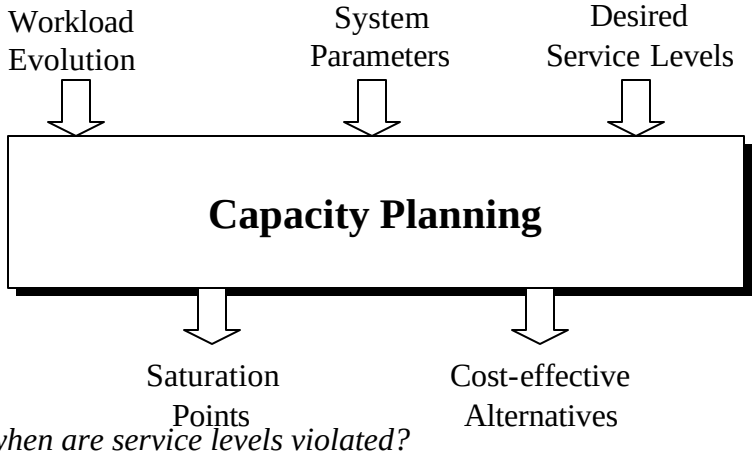
Capacity Planning Input and Output Variables

•*intensity* • *processors, disks, networks* • *RT <= 2 sec*
•*nature* • *max. no. connections* • *tput > 10 tps*



when are service levels violated?

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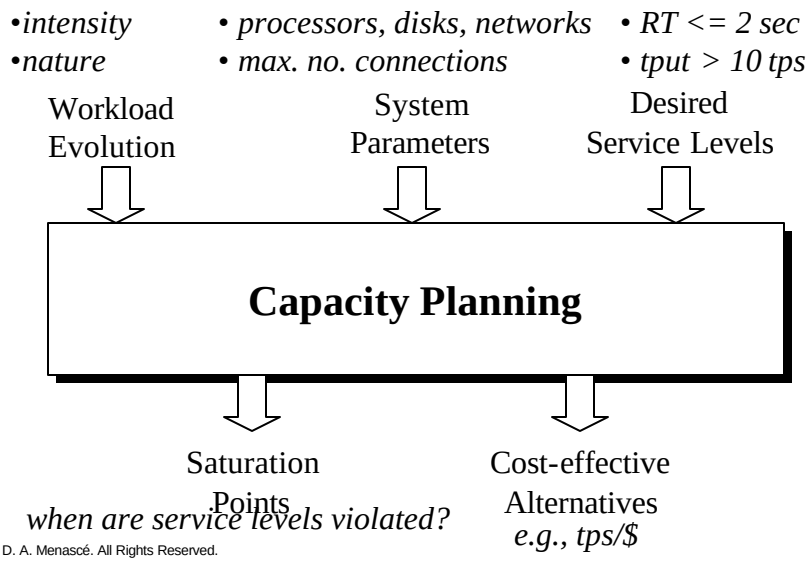
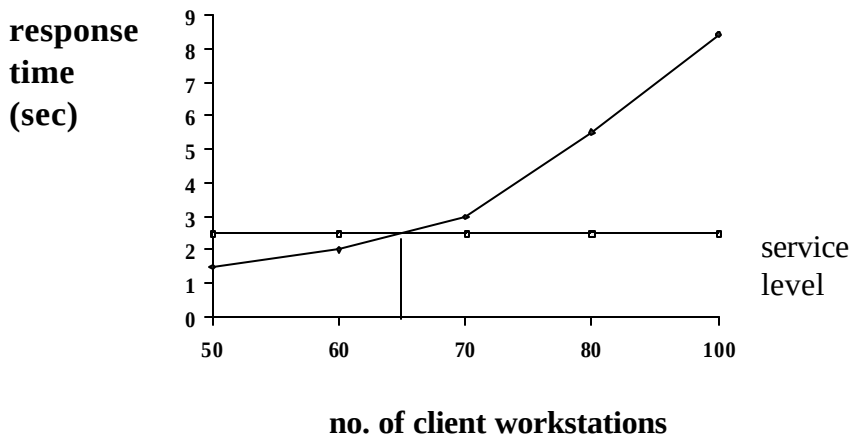
Capacity Planning Input and Output Variables



Capacity Planning Definition

Capacity Planning is the process of *predicting* when the *service levels* will be violated as a function of the *workload evolution*, as well as the determination of the most cost-effective way of delaying system saturation.

Capacity Planning Concept



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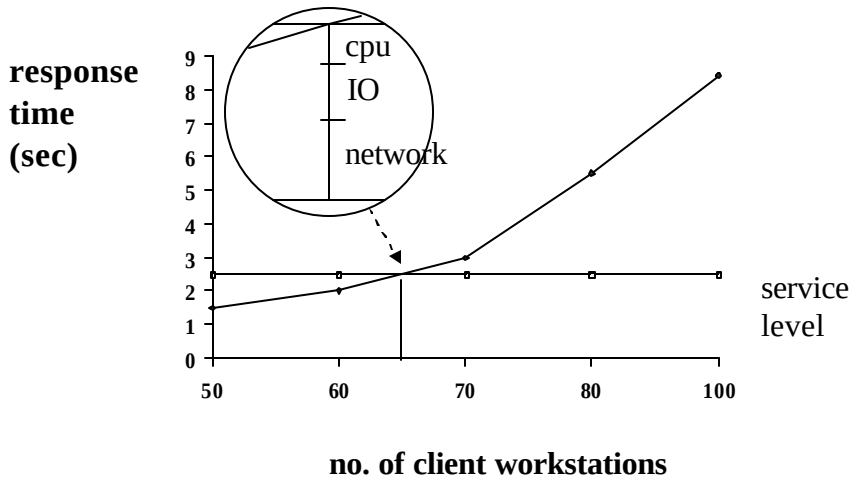
Capacity Planning Concept



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Typical Capacity Planning Questions

- Situation: migrating from a mainframe based to a C/S system.
- Questions:
  - how many clients will the new system support with acceptable response time?
  - How many servers and how should they be configured to handle the load?
  - Should I use a two-tier or a three-tier architecture?

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