Selection of Techniques and Metrics

Raj Jain
Washington University in Saint Louis
Saint Louis, MO 63130
Jain@cse.wustl.edu

These slides are available on-line at:

http://www.cse.wustl.edu/~jain/cse567-08/

Overview

- Criteria for Selecting an Evaluation Technique
- Three Rules of Validation
- Selecting Performance Metrics
- Commonly Used Performance Metrics
- Utility Classification of Metrics
- Setting Performance Requirements

Criteria for Selecting an Evaluation Technique

Criterion	Analytical Modeling	Simulation	Measurement
1. Stage	Any	Any	Postprototype
2. Time required	Small	Medium	Varies
3. Tools	Analysts	Computer languages	Instrumentation
4. Accuracy[a]	Low	Moderate	Varies
5. Trade-off evaluation	Easy	Moderate	Difficult
6. Cost	Small	Medium	High
7. Saleability	Low	Medium	High

[a] In all cases, result may be misleading or wrong.

Three Rules of Validation

- Do not trust the results of a **simulation model** until they have been validated by analytical modeling or measurements.
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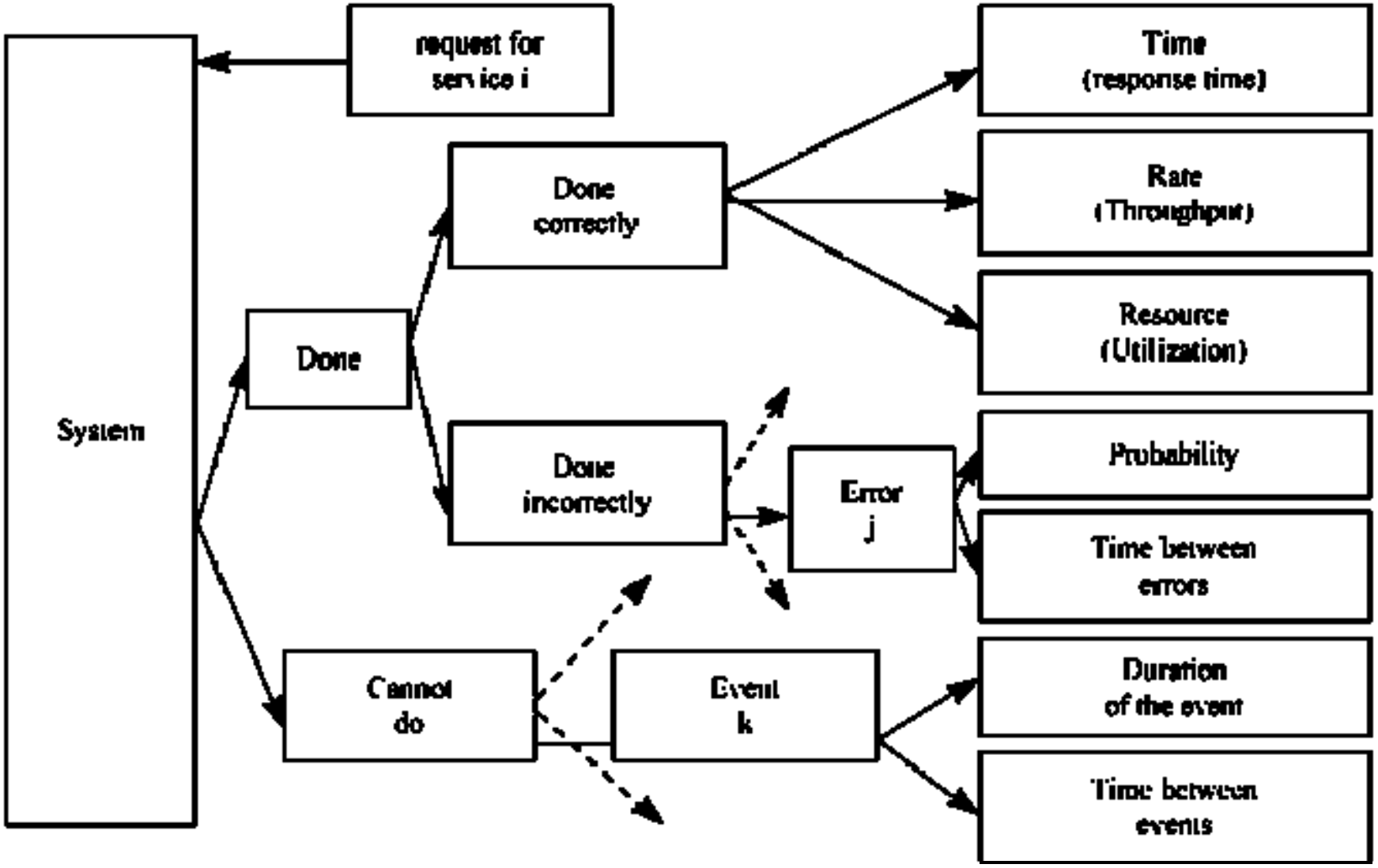
Selecting Performance Metrics



Selecting Metrics

- Include:
  - Performance Time, Rate, Resource
  - Error rate, probability
  - Time to failure and duration
- Consider including:
  - Mean and variance
  - Individual and Global
- Selection Criteria:
  - Low-variability
  - Non-redundancy
  - Completeness

Case Study: Two Congestion Control Algorithms

- Service: Send packets from specified source to specified destination in order.
- Possible outcomes:
  - Some packets are delivered in order to the correct destination.
  - Some packets are delivered out-of-order to the destination.
  - Some packets are delivered more than once (duplicates).
  - Some packets are dropped on the way (lost packets).

Case Study (Cont)

- Performance: For packets delivered in order,
  - Time-rate-resource $\Rightarrow$
    - Response time to deliver the packets
    - Throughput: the number of packets per unit of time.
    - Processor time per packet on the source end system.
    - Processor time per packet on the destination end systems.
    - Processor time per packet on the intermediate systems.
  - Variability of the response time $\Rightarrow$ Retransmissions
    - Response time: the delay inside the network

Case Study (Cont)

- Out-of-order packets consume buffers
  $\Rightarrow$ Probability of out-of-order arrivals.
- Duplicate packets consume the network resources
  $\Rightarrow$ Probability of duplicate packets
- Lost packets require retransmission
  $\Rightarrow$ Probability of lost packets
- Too much loss cause disconnection
  $\Rightarrow$ Probability of disconnect

Case Study (Cont)

- Shared Resource ⇒ Fairness

$$f(x_1, x_2, \ldots, x_n) = \frac{\left(\sum_{i=1}^{n} x_i\right)^2}{n\sum_{i=1}^{n} x_i^2}$$

- Fairness Index Properties:
  - Always lies between 0 and 1.
  - Equal throughput ⇒ Fairness =1.
  - If *k* of *n* receive *x* and *n*-*k* users receive zero throughput: the fairness index is *k*/*n*.

Case Study (Cont)

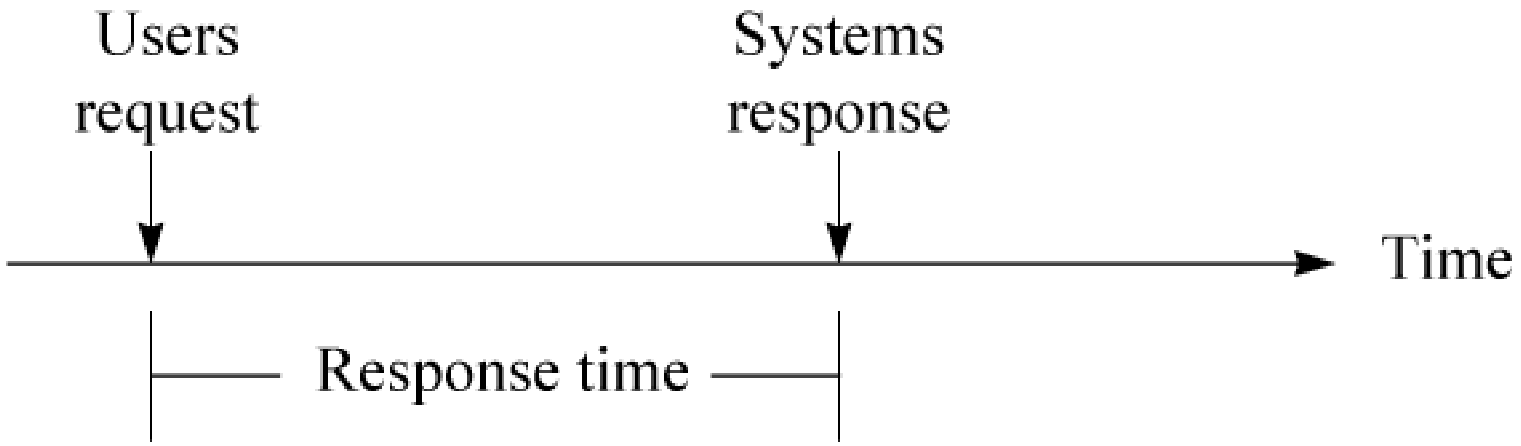
- Throughput and delay were found redundant ⇒ Use Power.

$$\text{Power} = \frac{\text{Throughput}}{\text{Response Time}}$$

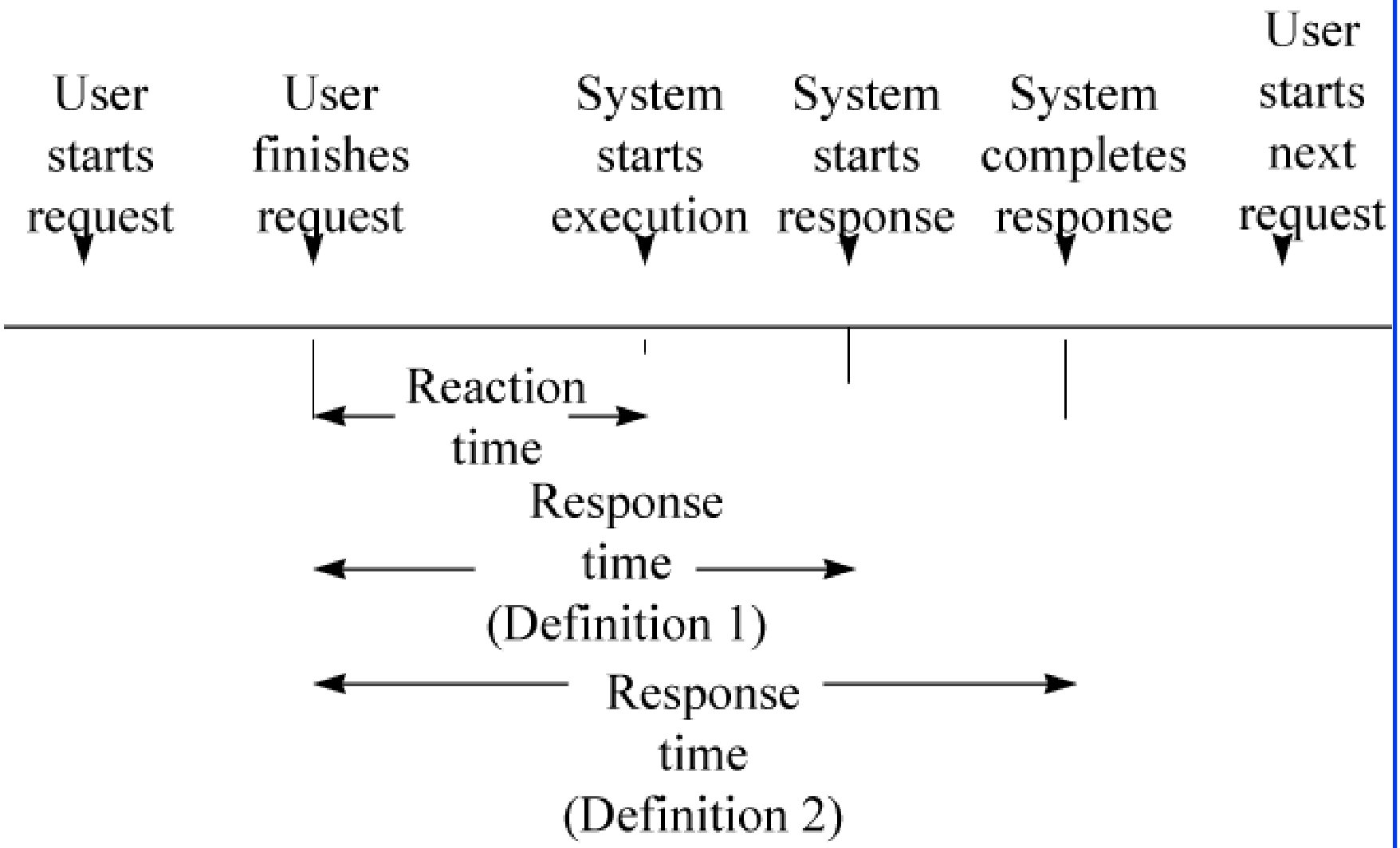
- Variance in response time redundant with the probability of duplication and the probability of disconnection
- Total nine metrics.

Commonly Used Performance Metrics

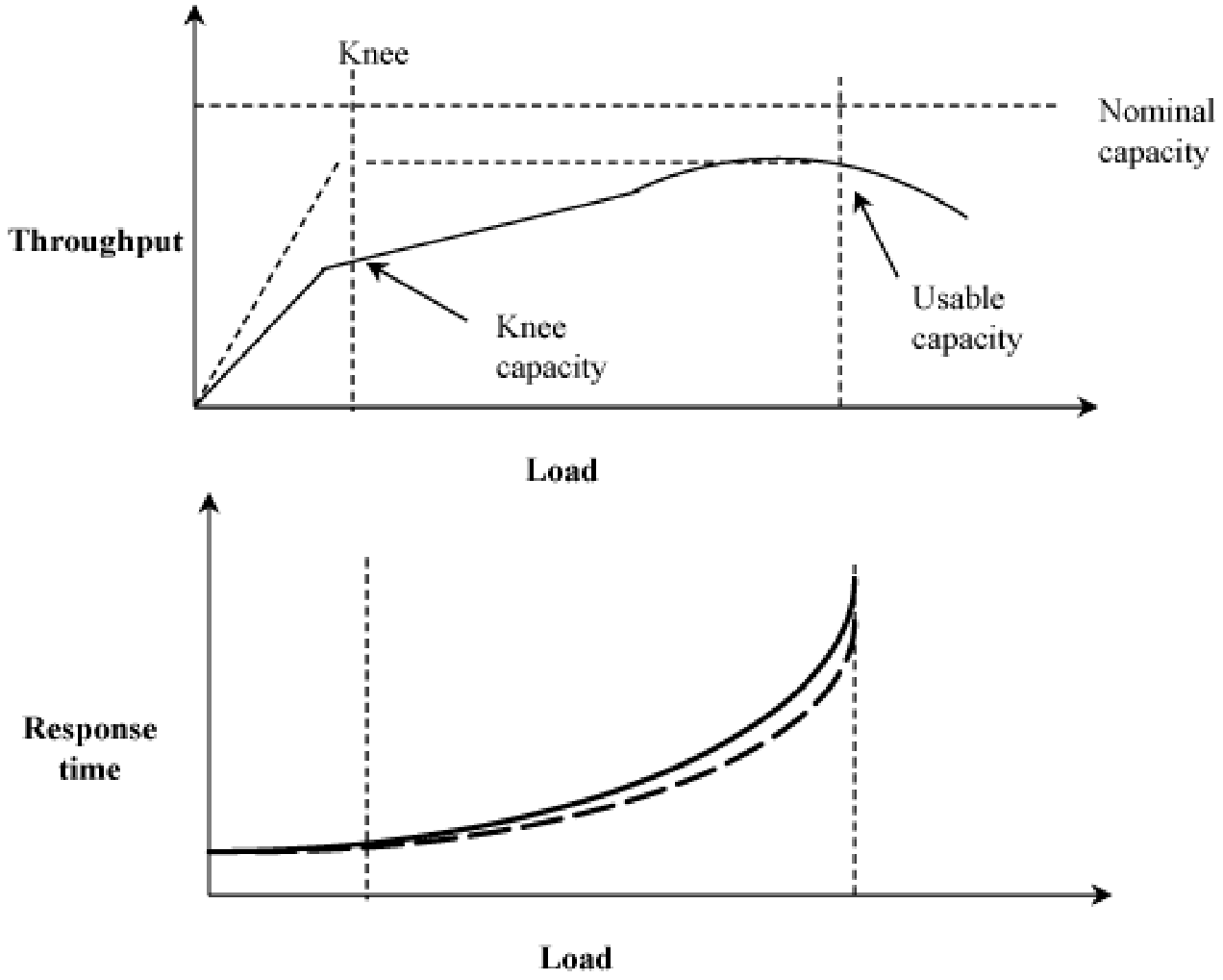
- **Response time and Reaction time**



Response Time (Cont)



Capacity


Knee
Nominal capacity
Throughput
Knee capacity
Usable capacity
Load
Response time
Load

Common Performance Metrics (Cont)

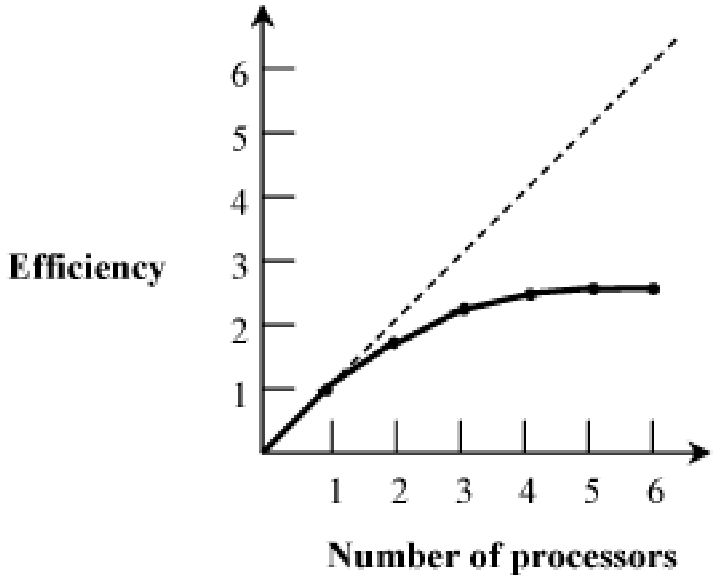
- **Nominal Capacity**: Maximum achievable throughput under ideal workload conditions. E.g., bandwidth in bits per second. The response time at maximum throughput is too high.
- **Usable capacity**: Maximum throughput achievable without exceeding a pre-specified response-time limit
- **Knee Capacity**: Knee = Low response time and High throughput

Common Performance Metrics (cont)

- **Turnaround time** = the time between the submission of a batch job and the completion of its output.
- **Stretch Factor**: The ratio of the response time with multiprogramming to that without multiprogramming.
- **Throughput**: Rate (requests per unit of time) Examples:
  - Jobs per second
  - Requests per second
  - Millions of Instructions Per Second (MIPS)
  - Millions of Floating Point Operations Per Second (MFLOPS)
  - Packets Per Second (PPS)
  - Bits per second (bps)
  - Transactions Per Second (TPS)

Common Performance Metrics (Cont)

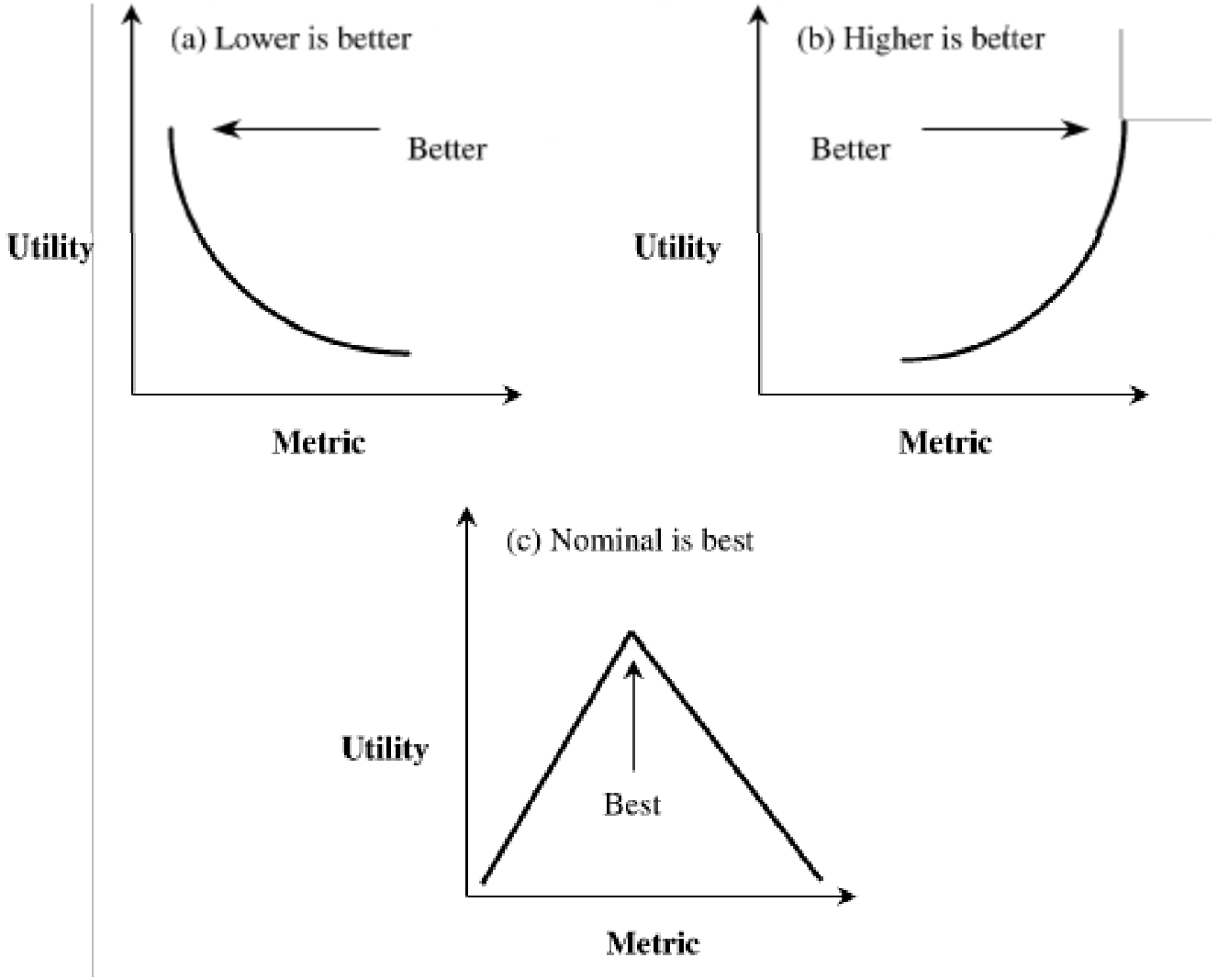
- **Efficiency**: Ratio usable capacity to nominal capacity. Or, the ratio of the performance of an *n*-processor system to that of a one-processor system is its efficiency.
- **Utilization**: The fraction of time the resource is busy servicing requests. Average fraction used for memory.



Common Performance Metrics (Cont)

- **Reliability**:
  - Probability of errors
  - Mean time between errors (error-free seconds).
- **Availability**:
  - Mean Time to Failure (MTTF)
  - Mean Time to Repair (MTTR)
  - MTTF/(MTTF+MTTR)

Utility Classification of Metrics



Setting Performance Requirements

- **Examples**:
  - " The system should be both processing and memory efficient. It should not create excessive overhead"
  - " There should be an extremely low probability that the network will duplicate a packet, deliver a packet to the wrong destination, or change the data in a packet."
- **Problems**:
  - Non-Specific
  - Non-Measurable
  - Non-Acceptable
  - Non-Realizable
  - Non-Thorough

  $\Rightarrow$ SMART

Case Study 3.2: Local Area Networks

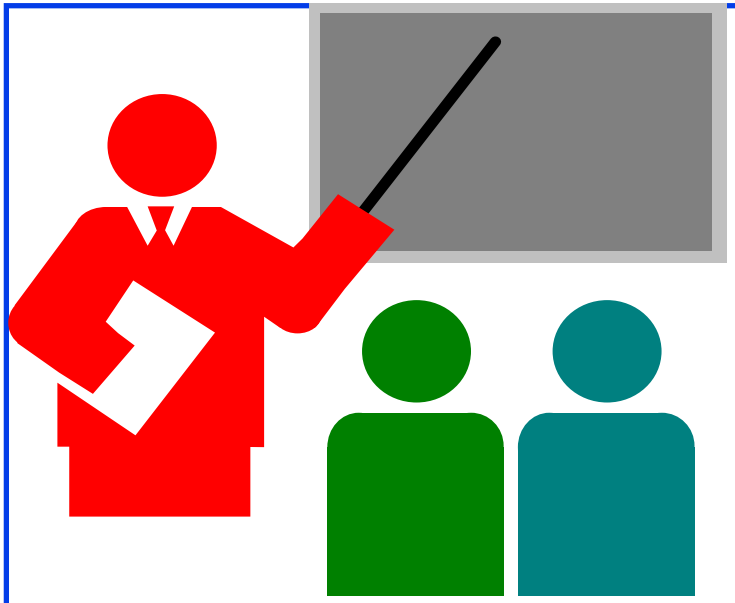
- **Service**: Send frame to D
- **Outcomes**:
  - Frame is correctly delivered to D
  - Incorrectly delivered
  - Not delivered at all
- **Requirements**:
- **Speed**
  - The access delay at any station should be less than one second.
  - Sustained throughput must be at least 80 Mbits/sec.
- **Reliability**: Five different error modes.
  - Different amount of damage
  - Different level of acceptability.

Case Study (Cont)

- The probability of any bit being in error must be less than 1E-7.
- The probability of any frame being in error (with error indication set) must be less than 1%.
- The probability of a frame in error being delivered without error indication must be less than 1E-15.
- The probability of a frame being misdelivered due to an undetected error in the destination address must be less than 1E-18.
- The probability of a frame being delivered more than once (duplicate) must be less than 1E-5.
- The probability of losing a frame on the LAN (due to all sorts of errors) must be less than 1%.

Case Study (Cont)

- **Availability**: Two fault modes –
  Network reinitializations and permanent failures
  - The mean time to initialize the LAN must be less than 15 milliseconds.
  - The mean time between LAN initializations must be at least one minute.
  - The mean time to repair a LAN must be less than one hour. (LAN partitions may be operational during this period.)
  - The mean time between LAN partitioning must be at least one-half a week.



Summary of Part I

- **Systematic Approach**: Define the system, list its services, metrics, parameters, decide factors, evaluation technique, workload, experimental design, analyze the data, and present results
- **Selecting Evaluation Technique**: The life-cycle stage is the key. Other considerations are: time available, tools available, accuracy required, trade-offs to be evaluated, cost, and saleability of results.

Summary (Cont)

- **Selecting Metrics**:
  - For each service list time, rate, and resource consumption
  - For each undesirable outcome, measure the frequency and duration of the outcome
  - Check for low-variability, non-redundancy, and completeness.
- **Performance requirements**: Should be SMART. Specific, measurable, acceptable, realizable, and thorough.

Exercise 3.1

What methodology would you choose:

a. To select a personal computer for yourself?

b. To select 1000 workstations for your company?

c. To compare two spread sheet packages?

d. To compare two data-flow architectures, if the answer was required:

i. Yesterday?

ii. Next quarter?

iii. Next year?

Homework #2

- Read chapters 3
- Submit answers to
  - Exercise 3.1