# Selection of Techniques and Metrics

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These slides are available on-line at:

http://www.cse.wustl.edu/~jain/cse567-13/

# 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

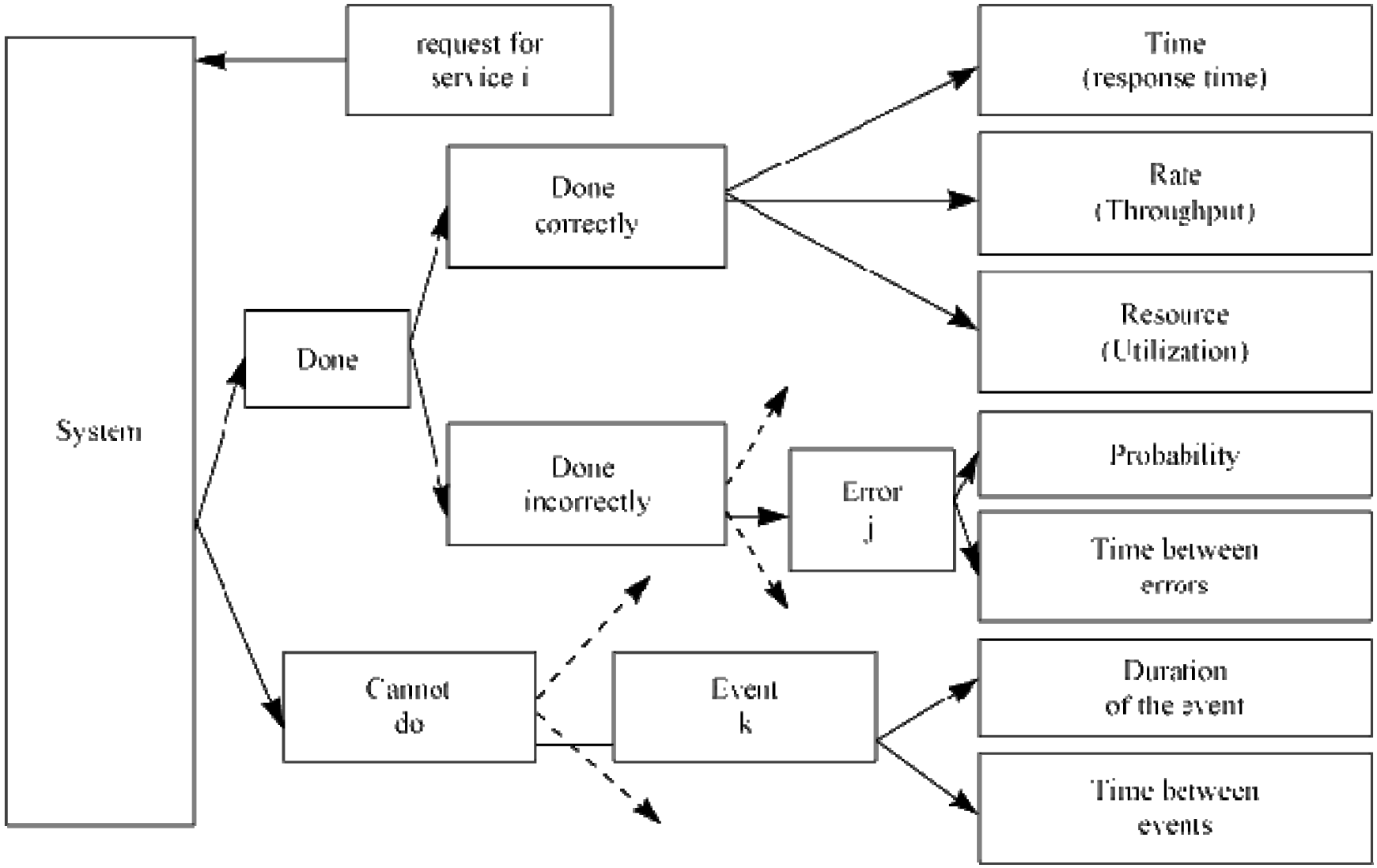
| Criterion | Analytical Modeling | Simulation | Measurement |
|---|---|---|---|
| 1. Stage | Any | Any | Postprototype |
| 2. Time required | Small | Medium | Varies |
| 3. Tools | Analysts | Computer languages | Instrumentation |
| 4. Accuracy[a] | Low | Moderate | Varies |
| 5. Trade-off evaluation | 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.
- Do not trust the results of an **analytical model** until they have been validated by a simulation model or measurements.
- Do not trust the results of a **measurement** until they have been validated by simulation or analytical modeling.

# 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)

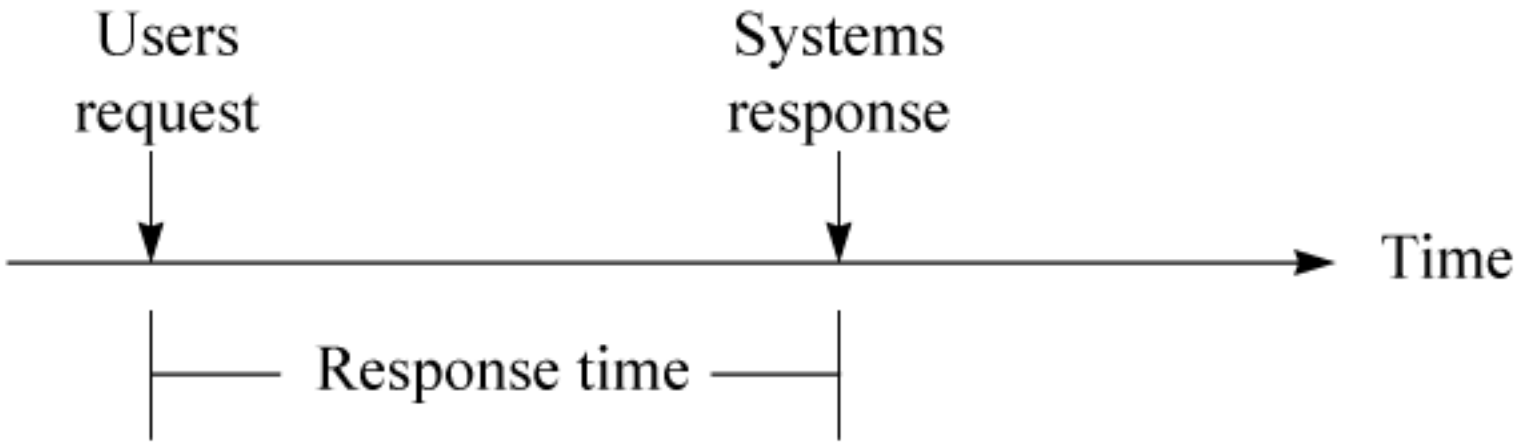
- Throughput and delay were found redundant ⇒ Use Power.

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

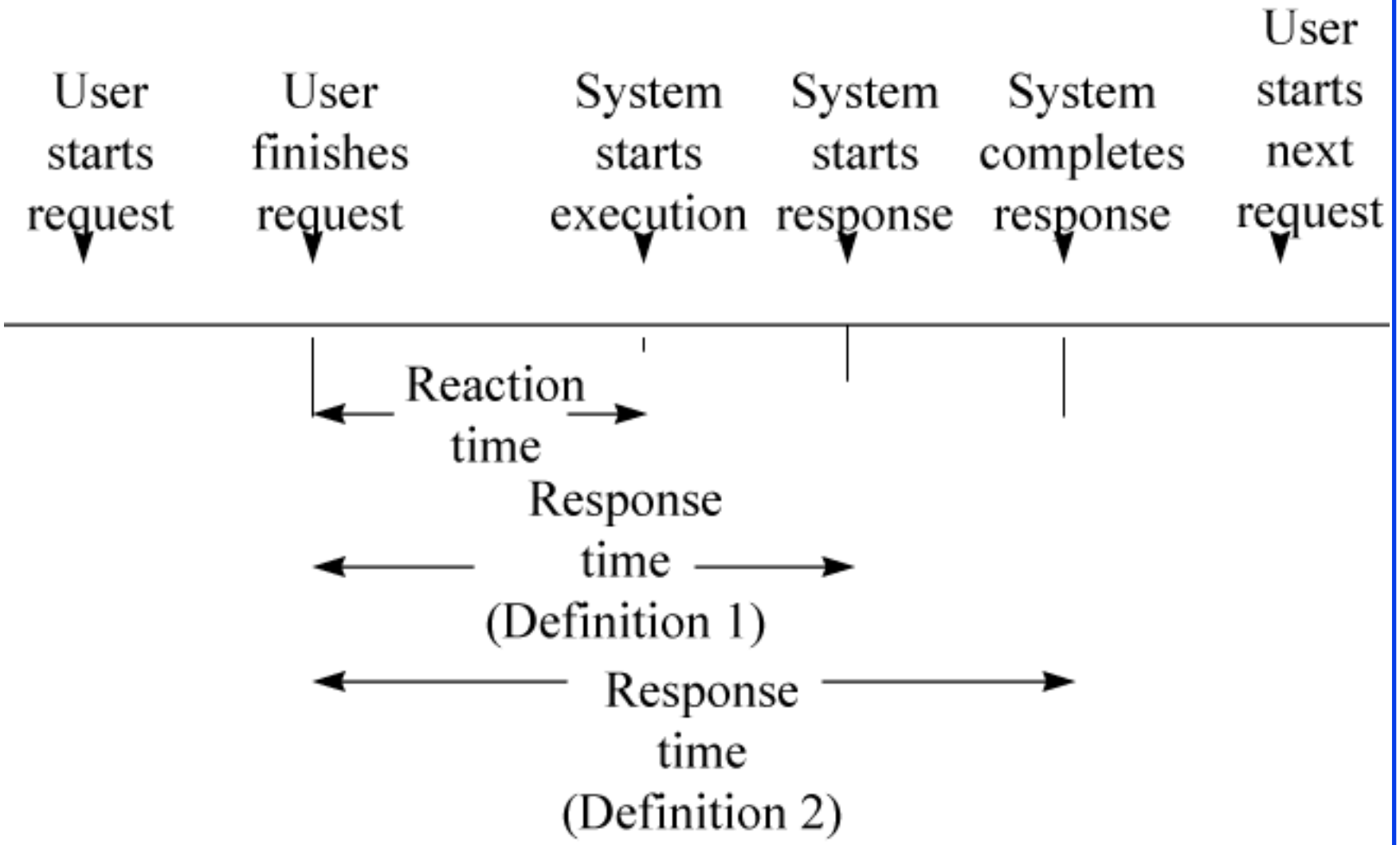
- Variance in response time redundant with the probability of duplication and the probability of disconnection
- Total nine metrics.

# Commonly Used Performance Metrics

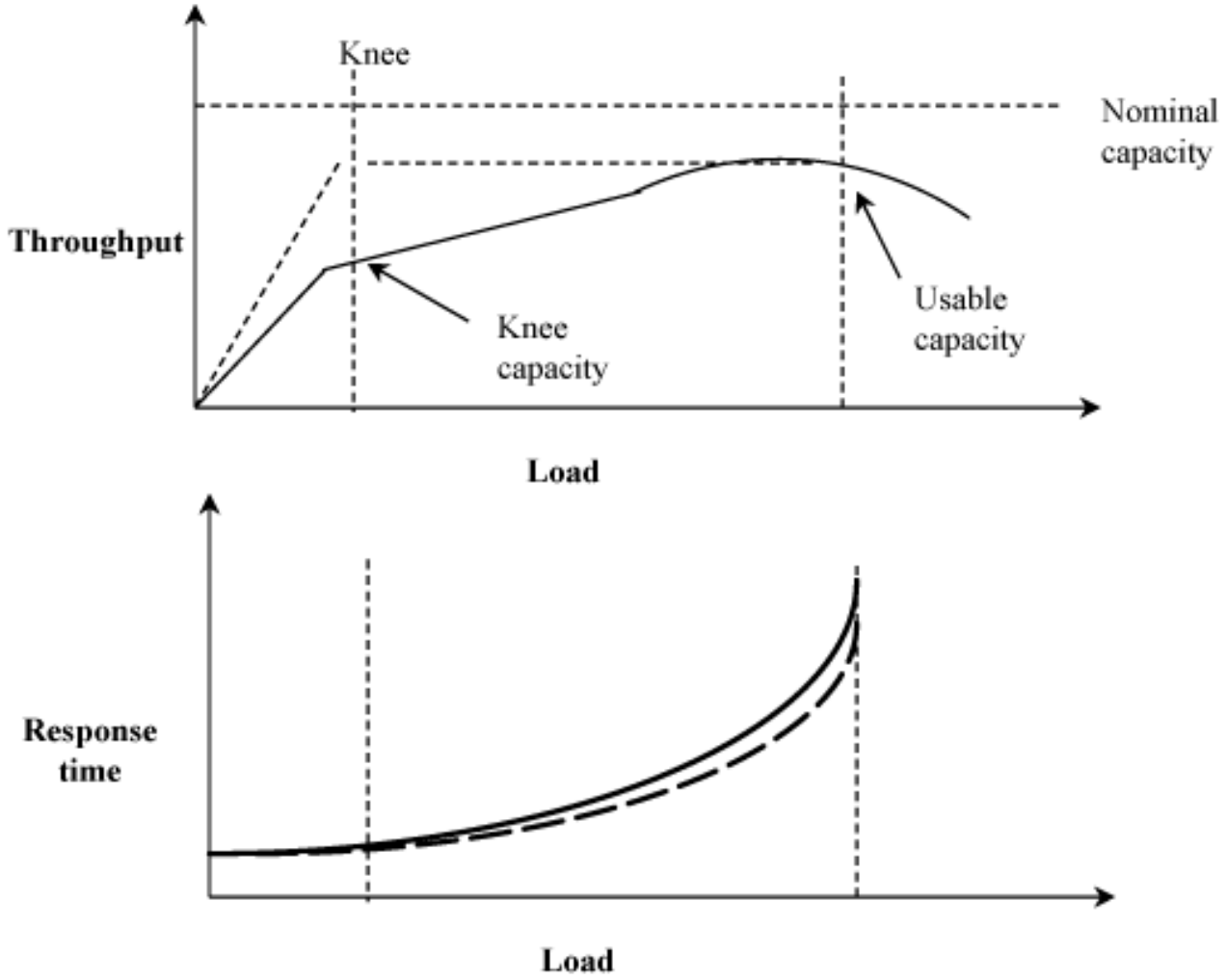
- **Response time and Reaction time**



# Response Time (Cont)



# Capacity



# Common Performance Metrics (Cont)

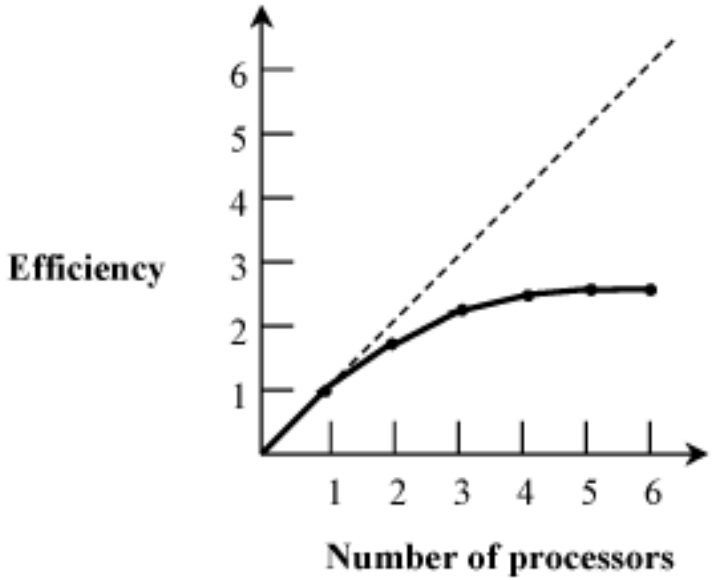
- **Nominal Capacity**: Maximum achievable throughput under ideal workload conditions. E.g., bandwidth in bits per second. The response time at maximum throughput is too high.
- **Usable capacity**: Maximum throughput achievable without exceeding a pre-specified response-time limit
- **Knee Capacity**: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

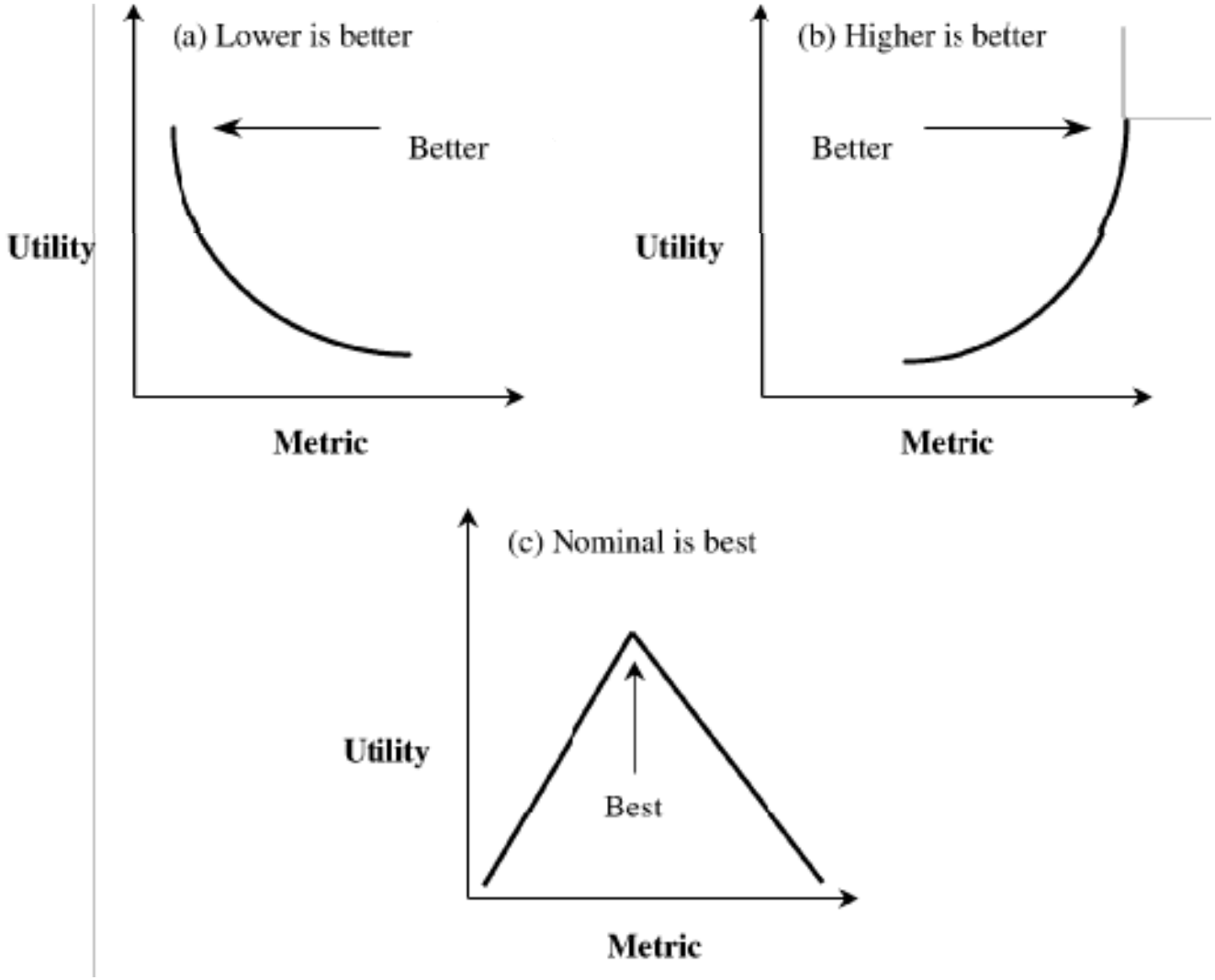
- **Efficiency**: Ratio usable capacity to nominal capacity. Or, the ratio of the performance of an *n*-processor system to that of a one-processor system is its efficiency.
- **Utilization**: The fraction of time the resource is busy servicing requests. Average fraction used for memory.



# 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

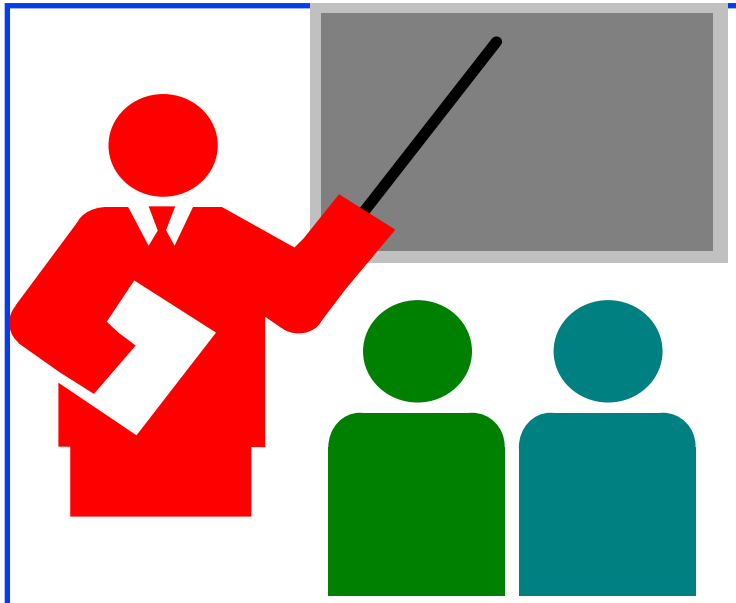
- **Service**: Send frame to D
- **Outcomes**:
  - Frame is correctly delivered to D
  - Incorrectly delivered
  - Not delivered at all
- **Requirements**:
- **Speed**
  - The access delay at any station should be less than one second.
  - Sustained throughput must be at least 80 Mbits/sec.
- **Reliability**: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

# Homework 3: 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?

Prepare a table of 12 entries. Write 1 line explanation of each of 12 choices.

Common Mistake: Not specifying all 12 combinations.