Selection of Techniques and Metrics

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Outline

1. Technique selection
2. Metric selection
   - Case study
3. Common performace metrics
4. Utility classification of metrics

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Criteria in selection

Criterion	Analytical modeling	Simulation	Measurement
Stage	Any	Any	Postprototype
Time required	Small	Medium	Varies
Tools	Analysts	Computer languages	Instrumentation
Accuracy	Low	Moderate	Varies
Trade-off evaluation	Easy	Moderate	Difficult
Cost	Small	Medium	High
Saleability	Low	Medium	High

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- Analytical modeling: to provide the best insight (effects of various parameters and their interactions).
- Simulation: to search the space of parameter values for the optimal combination.
- Measurement: to prove outcomes in practice and also to validate modeling and simulation.

Rules of thumb

Until validated, all evaluation results are suspect.

- A simulation model trusted if validated by analytical modeling, measurements
- An analytical model trusted if validated by simulation modeling, measurements
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Techniques can be used sequentially.

1. Simple analytical modeling to find range of system parameters
2. Simulation to study performance in that range ⇒ reducing number of simulations.

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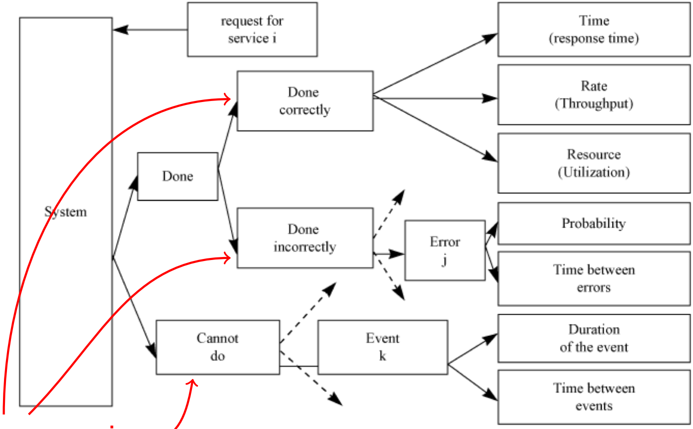
A systematic way to metrics

Path to metrics

List system's services → list outcomes per service → determine metrics per outcomes.



3 outcome categories

Selecting metrics (1)

- Done correctly:

  Time-rate-resource $\equiv$ responsiveness-productivity-utilization
- Done incorrectly: rate, probability of errors
- Cannot do: time to failure and duration

- (Computer network) Responsiveness $\ni$ response time
- (Operating system) Productivity $\ni$ throughput
- (System) Highest utilization $\equiv$ bottleneck
- (Computer network) Timeout rate

Selecting metrics (2)

Correct service	Incorrect service	Not service
Time	Rate	Resource
Responsiveness	Productivity	Utilization
Speed	Reliability	Availability

Aspects of a metric

- Mean and Variability: both need to be considered.
- Global and individual
  - Resource utilization, reliability, availability: global metrics.
  - Response time, throughput: individual and global metrics.
  - Only using system (global) or individual thoughtput ⇒ unfair situations.

Congestion control algorithms

A service and its outcomes

System definition

- A computer network consists of a number of end systems interconnected via a number of intermediate systems.
- Intermediate systems forward the packets along the right path.
- Congestions occur when
  - Number of packets waiting at intermediate systems $>$ their buffer capacity.
  - Some packets have to be dropped.

Congestion control algorithms

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- 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).
  - ...

Packet delivery service

Done correctly: delivered in order

- Time-rate-resource
  - Response time to deliver the packets
  - Throughput: the number of packets per unit of time.
  - Processor time per packet on the source end system.
  - ...
- Variability of the response time → retransmissions
  - Response time: the delay inside the network.

Packet delivery service

Done incorrectly: out-of-order delivery

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

Packet delivery service

Sharing system: a fairness metric

- Given set of user throughputs: $x_1, x_2, \ldots, x_n$.
- Fairness metric (Jain's fairness index)

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

- 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.

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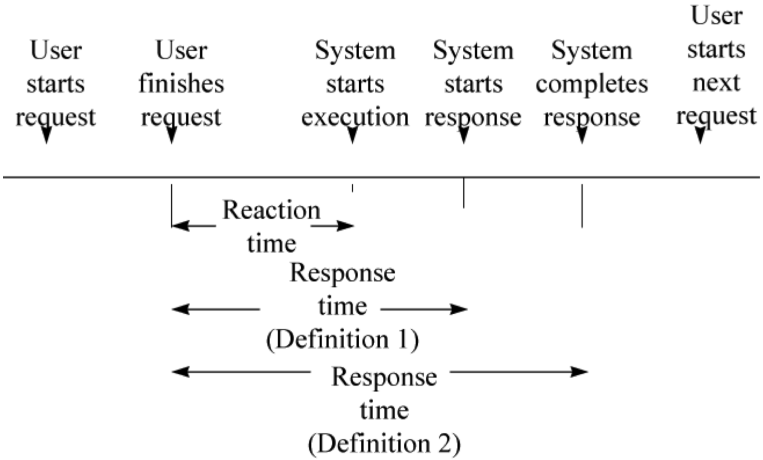
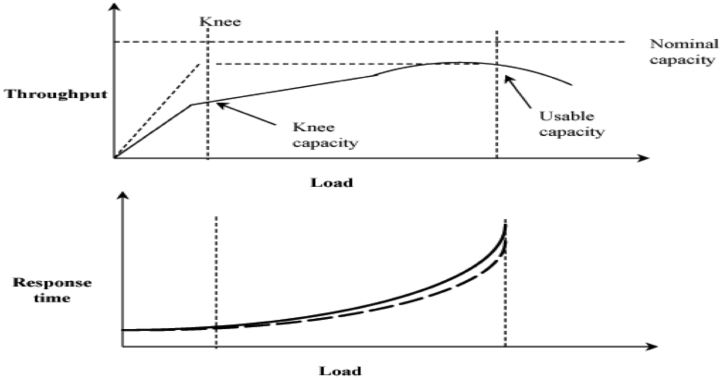
Response time, reaction time, turnaround time



- Turnaround time: the time between the submission of a batch job and the completion of its output.

Throughput
Capacity vs. load (1)



- Jobs/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)

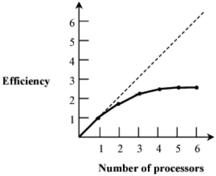
Throughput

Capacity vs. load (2)

- Nominal Capacity: Maximum achievable throughput under ideal workload conditions.
- Usable capacity: Maximum throughput achievable without exceeding a pre-specified response-time limit.
- Knee Capacity: Knee = Low response time and High throughput ⇒ optimal operating point

Efficiency and Utilization

- Efficiency: ratio between usable capacity and nominal capacity
  - Example: maximum throughput of 100Mbps LAN = 85 Mbps ⇒ Efficiency = 85%.
  - (Multiprocessor system): Efficiency = ratio of the performance of an n-processor system to that of a one-processor system.



- Utilization: fraction of time the resource is busy servicing requests.

Reliability and Availability

- 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).

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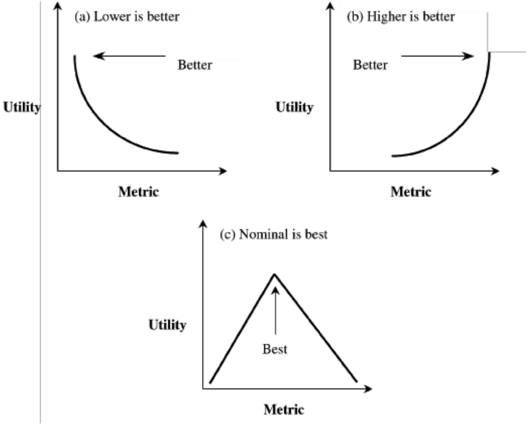
Utility classification

Which values are better/worse?

- Higher is Better (HB): e.g., System throughput
- Lower is Better (LB): e.g., Response time
- Nominal is Best (NB)



Setting performance requirements

SMART

- *Non-Specific*: No clear numbers are specified.
- *Non-Measurable*: No way to measure/verify with requirements.
- *Non-Acceptable*: Low numerical values in order to be realistic ⇒ unacceptable.
- *Non-Realizable*: High performance ⇒ unrealizable.
- *Non-Thorough*: no all possible outcomes.

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The system should be both processing and memory efficient. It should not create excessive overhead.