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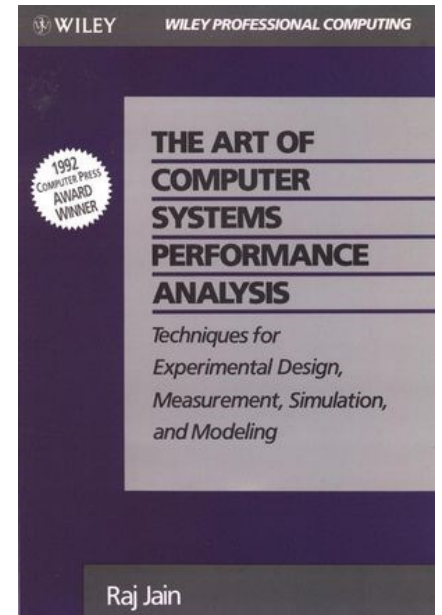


Introduction to Performance Evaluation

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References

- Raj Jain, **The Art of Computer Systems Performance Analysis**, Wiley, 1991.
 - Part I: An Overview of Performance Evaluation
 - Part II: Measurement Techniques and Tools
 - Part III: Probability Theory and Statistics
 - Part IV: Experimental Design and Analysis
 - Part V: Simulation



Outline

- Introduction
- Common Mistakes in Performance Evaluation
- A Systematic Approach to Performance Evaluation
- Criteria for Selecting an Evaluation Technique
- Selecting Performance Metrics
- Commonly Used Performance Metrics
- Utility Classification of Metrics
- Setting Performance Requirements

Introduction

- **Key terms**

- **System**: Any collection of hardware, software, and firmware.
- **Metrics**: Criteria used to evaluate the performance of the system.
- **Workloads**: The requests made by the users of the system.

- **Main performance evaluation techniques**

1. **Measurement**
2. **Analytical Modeling**
3. **Simulation**

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Common Mistakes in Performance Evaluation

1. No Goals
2. Biased Goals
 - “To show that OUR system is better than THEIRS”
3. Unsystematic Approach
4. Analysis Without Understanding the Problem
5. Incorrect Performance Metrics
6. Unrepresentative Workload
7. Wrong Evaluation Technique
8. Overlook Important Parameters
9. Ignore Significant Factors
10. Inappropriate Experimental Design
11. Inappropriate Level of Detail

Common Mistakes (Cont.)

- 12. No Analysis
- 13. Erroneous Analysis
- 14. No Sensitivity Analysis
- 15. Ignoring Errors in Input
- 16. Improper Treatment of Outliers
- 17. Assuming No Change in the Future
- 18. Ignoring Variability
- 19. Too Complex Analysis
- 20. Improper Presentation of Results
- 21. Ignoring Social Aspects
- 22. Omitting Assumptions and Limitations

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A Systematic Approach to Performance Evaluation

1. State Goals and Define the System
2. List Services and Outcomes
3. Select Metrics
4. List Parameters
5. Select Factors to Study
6. Select Evaluation Technique
7. Select Workload
8. Design Experiments
9. Analyze and Interpret Data
10. Present Results

Repeat

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Criteria for Selecting an Evaluation Technique

Criterion	Measurement	Analytical Modeling	Simulation
Stage	Post-prototype	Any	Any
Time required	Varies	Small	Medium
Tools	Instrumentation	Analysts	Computer languages
Accuracy	Varies	Low	Moderate
Trade-off Evaluation	Difficult	Easy	Moderate
Cost	High	Small	Medium
Salability	High	Low	Medium

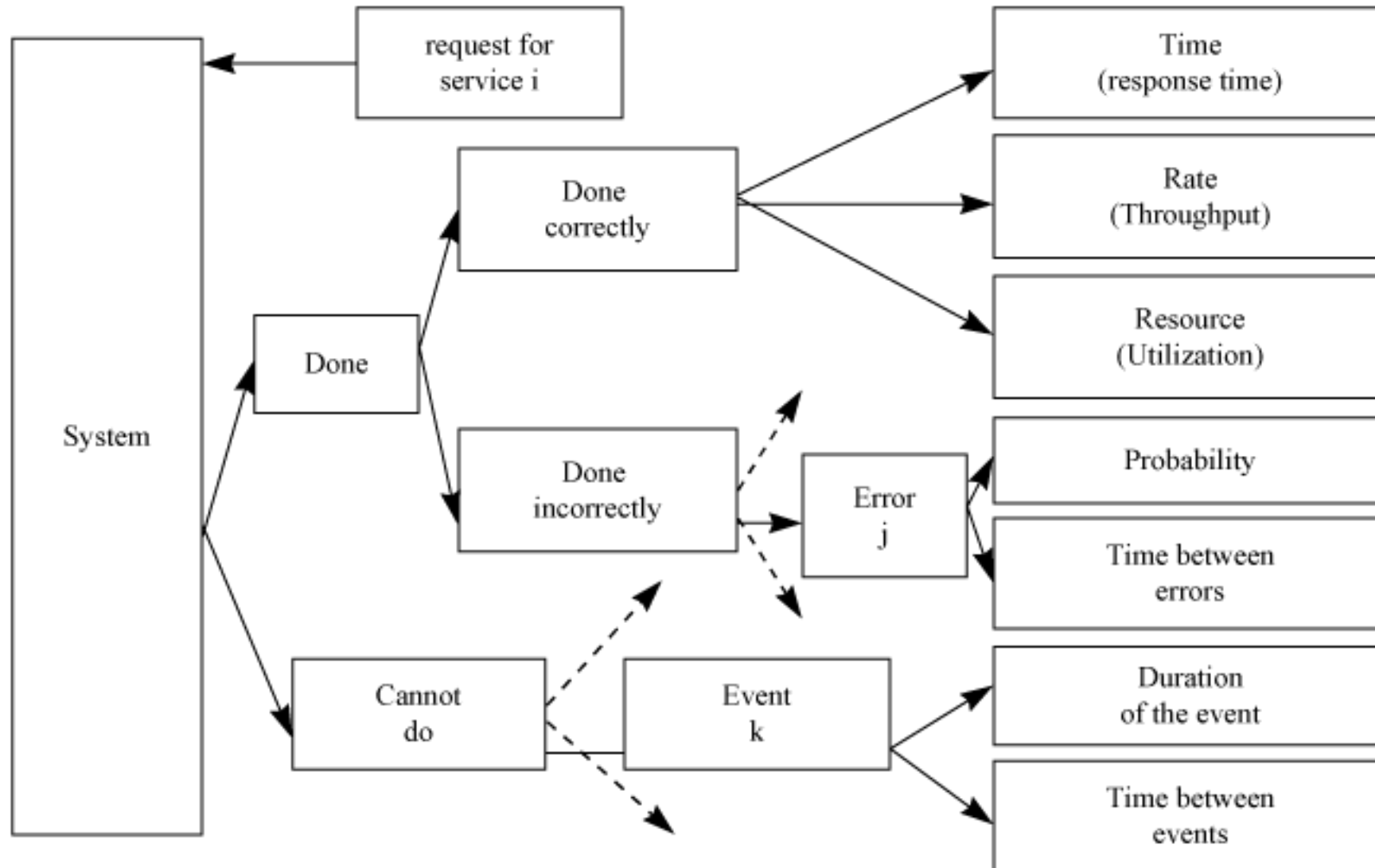
Three Rules of Validation

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

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Selecting Performance Metrics



Selecting Metrics

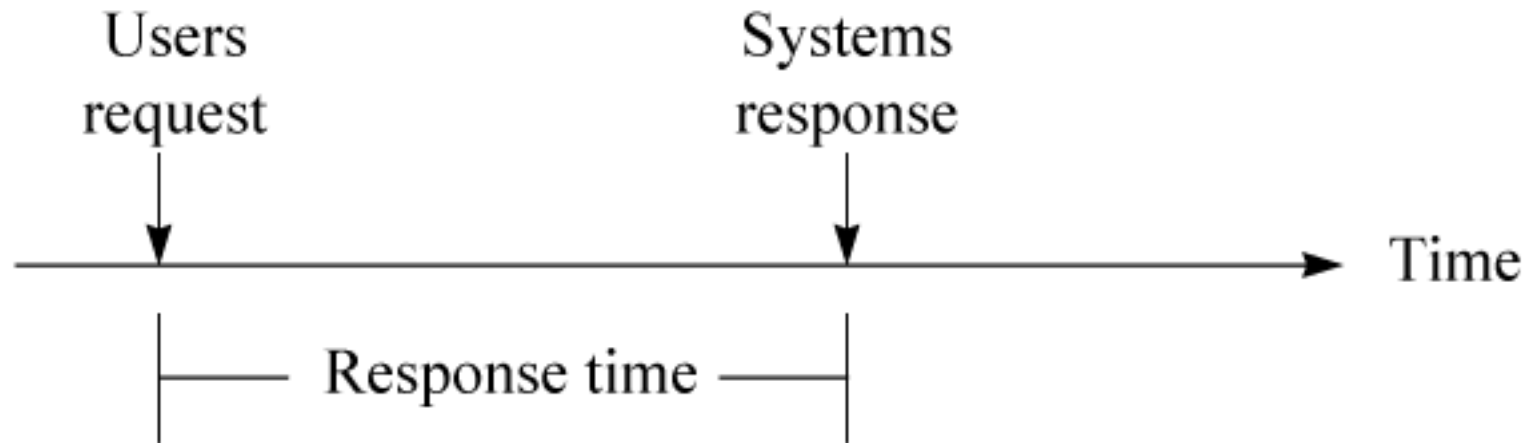
- Include
 - Performance: Time, Rate, Resource
 - Error rate, probability
 - Time to failure and duration
 - Cost, *etc.*
- Consider including
 - Mean and variance
 - Individual and Global
- Selection Criteria
 - Low-variability
 - Non-redundancy
 - Completeness

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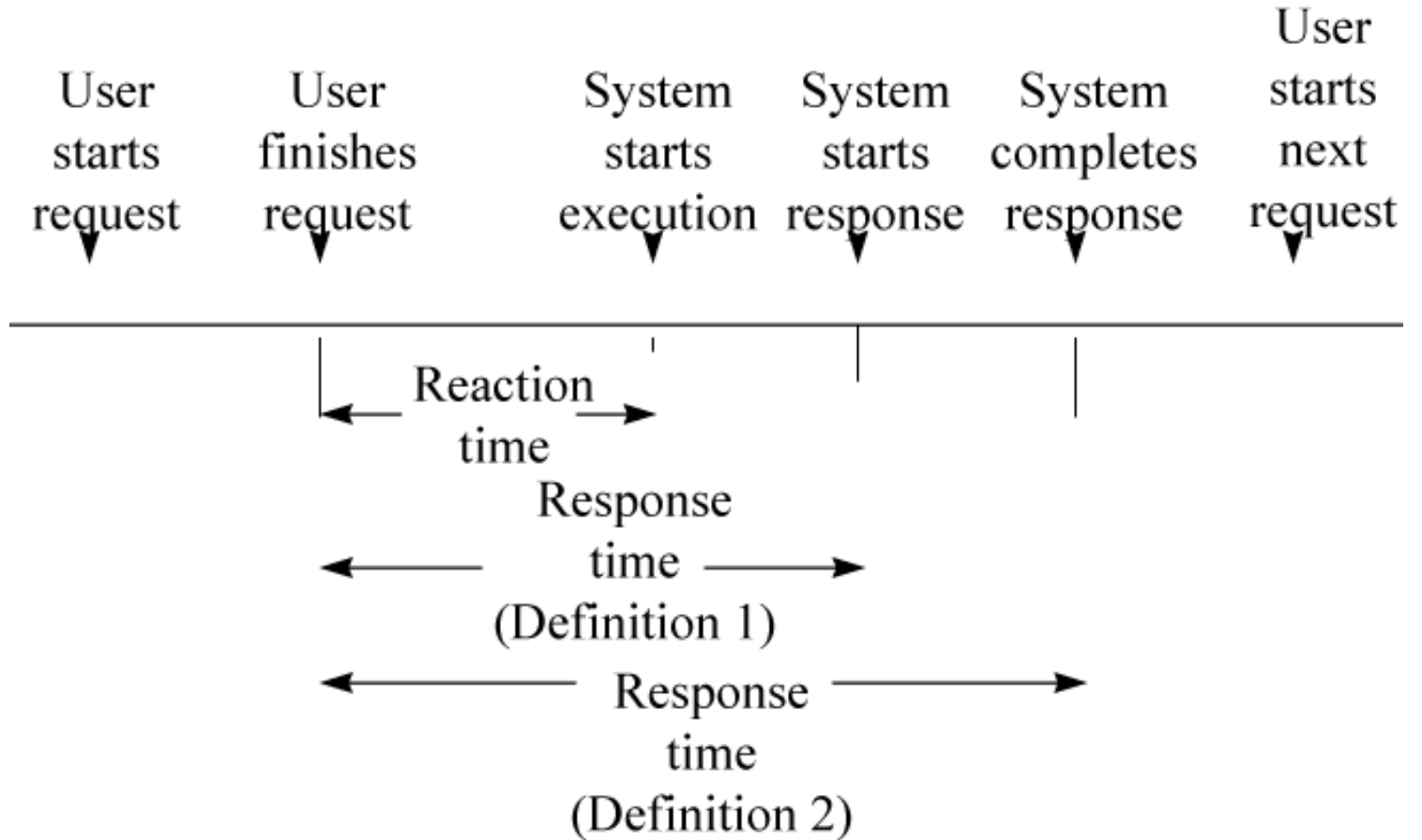
Common Performance Metrics

- **Response time** and Reaction time



Common Performance Metrics (Cont.)

- **Response Time** (cont.)
- **Turnaround time:** From the submission of a batch job and the completion of its output.
- **Cycle Time**
- **Stretch Factor:** Due to multi-programming.

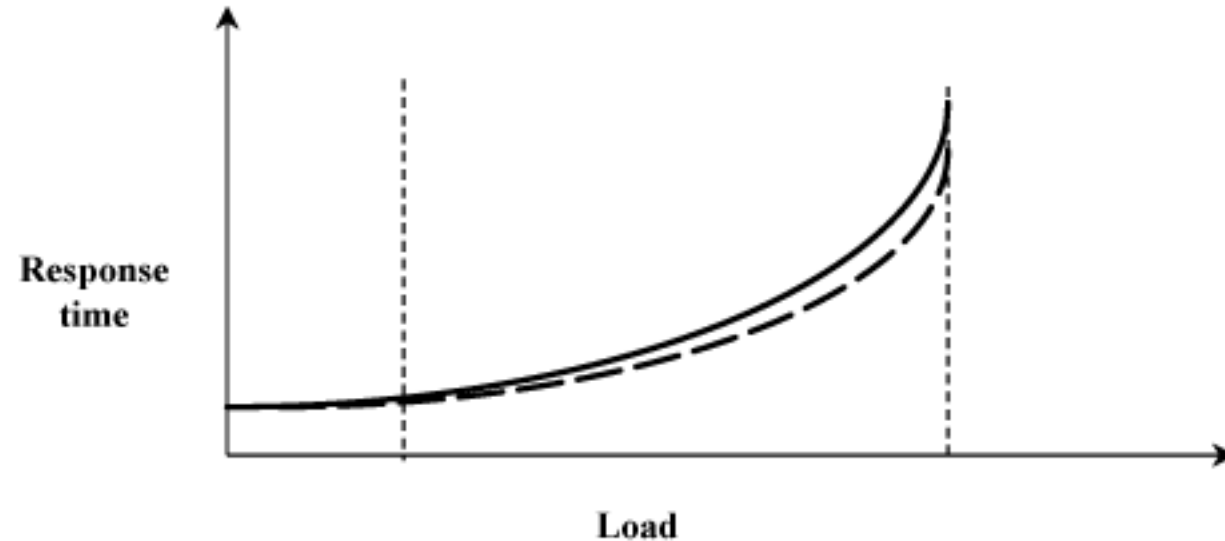
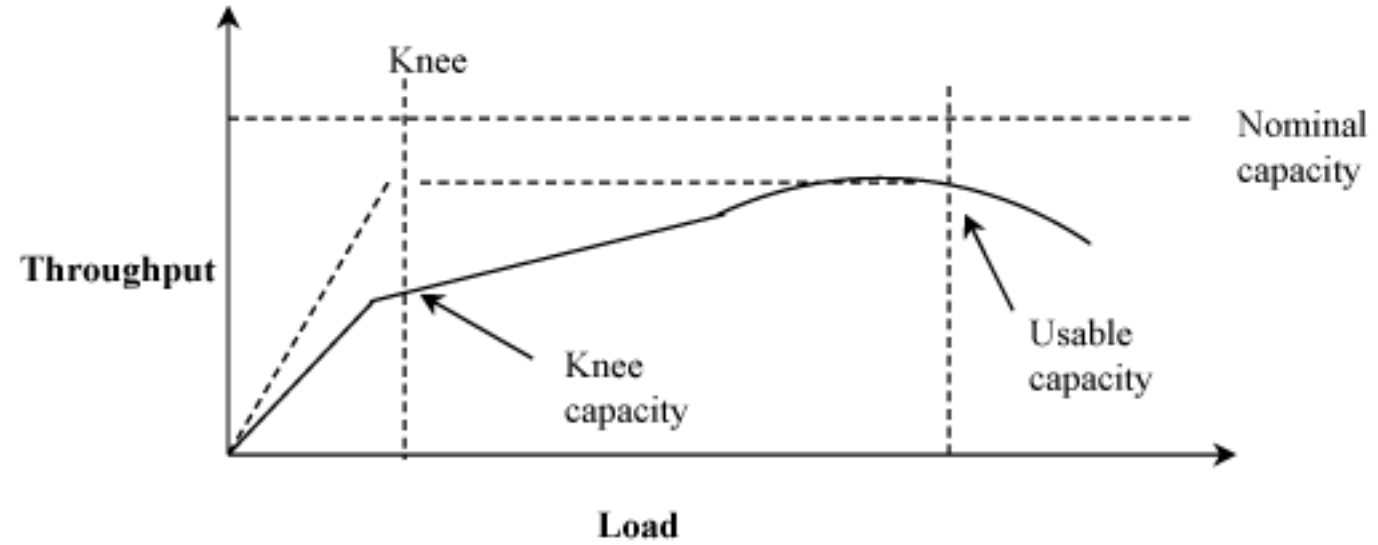


Common Performance Metrics (Cont.)

- **Throughput**, Rate (requests per unit of time)
- **Examples**
 - Jobs per hour
 - Transactions per second (tps)
 - Millions of instructions per second (MIPS)
 - Millions of floating-point operations per second (MFLOPS)
 - Packets per second (PPS)
 - Bits per second (bps)

Common Performance Metrics (Cont.)

- Capacity



Common Performance Metrics (Cont.)

- **Nominal Capacity**: Maximum achievable throughput under ideal workload conditions.
- **Usable Capacity**: Maximum throughput achievable without exceeding a pre-specified response-time limit.
- **Knee Capacity**: Maximum throughput with low response time.
- **Efficiency**: Ratio of usable capacity to nominal capacity.

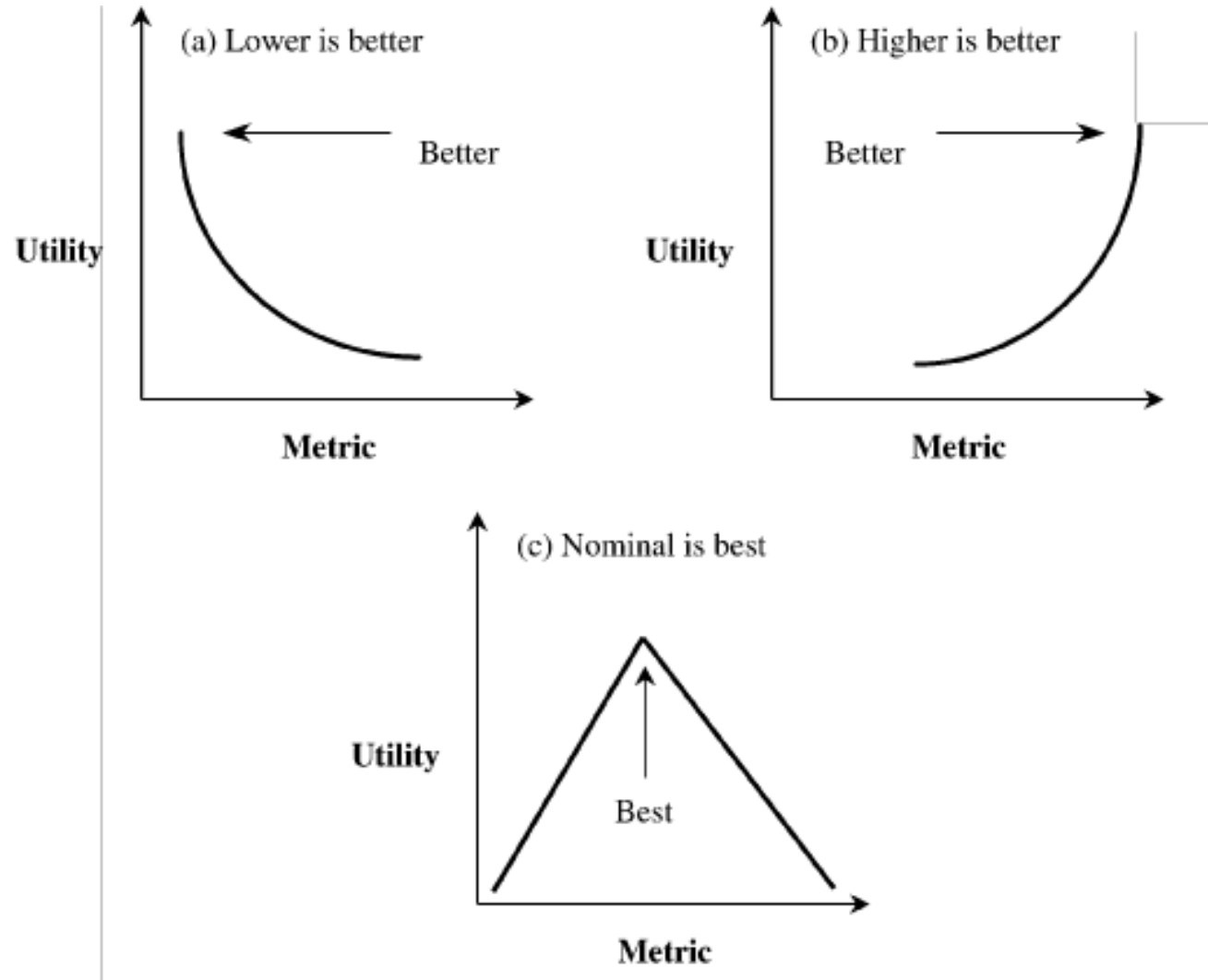
Common Performance Metrics (Cont.)

- **Utilization**: The fraction of time the resource is busy servicing requests. Average fraction used for memory.
- **Reliability**
 - Probability of errors
 - Mean time between errors (error-free seconds)
- **Availability**
 - $\text{Availability} = \text{MTTF} / (\text{MTTF} + \text{MTTR})$
 - Mean time to failure (MTTF) \leftarrow Reliability
 - Mean time to repair (MTTR)

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Utility Classification of Metrics



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Setting Performance Requirements

- **Bad 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-**S**pecific
- Non-**M**easurable
- Non-**A**ceptable
- Non-**R**ealizable
- Non-**T**horough

- Good requirements should be **SMART**

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