MODULE 14: Selected Topics 2

Lecture 14.2
Performance Measurement

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Lecture 14.2 Objectives

- Describe the motivation for performance measurements and analysis
- List and give examples of the three types of performance study methods – analytical, simulation, and measurements – and describe their characteristics
- List the basic steps for a performance study
- Define common metrics used in computer and network systems performance studies, including response time, latency, throughput, blocking probability, and availability

Motivation for Performance Analysis

- Why worry about performance? Answers should be obvious!
  - Budgets are never unlimited – there is always a cost/performance trade-off
  - Excessive periods of poor performance lead to disgruntled users
  - Lack of performance analysis may lead to solutions that do not fix a problem
  - Without performance analysis, one may be responding to perception, not reality
  - Performance is a key parameter in the “interface” to vendors (including service providers) and customers

A Simple Example

- You are buying a PC with a fixed budget
- You are considering two systems – both exactly match your budget and are otherwise the same
    - A PC with a faster processor, but less main memory
    - A PC with a slower processor, but more main memory
- Which one is better? It depends!
    - What operating system is used?
    - What applications are used?
    - Which applications are important?
- Performance analysis can help you decide which PC to buy

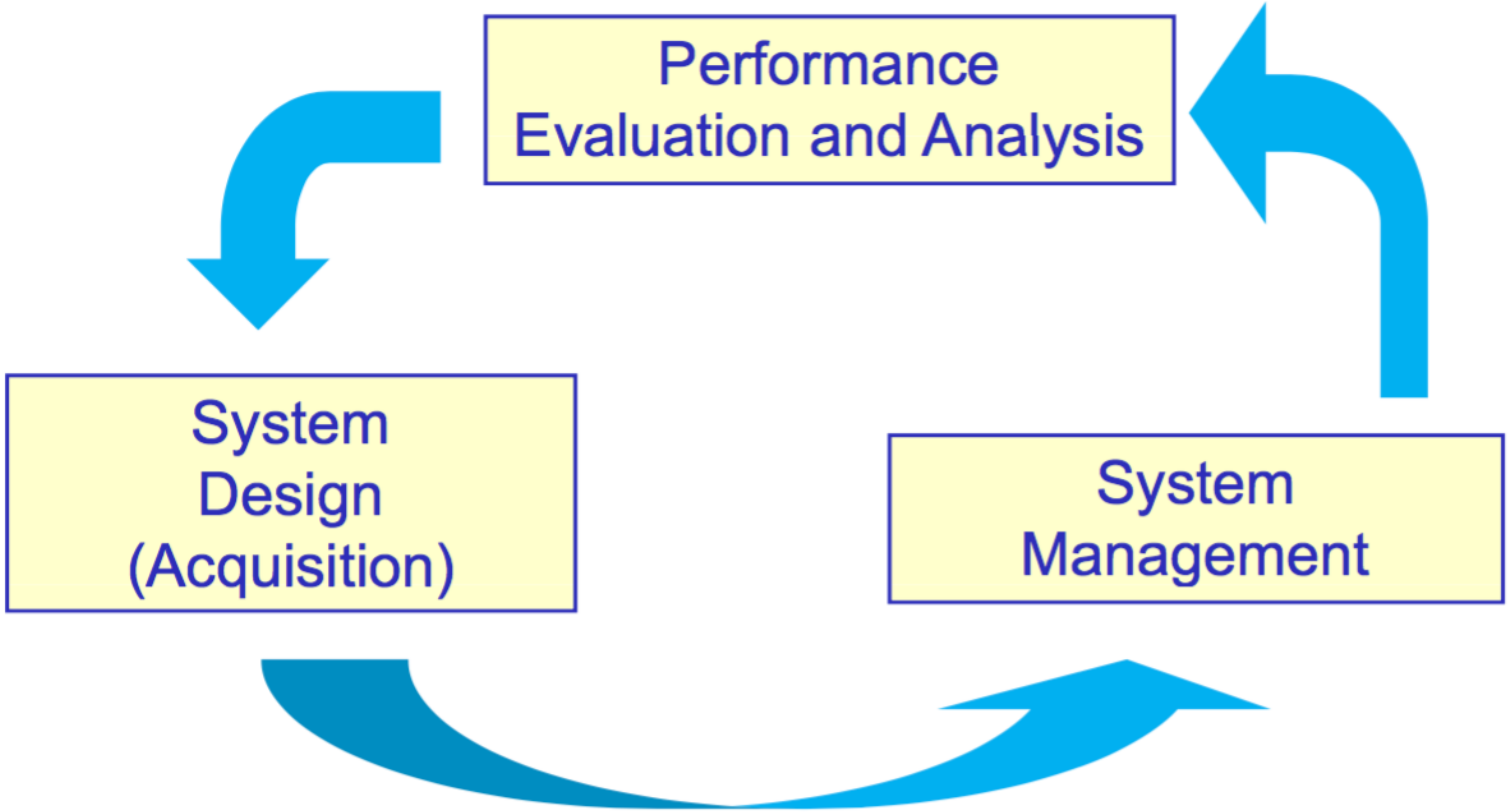
Performance Analysis

- Why?
  - Bottleneck or capacity analysis
  - Sensitivity of performance to parameters
  - Detecting problem areas to guide system tuning
  - Configuration planning and trade-offs
  - Benchmarking
- When?
  - Architecture/system design (before realization or acquisition)
  - Detailed design, implementation, and configuring
  - Operation and management

Performance Analysis (cont’d)

- How?
  - Analytical models, e.g., queuing models with closed form or numerical solutions
  - Simulation experiments, e.g., discrete-event simulation with statistical results
  - Empirical measurements, e.g., instrumented code and network monitoring

Performance, Design, and Management



Performance Evaluation and Analysis

System Design (Acquisition)

System Management

CHECK POINT

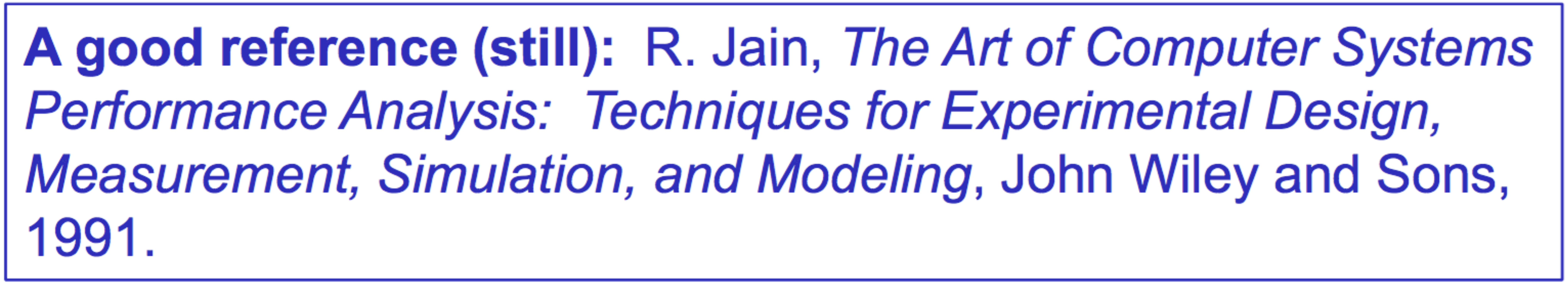
As a checkpoint of your understanding, please pause the video and make sure you can do the following:

- Describe the motivation for performance measurements and analysis
- List and give examples of the three types of performance study methods – analytical, simulation, and measurements – and describe their characteristics

If you have any difficulties, please review the lecture video before continuing.

Systematic Approach

1. State goals of the study and define the system
   - Delineate system boundaries
   - Goals will determine appropriate boundaries
2. List services (functions) and outcomes of services
3. Select metrics
   - Examples: throughput, latency, availability, etc.



A good reference (still): R. Jain, *The Art of Computer Systems Performance Analysis: Techniques for Experimental Design, Measurement, Simulation, and Modeling*, John Wiley and Sons, 1991.

Systematic Approach (cont'd)

4. List parameters that affect performance
   - System parameters
   - Workload parameters
5. Select factors to study
   - Factors are parameters that will be varied
   - Other parameters will remain fixed
6. Select evaluation technique
   - Analytical
   - Simulation
   - Measurement

Systematic Approach (cont'd 2)

7. Select workload, or list of service requests
    - Probability distributions for analytical study
    - Trace or distribution for simulation study
    - Scripts for measurements
8. Design experiments
    - Phase 1: Large number of factors, few values
    - Phase 2: Small number of factors, many values

Systematic Approach (cont’d 3)

9. Analyze and interpret results
   - Results are random
   - Statistical techniques needed to compare results
10. Present results
    - Graphical techniques
    - Refinement and iteration may be needed

Evaluation Techniques

Criterion	Analytical	Simulation	Measurement
Stage	Any	Any	Post-prototype
Time required	Small	Medium	Varies
Accuracy	Low	Moderate	Varies
Trade-off Evaluation	Easy	Moderate	Difficult
Cost	Low	Medium	High
“*Saleability*”	Low	Medium	High

☑ Use of multiple techniques allows validation

CHECK POINT

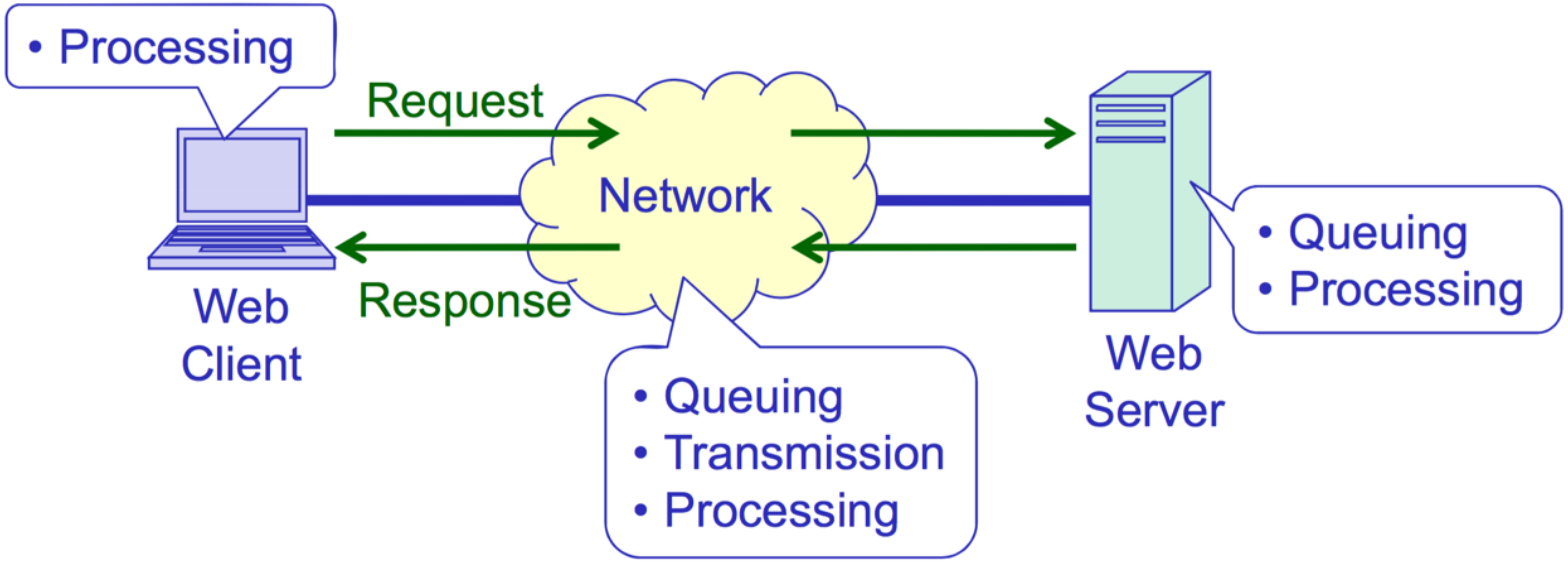
As a checkpoint of your understanding, please pause the video and make sure you can do the following:

- List the basic steps for a performance study

If you have any difficulties, please review the lecture video before continuing.

Metrics: Response Time

- Given a request or other event, the response time is the wait until the system responds or completes the action
- Often depends on a number of performance characteristics for a number of system components
- Example: time for a web page to load after clicking a link



Metrics: Latency

- Latency is just the delay from some event until another event (caused by the first)
- Response time is a special case of latency
- Often depends on a number of performance characteristics and it can contribute to other metrics
- Example: time from when one host (a client) until the message (a request) is received by the destination host (a server)

Metrics: Throughput

- Throughput is a measure of productivity – how many units of work (computations, packet transmissions, queries processed, etc.) are performed in a unit of time
- Higher throughput may lead to:
  - Low response time if higher throughput is applied to the tasks of a fixed number of users, or
  - Similar response time if throughput is used to support an increased number of users
- Examples:
  - Instructions per second
  - Packets per second
  - Database queries per second

Metrics: Blocking Probability

- “Blocking systems” limit the number of users or sessions
  - Fixed resources (e.g., fixed number of software license connections or channels)
  - Assured service levels require limits on users (e.g., throughput for a batch computing system)
- Performance measure is the probability that a request for service is accepted (the call goes through) or is blocked (a system busy signal is received)
- Depends on:
  - Arrival rate (number of requests)
  - Time in service (time to complete accepted requests)

Metrics: Availability

- Availability is used to express the probability that a system is available for use
  - Maybe unavailable due to failure (including due to intentional or unintentional attack)
  - Maybe unavailable for planned maintenance
- Availability depends on:
  - Mean time to failure (MTTF)
  - Mean time to repair (MTTR)

CHECK POINT

As a checkpoint of your understanding, please pause the video and make sure you can do the following:

- Define common metrics used in computer and network systems performance studies, including response time, latency, throughput, blocking probability, and availability

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Summary

- Performance measurements are important to many aspects of designing, acquiring, operating, and/or using computer and network systems
- Performance studies should have well defined goals and scope and should be based on an understanding of metrics, parameters, and factors
- Three type of analysis are commonly used:
    - Analytical – for basic understanding and early analysis
    - Simulation – measure a system that is not available
    - Measurements – requires a system for the study
- Common metrics used in computer and network systems performance studies include response time, latency, throughput, blocking probability, and availability

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