Networking … at a glance

- Discrete Mathematics
- Operating Systems
- Computer Networks
- Network Security
- Advance Networking
- Network Analysis
- Multimedia Networking
- Network Programming
- Distributed Systems
- Server and System Administrations
Course Design

- **Classes**
  - 2 Credits

- **Exercises (assistant required)**
  - 1 Credits

- **Evaluation**
  - 2 Structured Task (20 %)
  - 1 Midterm Test (40 %)
  - 1 Final Test (40 %)
Reference


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01 Introduction

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1.1 Overview

- **Network analysis, architecture, and design** are processes used to produce designs that are logical, reproducible, and defensible.

- **Network analysis** entails learning what users, their applications, and devices need from the network.
1.1 Overview

• **Network analysis** also defines, determines, and describes relationships among users, applications, devices, and networks.

• The **purpose** of network analysis is twofold:
  • first, to listen to users and understand their needs; and
  • second, to understand the system.
1.1 Overview

- **Network architecture** uses the information from the analysis process to develop a conceptual, high-level, end-to-end structure for the network.

- **Network architecture** process
  - determines sets of technology and topology choices;
  - the classes of equipment needed; and
  - the relationships among network
1.1 Overview

• **Network design** provides physical detail to the architecture.

• Physical detail includes:
  • blueprints and drawings of the network;
  • selections of vendors and service providers; and
  • selections of equipment

• Network design is also about applying the trade-offs, dependencies, and constraints developed as part of the network architecture.
1.1 Overview

1.1.1 Process Components

- Each of network design, architecture and analysis processes describe specific actions or results.
- Set of process components represents a complete implementation of network analysis, architecture, and design.
1.1 Overview

1.1.2 Tactical and Strategic Significance

- Network analysis, architecture, and design are part of the engineering process that form the basis of networking projects.
- Such projects have immediate, tactical (near-term), and strategic (long-term) significance, and networking projects should consider all of these areas.
- These plans are intended to be iterative and should be regularly reviewed.
1.1 Overview

- Requirements Gathering
- One Iteration of Process
- Network Implementation, Test, and Acceptance
- Network Architecture and Design
- Requirements and Flow Analyses

Steps in Process
1.1 Overview
1.1 Overview

1.1.3 Importance of Network Analysis

• In general, networks and the systems they support are becoming increasingly complex.

• Network analysis is important in that it helps us understand the complexity and nuances of each network and the systems they support.

• Also, analysis helps us understand how technologies influence networks, users, applications, and devices (and vice versa).
1.1 Overview

- Fourth Generation: Rudimentary Decision-Making Capability
- Third Generation: Services (Performance, Security, Manageability)
- Second Generation: Interoperability (Flexibility)
- First Generation: Connectivity (Technology Choices, Price)
1.1 Overview

1.1.4 Model for Network Analysis, Architecture and Design

- Network analysis, architecture, and design are similar to other engineering processes in that they address the following areas:
  - Defining the problems to be addressed
  - Establishing and managing customer expectations
  - Monitoring the existing network, system, and its environment
  - Analyzing data
  - Developing a set of options to solve problems
1.1 Overview

- Evaluating and optimizing options based on various trade-offs
- Selecting one or more options
- Planning the implementation
1.2 System Methodology

- **Systems methodology** means viewing the network that you are architecting and designing, along with a subset of its environment (everything that the network interacts with or impacts), as a system.

- The fundamental concepts of the systems methodology is that network architectures and designs take into account the services that each network will provide and support.
1.2 System Methodology

• This reflects the growing sophistication of networks, which have evolved from providing basic connectivity and packet-forwarding performance to being a platform for various services.

• System methodology helps in determining, defining, and describing the important characteristics and capabilities of your network.
1.3 System Description

- A *system* is a set of components that work together to support or provide connectivity, communications, and services to users of the system.

- Generically speaking, components of the system include users, applications, devices, and networks.
1.3 System Description
1.4 Service Description

- **Network services**, or services, are defined here as levels of performance and function in the network.

- Two perspectives of network services:
  - as services being offered by the network to the rest of the system, or
  - as sets of requirements from the network that are expected by the users, applications, or devices.
1.4 Service Description

- Network services in most of today’s networks are based on best-effort (unpredictable and unreliable) delivery.
1.4 Service Description

Network Service Description

Service Levels
- Level A
- Level B
- ...

Service Characteristics for Each Service Level
- Characteristic 1
- Characteristic 2
- Characteristic 3
- ...

- Basic Service (No Priority)
- Gold Service (High Capacity)
- Platinum Service (High Capacity, Reliability, Low Delay)

- Delay Characteristic (e.g., 100 ms)
- Capacity Characteristic (e.g., 10 Mb/s)
- RMA Characteristic (e.g., 99.99% Uptime)
- Security Characteristic (e.g., Encryption)

Characteristics Used to Configure Services in Network, and as Service Metrics to Measure and Verify Services

- End-to-End Delay, Round-Trip Delay
- Capacity, Throughput, Goodput
- Buffer/Queue Utilization
- Priority levels
1.5 Services Characteristics

- One of the goals of network analysis is to be able to characterize services.
- For services to be useful and effective, they must be described and provisioned end-to-end at all network components between well-defined demarcation points.
- The demarcation points determine where end-to-end is in the network. Determining these demarcation points is an important part of describing a service.
1.5 Services Characteristics
1.5 Services Characteristics

1.5.1 Service Levels

• Service characteristics can be grouped together to form one or more service levels for the network.

• There are many ways to describe service levels, including:
  • committed information rates (CIRs);
  • levels of capacity;
  • classes of service (CoSs);
  • delay and capacity characteristics;
  • types of service (ToSs);
  • qualities of service (QoSs);
1.5 Services Characteristics
1.5 Services Characteristics

1.5.2 System Components and Network Services

• Network services are derived from requirements at each of the components in the system.

• Defining network services and service metrics helps keep the system functioning and can provide extra value or convenience to users and their applications.

• Recall that network services are sets of performance and function, so requirements may also include functions of one of the components.
1.5 Services Characteristics
1.5 Services Characteristics

1.5.3 Service Requests & Requirements

• Service requests and requirements are, in part, distinguished by the degree of predictability needed from the service by the user, application, or device making the request.

• Based on their predictability, service requests are categorized as best effort, predictable, or guaranteed.

• *Best-effort service* means that there is no control over how the network will satisfy the service request—that there are no guarantees associated with this service.
1.5 Services Characteristics

- **Guaranteed service** is the opposite of best-effort service. It must be predictable and reliable to such a degree that, when service is not available, the system is held accountable.

- **Predictable services**, is placed in between best-effort and guaranteed. It requires some degree of predictability (more than best effort) yet does not require the accountability of a guaranteed service.

- Note that there are times when a service can be best effort, predictable, or guaranteed, depending on how it is interpreted.
1.5 Services Characteristics

- For service performance requirements and characteristics to be useful, they must be configurable, measurable, and verifiable within the system.

- Therefore, performance requirements and characteristics were described in terms of service metrics, which are intended to be:
  - **configurable**, set a value for threshold and limit; and,
  - **measurable**, by monitoring current state value.
1.5 Services Characteristics

- **Boundary Exceeded—Action Taken (e.g., Packets Dropped)**
- **Limit on Capacity**
- **Conformance—Warning (e.g., Color: Yellow)**
- **Threshold Exceeded—Noted in Network Management Database**
- **Nonconformance (e.g., Color: Red)**
1.6 Performance Characteristics

- Services may include one or more of the performance characteristics:
  - capacity, is used as a label for the class of characteristics that involves moving information from place to place, including bandwidth, throughput, and so forth.
  - delay, is a label for the class of characteristics that includes end-to-end delay, round-trip delay, and delay variation.
  - RMA, is a label for the class of characteristics that includes reliability, maintainability, and availability.
1.6 Performance Characteristics

• Performance requirements can be combined to describe a performance range for the system.

• A performance envelope is a combination of two or more performance requirements, with thresholds and upper and/or lower limits for each.
1.6 Performance Characteristics
1.6 Performance Characteristics

![Diagram of performance characteristics with axes for capacity, delay, RMA, threshold, low-performance region, upper limit, and high-performance region.]
1.7 Network Supportability

- Good network architects/designers take into account the major factors that affect operability and supportability as they make their decisions.

- The post-implementation phases of a network’s life cycle can be broken into three elements:
  - operations,
  - maintenance, and
  - human knowledge.
1.7 Network Supportability

- Failure to consider supportability in the analysis, architecture, and design processes has a number of serious consequences.
  - Customer will reject the network project or refuse to pay for it.
  - Customer will have inadequate resources, experience unacceptable performance.
  - Other customers will be highly dissatisfied with their network.
1.7 Network Supportability

- Key characteristics of a network architecture and design that affect the post-implementation costs include:
  - Network and system reliability
  - Network and system maintainability
  - Training of the operators to stay within operational constraints
  - Quality of the staff required to perform maintenance actions
1.7 Network Supportability

- Two major tasks must be accomplished to ensure supportability:
  - Conformance to the network architecture and design must be validated and nonconformance corrected or (at least) documented to ensure that performance is adequate and that maintenance can be performed.
  - Operations and maintenance personnel must understand and be trained in the technologies that are being deployed.