Course Overview

• Outline
  – Administrative Information
  – Topics and Schedule
  – Assessment/Grading

Administrative Information

• Welcome back from break!
  • Instructor: Aaron Striegel
  – 383 Fitzpatrick Hall
  – Office Hours: M, T, W, Th, F, 10
  • TA: Shu Liu
  – Office Hours: By appointment
  • Will schedule during project weeks
  – E-Mail: shu.11@nd.edu
• Course Website
  – http://netscale.coe.nd.edu/CompNet
  or
  http://netscale.coe.nd.edu/twiki/bin/view/Edu/CompNetS10
Meet Prof. Striegel

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• Associate Professor
  – Comp Sci & Engr. (CSE)

• Teaching
  – Networking
  – System Interface Design

• Research
  – Computer networks
  – Computer security
  – System management
  – Stroke rehabilitation

Finding My Office

Office Hours
M 1, T 10, W 10, F 10, stop on by

Textbook

• Larry L. Peterson and Bruce S. Davie, "Computer Networks, A Systems Approach", Morgan Kaufmann Publishers (Elsevier)
  – Third Edition:
    • ISBN-10: 155860832X
  – Fourth Edition:
    • ISBN-10: 0123705487
Course Goals

- Learn fundamental computer network principles
- Prepare for advanced CSE courses
- Homework assignments, exams
- Learn algorithms, protocols, etc., that drive the Internet
  - Homework assignments
- Get hands dirty with implementations and experiments
  - Programming assignments
- Learn to solve problems in teams
  - Team-based programming assignments

Topics

- Acronym soup
  - TCP, UDP, MANET, IPSec, AH, ESP, RSSI, SSL, IPv4, IPv6, DHCP, GRE, MPLS, DNS, IS-IS, BGP, ARP, RPC, WTF
- Theory
  - How should it behave?
- Client/server programming
  - Roll your own P2P server
- Wireless connectivity
  - Technology awareness (2.5G, 3G, 4G)

Grading

- Homework assignments (20%)
  - Deepen understanding of principles and algorithms
- Programming projects (20%):
  - Deepen understanding of principles, practice protocols, experimental design, result presentation
- Quizzes (15%)
  - Combination of take home / in-class
- Midterm and final exam (20% each)
- Course participation (5%)
Other Items

- Academic Honor Code
- Locate team members (2-3 members / team)
  - Ask if you need help
- Participate! Ask questions! Use resources!

Introduction

Outline
  - Computer Networks Overview
  - Statistical Multiplexing
  - Inter-Process Communication
  - Network Architecture
  - Performance Metrics
  - Implementation Issues

Applications

- What applications do you use on the network?

  Split into groups of 2-4 students and come up with as many network applications as you can think of in the next 60 seconds.
Computer Networks

- Computer networking has grown explosively
- ARPANet
  - Circa early 70’s
  - Research topic -> infrastructure
- Internet
  - 1980 - Research project that involved a few dozen sites
- Today
  - How big?

Complexity of Computer Networks

- Many technologies exist; each technology has features that distinguish it from the others
- Companies create commercial network products and services
- No single underlying theory exists that explains the relationship among all parts
- Multiple organizations have created computer networks standards (some standards are incompatible with others)
- Various organizations have attempted to define conceptual models
- The set of technologies is diverse and changes rapidly
  - models are either so simplistic that they do not distinguish among details
  - or so complex that they do not help simplify the subject

Examples – Outside Networking
Complexity of Computer Networks

- The lack of consistency in the field has produced another challenge for beginners:
  - Multiple groups each attempt to create their own terminology
  - Researchers cling to scientifically precise terminology
  - Marketing teams often invent new terms to distinguish their products or services from others
  - Technical terms are confused with the names of popular products
  - Professionals sometimes use a technical term from one technology when referring to an analogous feature of another technology
  - A large set of terms and acronyms that contains many synonyms
  - Computer networking jargon contains terms that are often abbreviated, misused, or associated with products

Example

Network Applications and Programming

- Network services are provided by an application software
  - an application on one computer communicates across a network with an application program running on another computer
- Each application offers a specific service with its own form of user interface
  - but all applications can communicate over a single, shared network
- A unified underlying network that supports all applications makes a programmer's job much easier
  - only programmer needs to learn about one interface to network and one basic set of functions to be used
  - it is possible to understand network applications, and even possible to write code that communicates over a network, without understanding the hardware/software technologies
  - once a programmer masters the interface, no further knowledge of networking may be needed
- However, knowledge of the underlying network system allows a programmer to write better code and develop more efficient applications
Translation: Socket Programming

• Open a socket to another host
  – Connection
    • Computer A, Port X to Computer B, Port Y
  – Stream data
    • Send structured messages
    QUERY: I can haz cheeseburger?
    – RESP: Pai moniez first

Data Communications

• Data communications refers to the study of low-level mechanisms and technologies used to send information across a physical communication medium
  – such as a wire, radio wave, or light beam
• Data communications focuses on ways to use physical phenomena to transfer information
  – the subject may only seem useful for engineers who design low-level transmission facilities
  • however, we will see that several key concepts that arise from data communications influence the design of many protocol layers
• Data communications provides a foundation of concepts
  – on which the rest of networking is built

Building Blocks for Data Communications

• Nodes: PC, special-purpose hardware…
  – hosts
  – switches
• Links: coax cable, optical fiber…
  – point-to-point
  – multiple access
Packet Switching and Networking Technologies

• In 1960s, the packet switching concept revolutionized data communications
• Early communication networks had evolved from telegraph and telephone systems
  – a physical pair of wires between two parties to form a dedicated circuit
• Although mechanical connections of wires was being replaced by electronic switches, the underlying paradigm remained the same:
  – form a circuit and then send information across the circuit
• Packet switching changed networking in a fundamental way
  – it provided the basis for the modern Internet
  – packet switching allows multiple users to share a network
  – packet switching divides data into small blocks, called packets
  – it includes an identification of the intended recipient in each packet
  – devices throughout the network each have information about how to reach each possible destination

Switched Networks

• A network can be defined recursively as...
  – two or more nodes connected by a link, or
  – two or more networks connected by a node
Packet Switching and Networking Technologies

- Many designs for packet switching are possible
- But there is a need for answers to basic questions:
  - how should a destination be identified?
  - how can a sender find the identification of a destination?
  - how large should a packet be?
  - how can a network recognize the end of one packet?
  - how can a network recognize the beginning of another packet?
  - if a network is shared, then how can they coordinate to insure that each receives a fair opportunity to send?
  - how can packet switching be adapted to wireless networks?
  - how can network technologies be designed to meet various requirements for speed, distance, and economic cost?
- Many packet switching technologies have been created
  - to meet various requirements for speed, distance, and economic cost

Internetworking with TCP/IP

- In the 1970s, another revolution in computer networks arose: Internet
- In 1973, Vinton Cerf and Robert Kahn observed that
  - no single packet switching technology would ever satisfy all needs
- They suggested to stop trying to find a single best solution
  - instead, explore interconnecting many packet switching technologies into a functioning whole
  - they proposed a set of standards be developed for such an interconnection
  - the resulting standards became known as the TCP/IP Internet Protocol Suite (usually abbreviated TCP/IP)
- The success of TCP/IP lies in its tolerance of heterogeneity
- TCP/IP takes a virtualization approach
  - that defines a network-independent packet and a network-independent identification scheme
Public/Private Internet

- The Internet consists of parts that are owned and operated by individuals or organizations.
- From an ownership point of view, we can categorize networks into public and private networks.
  - A public network is run as a service that is available to subscribers. Any individual or corporation who pays the subscription fee can use it. A company that offers service is known as a service provider. Public refers to the general availability of service, not to the data being transferred.
  - A private network is controlled by one particular group. Network use is restricted to one group. A private network can include circuits leased from a provider.

Networks, Interoperability, Standards

- Communication always involves at least two entities: one that sends information and another that receives it.
- All entities in a network must agree on how information will be represented and communicated. Agreement requires many details:
  - the way that electrical signals are used to represent data
  - procedures used to initiate and conduct communication, and the format of messages
- An important issue is interoperability. It refers to the ability of two entities to communicate.
  - All communicating parties agree on details and follow the same set of rules, an exact set of specifications.
  - Communication protocol, network protocol, or simply protocol to refer to a specification for network communication.
  - A protocol specifies the details for one aspect of communication:
    - including actions to be taken when errors or unexpected situations arise.

Protocol Suites and Layering Models

- A set of protocols must be constructed to ensure that the resulting communication system is complete and efficient.
- Each protocol should handle a part of communication not handled by other protocols.
- How can we guarantee that protocols work well together?
  - Instead of creating each protocol in isolation, protocols are designed in complete, cooperative sets called suites or families.
- Each protocol in a suite handles one aspect of networking:
  - the protocols in a suite cover all aspects of communication.
  - the entire suite is designed to allow the protocols to work together efficiently.
Protocol Suites and Layering Models

- The fundamental abstraction used to collect protocols into a unified whole is known as a layering model.
- All aspects of a communication problem can be partitioned into pieces that work together, each piece is known as a layer.
- Dividing protocols into layers helps both protocol designers and implementers manage the complexity to concentrate on one aspect of communication at a given time.

Example of Layering

Lecture Wrap-Up

- Questions?

Read Ch 1
Homework 1