Course Overview

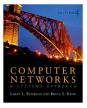
Outline
- Administrative Information
- Topics and Schedule
- Assessment/Grading

Administrative Information

- Welcome to CSE30264!
- Instructor: Christian Poellabauer
- How to contact me:
  - before/after class
  - office hours: Tuesday 10am-11am, Wednesday 11am-12pm, and by appointment
  - office location: 354 Fitzpatrick
  - email: cpoellab@cse.nd.edu
  - phone: (574) 631 9131
- TA: Chris Miller and Veena Thomas (1/2)
  - office hours: Tuesday 3.15pm-4.15pm (Chris), Wednesday 11.30am-12.30pm (Veena)
  - office location: 356B Fitzpatrick ("DARTS Lab")
  - email: cmille17@nd.edu, vthomas2@nd.edu

Textbook

- Larry L. Peterson and Bruce S. Davie, "Computer Networks, A Systems Approach", Morgan Kaufmann Publishers (Elsevier)
  - Third Edition:
    - ISBN-10: 155860832X
    - ISBN-13: 978-1558608320
  - Fourth Edition:
    - ISBN-10: 0123705487
    - ISBN-13: 978-0123705488



Administrative Information

- http://www.cse.nd.edu/~cpoellab/teaching/cse30264
- Course information
- News
- Assignments
- Schedule
- Slides

Course Goals

- learn fundamental computer network principles
- prepare for advanced CSE courses
  - homework assignments, exams
- learn algorithms, protocol, 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

Grading

- 4 homework assignments (35%):
  - deepen understanding of principles, practice protocols, algorithms, etc.
- 4 project assignments (40%):
  - deepen understanding of principles, practice programming, learn how to build distributed programs, learn how to perform experiments, learn how to present results
- Midterm and final exam (10%, 15%):
  - open book, answer questions under time pressure

Other Items

- Academic Honor Code
- Knowing fundamentals of computer networks and distributed systems is extremely important!
- Look for team members, let me know if help needed. Team size = 2-3 (<2, >3 possible if good reason)
- Participate! Ask questions! Use resources!

Introduction

Outline

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

Applications

- Email
- WWW: www.cse.nd.edu
- Audio/Video:
  - http://www.apple.com/trailers/disney/up/trailer_large.html
- youtube.com
- File sharing
- Online gaming
- Social networks
- Others: embedded systems, banking, military, ...

Computer Networks

- Computer networking has grown explosively
- Since the 1970s, computer communication has changed from a research topic to an essential part of infrastructure
- In 1980, the Internet was a research project that involved a few dozen sites
- Today, the Internet has grown into a communication system that reaches all of the world

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

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

Network Applications and Programming

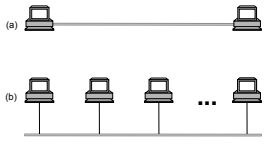
- Network services are provided by an application software
  - an application on one computer communicates across a network with an application program running on another computer
- Each application offers a specific service with its own form of user interface
  - but all applications can communicate 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

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

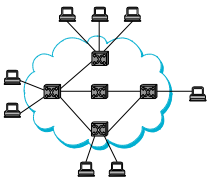


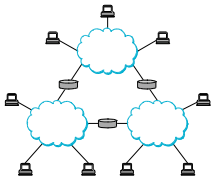
Packet Switching and Networking Technologies

- 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, but 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

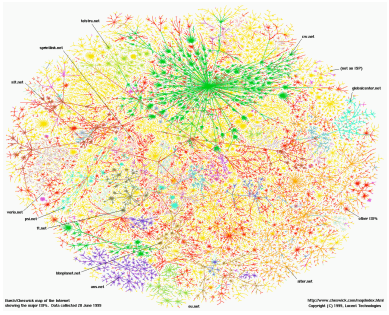
Switched Networks

- A network can be defined recursively as...
  - two or more nodes connected by a link, or
  - two or more networks connected by a node





"The Internet"



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 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
  - 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