

Networks and Distributed Systems

Lecture 1 – Introduction

Today's Lecture

- Administrivia
- Foundations of Networks

Instructors

- Instructor
 - Yasir Zaki

Course Goals

- Become familiar with the principles and practice of data networking
 - Routing, transport protocols, naming, ...
- Learn how to write applications that use the network
 - An IRC server
 - A peer-to-peer file transfer program
- Get some understanding about network internals in a hands-on way
 - You'll implement a routing protocol for your IRC server
 - TCP-style congestion control

Course Format

- ~25 lectures
 - Cover the “principles and practice”
 - Complete readings before lecture
- 4 homework assignments
 - “Paper”: Do you understand and can you apply the material?
 - Loosely tied to lecture materials
 - Teach networking concepts/tools
- 3 programming projects
 - How to use and build networks / networked applications
 - Application-layer programming; include key ideas from kernel
 - Larger, open-ended group projects. *Start early!*
- Midterm and final
 - Covers each of the above 3 parts of class

Administrative Stuff

- Watch the course web page on NYUclasses
 - Handouts, readings, ..
- Office hours posted on web page
 - Or by appointment

Grading

- Roughly equal weight in projects and testing
 - 45% for Project I, II and III
 - 15% for Midterm exam
 - 25% for Final exam
 - 15% for Homework
- You **MUST** demonstrate competence in both projects and tests to pass the course
 - Fail either and you fail the class!

Policy on Collaboration

- Working together is important
 - Discuss course material in general terms
 - Work together on program debugging, ..
 - Final submission must be your own work
 - Homeworks, midterm, final
- Projects: Solo (P1) + Teams of two (P2,P3)
 - Collaboration, group project skills
 - Both students should understand the entire project
- Web page has details
- *Things we don't want to have to say: We run projects through several cheat-checkers against all previously and concurrently handed in versions...*

Late Work and Regrading

- Late work
 - You have 5 grace days to distribute across 3 lab assignments with no penalty.
 - Late work beyond 5 grace days will not be accepted.
- Requests for regrading must be submitted in writing within 2 weeks.
- No assignments with a “short fuse”
 - Homeworks: ~1-2 weeks
 - Projects: ~5 weeks
 - Start on time!
 - A 5 week project cannot be completed in a week

Problem

- How to build a scalable network that will support different applications?
- What is a computer network?
- How is a computer network different from other types of networks?
- What is a computer network architecture?

Outline

- Applications
- Requirements
- Network Architecture
- Implementing Network Software
- Performance

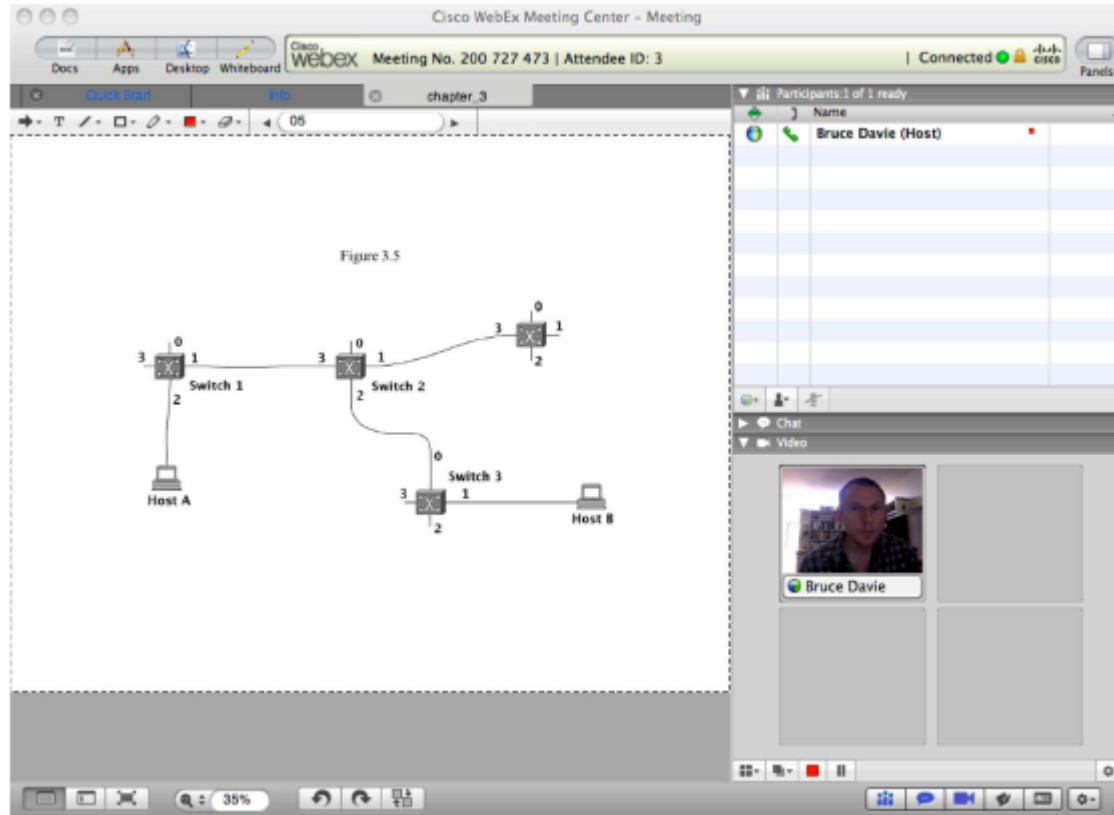
Goal

- Exploring the requirements that different applications and different communities place on the computer network
- Introducing the idea of network architecture
- Introducing some key elements in implementing Network Software
- Define key metrics that will be used to evaluate the performance of computer network

Applications

- Most people know about the Internet (a computer network) through applications
 - World Wide Web
 - Email
 - Online Social Network
 - Streaming Audio Video
 - File Sharing
 - Instant Messaging
 - ...

Example of an application



A multimedia application including video-conferencing

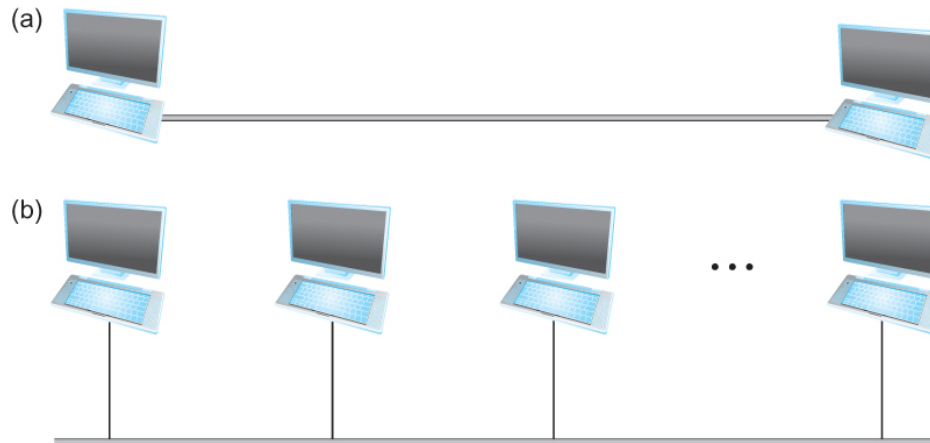
Application Protocol

- URL
 - Uniform resource locator
 - <http://www.cs.princeton.edu/~llp/index.html>
- HTTP
 - Hyper Text Transfer Protocol
- TCP
 - Transmission Control Protocol
- 17 messages for one URL request
 - 6 to find the IP (Internet Protocol) address
 - 3 for connection establishment of TCP
 - 4 for HTTP request and acknowledgement
 - Request: I got your request and I will send the data
 - Reply: Here is the data you requested; I got the data
 - 4 messages for tearing down TCP connection

Requirements

- Application Programmer
 - List the services that his application needs: delay bounded delivery of data
- Network Designer
 - Design a cost-effective network with sharable resources
- Network Provider
 - List the characteristics of a system that is easy to manage

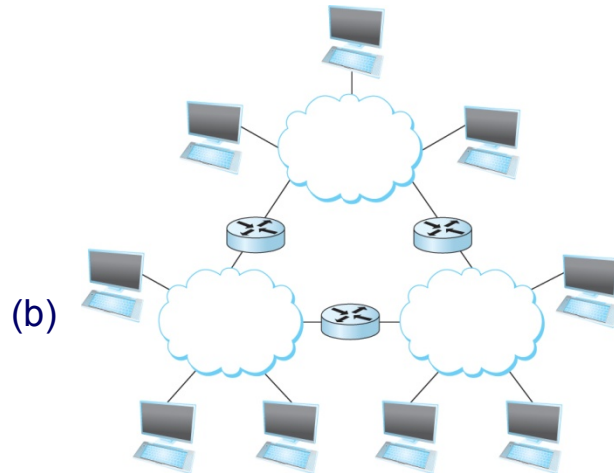
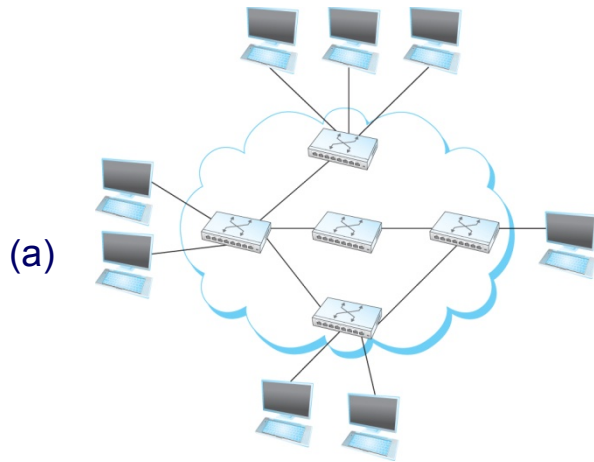
Connectivity



- Need to understand the following terminologies
 - Scale
 - Link
 - Nodes
 - Point-to-point
 - Multiple access
 - Switched Network
 - Circuit Switched
 - Packet Switched
 - Packet, message
 - Store-and-forward

- (a) Point-to-point
- (b) Multiple access

Connectivity

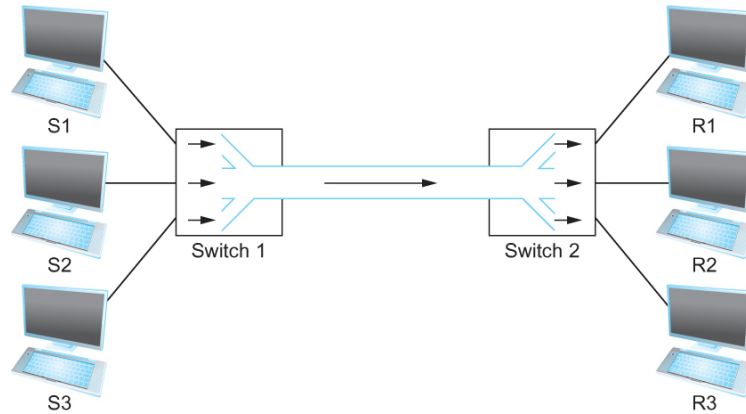


(a) A switched network

(b) Interconnection of networks

- Terminologies (contd.)
 - Cloud
 - Hosts
 - Switches
 - internetwork
 - Router/gateway
 - Host-to-host connectivity
 - Address
 - Routing
 - Unicast/broadcast/multicast

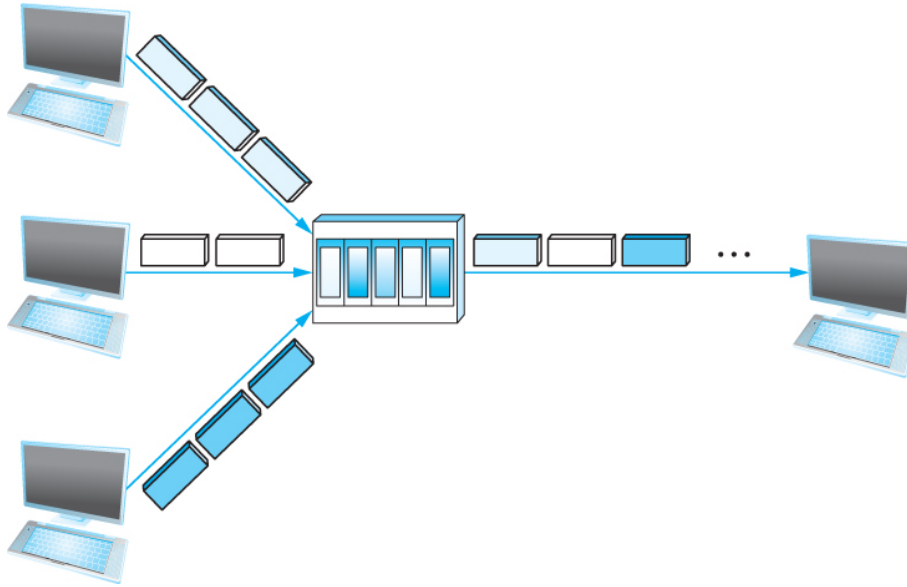
Cost-Effective Resource Sharing



Multiplexing multiple logical flows
over a single physical link

- Resource: links and nodes
- How to share a link?
 - Multiplexing
 - De-multiplexing
 - Synchronous Time-division Multiplexing
 - Time slots/data transmitted in predetermined slots

Cost-Effective Resource Sharing

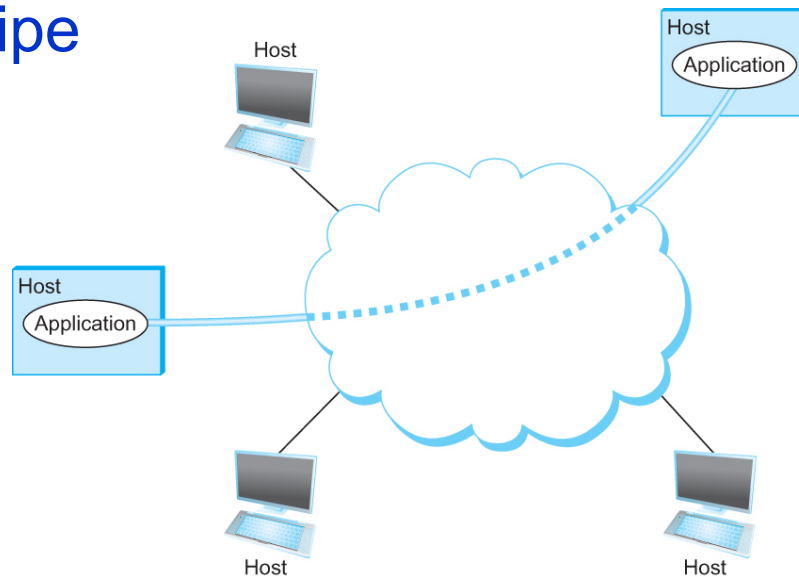


A switch multiplexing packets from multiple sources onto one shared link

- FDM: Frequency Division Multiplexing
- Statistical Multiplexing
 - Data is transmitted based on demand of each flow.
 - What is a flow?
 - Packets vs. Messages
 - FIFO, Round-Robin, Priorities (Quality-of-Service (QoS))
 - Congested?
- LAN, MAN, WAN
- SAN (System Area Networks)

Support for Common Services

- Logical Channels
 - Application-to-Application communication path or a pipe



Process communicating over an
abstract channel

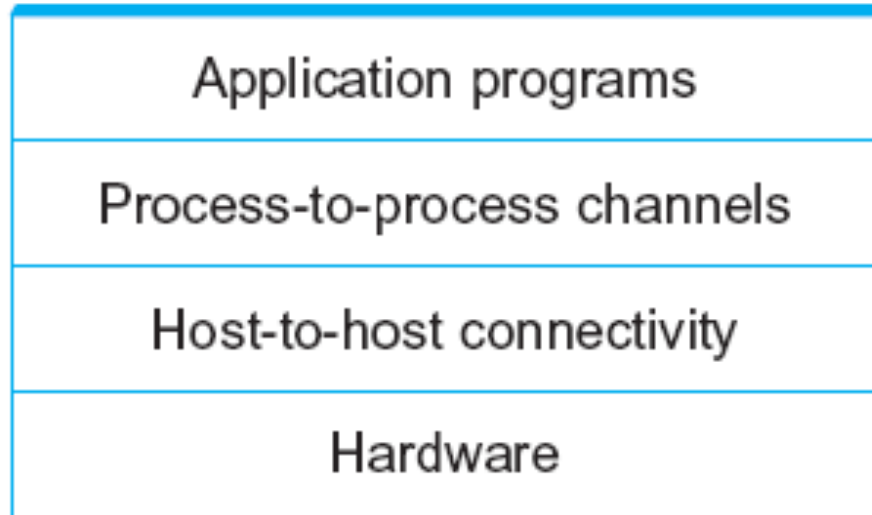
Common Communication Patterns

- Client/Server
- Two types of communication channel
 - Request/Reply Channels
 - Message Stream Channels

Reliability

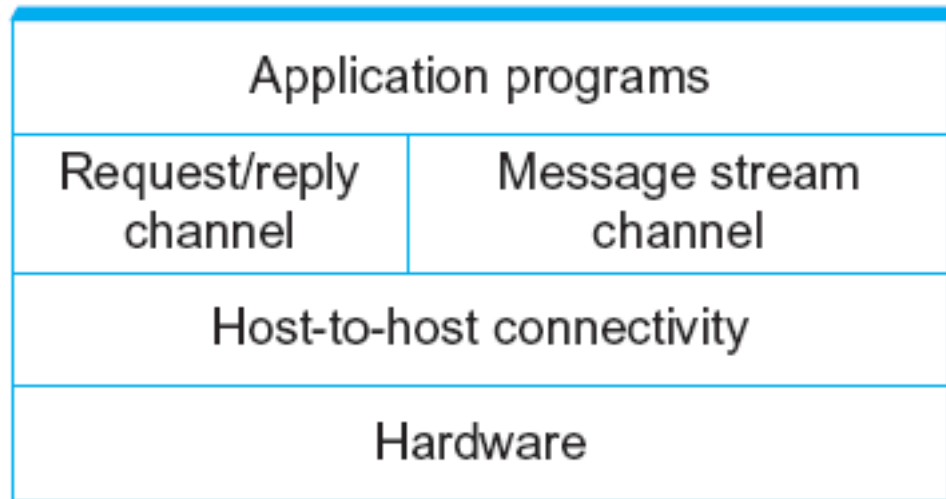
- Network should hide the errors
- Bits are lost
 - Bit errors (1 to a 0, and vice versa)
 - Burst errors – several consecutive errors
- Packets are lost (Congestion)
- Links and Node failures
- Messages are delayed
- Messages are delivered out-of-order
- Third parties eavesdrop

Network Architecture



Example of a layered network system

Network Architecture



Layered system with alternative abstractions available at a given layer