18-345 – Fall 08

Lecture 1
Course Overview

Peter Steenkiste

Reading: Chapter 1 (Leon-Garcia)

Outline

- Course organization
- Course objectives
- Network definition
- Layered network architecture
- Internetworking introduction
- Service economics

Instructors

- Instructor: Peter Steenkiste
- Two teaching assistants
  - Christina Johns
  - Xiaohui Wang
- Contact information on the web
  - Office hours will be added soon

Course Objective

- Telecom network overview
- Introduction to telephone networks
- Understand principal concepts of computer networks
  - OSI layers and their functions
  - Performance issues
- Introduction to the Internet

Course Outline

- Introduction to telephone networks
  - present network hierarchy
  - signaling system
- OSI Layers
  - Physical Layer
  - Data Link Layer
  - Network Layer
  - Transport Layer
  - Session, Presentation, and Application Layers
- LAN (Local Area Network) and Wireless Networks
- Key technologies (e.g. ATM, MPLS, Optical)
- Applications (e.g. peer-to-peer, web)

Course Format

- ~25 lectures
  - Covers the course contents
- 5 homeworks
  - Apply what you learned in class
  - Not graded
  - Test whether you understand material
  - Preparation fro quizzes
- 5 medium-small projects
  - Get some hands-on experience

Tests

- Five quizzes
  - Held in class – last 30 minutes of lectures
  - Forces you to keep up with the material
  - Best 4 quizzes count
- Two exams
  - Midterm held in class – full time slot
  - Final - maybe also held in class

Administrative Stuff

- Watch the course web page
  - Handouts, readings, ..
- Will use blackboard for projects
  - Getting help, announcements, ..
  - Handing in your solution
- Office hours posted on web page
- Course secretary
  - Angela Miller, Wean Hall 8215

Grading

- 30% for the projects
- 4 times 5% for quizzes
- 2 times 25% for the exams

Policy on Collaboration

- Working together is important
  - Discuss course material in general terms
  - Make sure you understand concepts
- But assignments must be completed individually
  - Homeworks, projects, exams, quizzes
- All cases of cheating will be reported
- Web page has more detail

Policy on Late Work and Regrading

- Assignments must be handed in on time.
  - Only exception is documented illness and family emergencies
- Start on time!
  - If we give you two weeks, there probably is a reason
- Regrading requests must be submitted in writing with secretary within 2 weeks
  - Regrading will be done by original grader

First Set of Lectures

- Networking basics (today)
  - Terminology, structure, players, …
  - How do we structure the network
- Layered network architecture (Wed)
  - Who does what?
- Physical layer (~4 lectures).
  - How to encode the bits
  - Capacity of networking links
  - Properties of different technologies

What is a communication network?

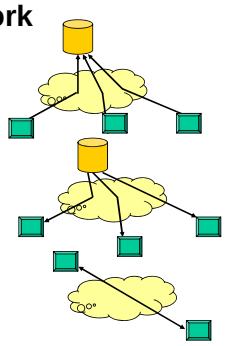
- Infrastructure consisting of equipment & facilities to *transfer information* between users in different locations
  - Telephone, TV broadcast, Internet, cellular, etc.
- Like railroads, highways, & airline infrastructure which transport people & goods across space
- Communications networks transport information across space, but
  - Much faster (usually at the speed of light)
  - At very high rates

Why build a network?

- Networks enable services
- The highway system enables one basic service - the transfer of objects
  - This enables other services that build on the basic service
  - E.g., postal service, passenger service, freight service
- Communications networks typically provide a basic information transfer service
  - telephony: basic service is two-way exchange of voice signals
    - Other services enabled by this : voice messaging, fax, modem, credit card validation...
  - Internet: basic service is transfer of information packets
    - Other services enabled by this : e-mail, web browsing, e-commerce, video conferencing, ...

Typical Interactions using a Network

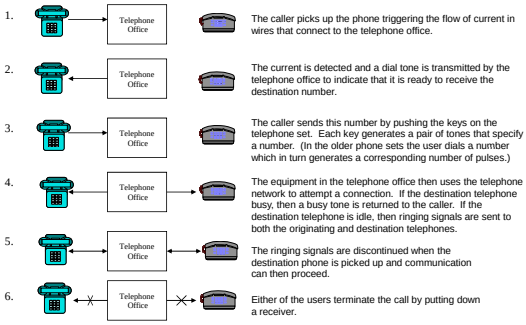
- Gathering/Concentration
  - traditional market day
  - bill payments / registration
  - polling, voting, auctions
- Distribution
  - newspaper delivery
  - television & radio broadcasting
  - mass e-mail, including spam
- Request/Reply
  - catalog ordering
  - Web browsing
- Two & Multi-way Interactive
  - telephone (& conferencing)
  - video-on-demand



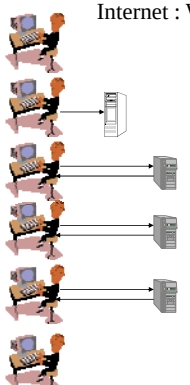
Two Examples of Networks & Services

- Telephone Networks were developed solely to provide two-way voice communications
- Internet was developed to provide a basic service (transfer of packets of information) which would provide a platform for developing many services
  - e-mail
  - web-browsing
  - video streaming
  - many variants of e-commerce

Telephone : Voice call



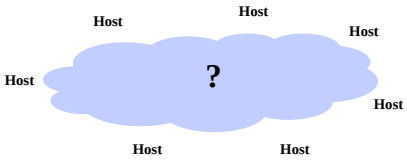
Internet : Web-browsing



Different Network Views

- A network is a shared infrastructure that supports communication for many users
  - Sharing view: how do users share the network?
- Many network technologies are used
  - Technology view: how do the technologies coexist?
- Networks are owned and managed by various organizations
  - Management view: how does global communication take place?
- Networks cover different geographic areas
  - Geographic view: network diameter?
- Networks run many protocols that are responsible for different functions
  - Protocol view: how are the many protocols coordinated?

A Network as a Shared Infrastructure

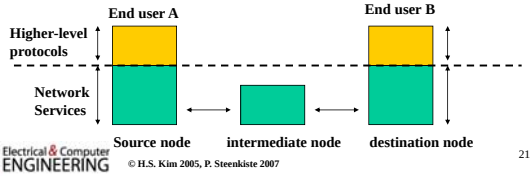


- How do we build an infrastructure that
  - Supports communication among many users?
  - Supports very diverse technologies?
  - Is owned by many organizations?
  - Can evolve over time?

Modularity!

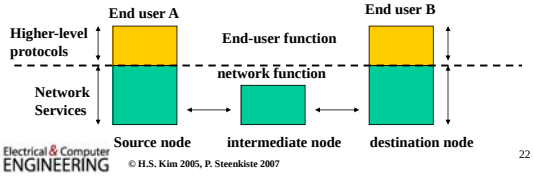
Layered Network Architecture

- Open System Interconnection (OSI): international standard for "layered architecture"
- Layering simplifies design, implementation, and testing of network architecture by partitioning overall communications process into parts (modular design)
- Example: A simple two-layer design could be as below
  - Network services : Delivers messages
  - Higher-level services : Builds applications (e.g., video telephony) using network services



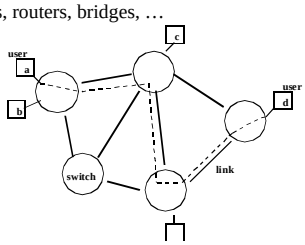
OSI Reference Model

- Seven Layers in OSI model:
  - Bottom three layers provide the network services (every network node needs these layers)
  - Upper layers provide services to the user and associated with the user only, not with the network.



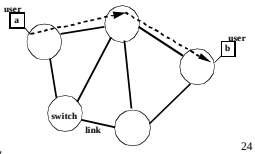
Network elements

- Transmission links
  - Wire, cable, radio, satellite, fiber optics, …
- Nodes
  - Switches, routers, bridges, …



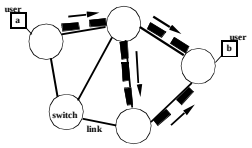
Switching in Telephone Networks

- "Circuit Switching": continuous flow of traffics through a dedicated path
  - A dedicated path is established before the traffic flow
  - Also called "connection-oriented" service – switches must remember the connection
  - Inefficient for bursty traffic



Switching in Computer Networks

- "Packet switching": blocks of data (packets) are forwarded from a source to a destination
  - No dedicated channel is established prior to traffic flow
  - Each packet may theoretically take a different path !
  - Also called "connectionless" service – switches do not know about connections

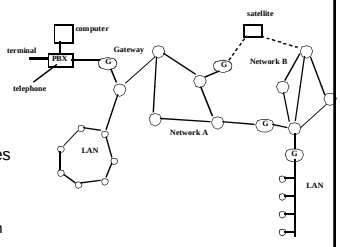


Circuit Switching versus Packet Switching

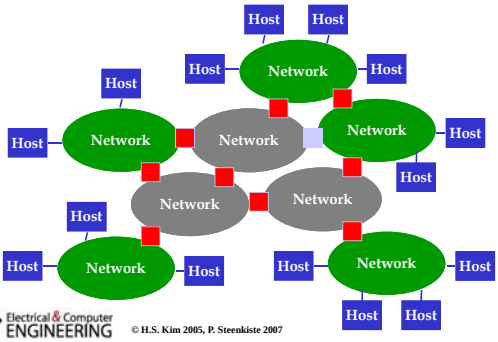
- With circuit switching, the sender has to wait until the connection has been established before sending.
  - Once the connection exists, communication can be very efficient
  - Unused bandwidth on links is wasted
  - Can have added value features, e.g. reservations
- With packet switching, communication can start immediately.
  - But routers have to find the path for every packet
  - More efficient for bursty traffic, but no reservations

Interconnection of Networks

- Many data networks are interconnected through the public telephone networks.
- Telephone networks in different countries are interconnected.
- "Gateway": geographically distributed networks are interconnected via machines called gateways.
  - provide the necessary protocol translation
  - proper interfacing between disparate technologies



An Internetwork



"The Internet"

- An inter-net: a network of networks.
  - A set of networks that are connected
- Networks are connected using routers that support communication in a hierarchical fashion
  - Often need other special devices at the boundaries for security, accounting, ..
- The Internet: the interconnected set of networks of the ISPs providing data communications services.
- In order to inter-operate, all participating networks have to follow a common set of rules.

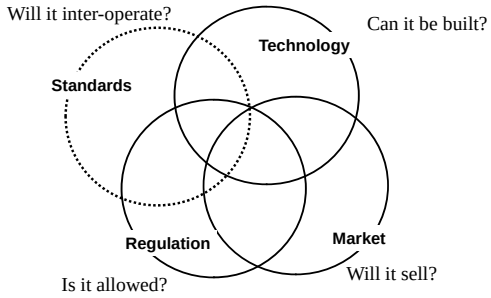
Different Types of Networks

- Internet Service Providers (ISPs).
  - Provide network service to customers
    - Can be corporate or individual users
  - ISPs can be international, national, regional, or local
  - Organized as hierarchy: Tier 1, Tier 2, Tier 3
  - Tier 1 networks form the backbone
- Corporate networks connect end-points in an organization.
  - Provide local connectivity and provide a path to an ISP
  - Local-area network, dial-up through modem, ..
- Small networks supporting few users.
  - Home networks, hot spots, …
  - Often use wireless for ease of deployment

Who Pays?

- ISP networks provide service to external customers.
  - The ISP gets paid for delivering service
  - For core networks, customers are other core networks and access networks
  - For access networks, customers are individual users, possibly running small LANs
- Corporate networks support internal users.
  - Typically not paid on a usage basis, but network is paid through some source of overhead
  - Higher level of thrust between users, and users and facilities
- Small networks can be based on either model.
  - But level of management is typically more limited

Economics for Success of a Network Service



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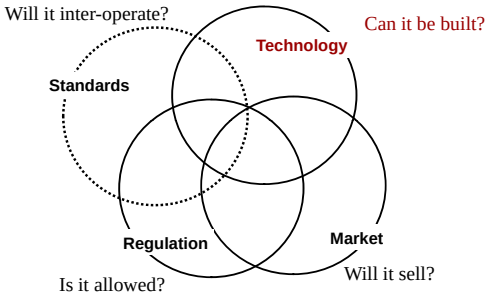
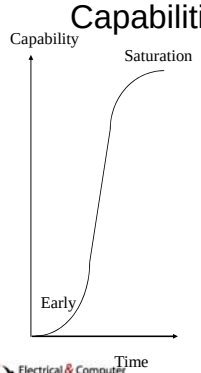


Technology

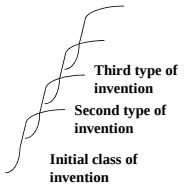
- Sustained improvements in technology allow complex networks and therefore new services
- Examples
  - microprocessor MIPs
  - RAM memory
  - storage: hard disk, CD-ROM, DVD, ...
  - operating systems
  - image & video compression
  - digital signal processing
  - wireless transmission
  - transmission data rates
  - network protocols

Capabilities of a Technology



- The capabilities of a technology follows an S-shaped curve over time
- Examples
  - Microprocessor power
  - RAM capacity
  - Storage capacity
  - Transmission speed
- Large improvements in early phase
- Improvements limited by fundamental factors at later phase

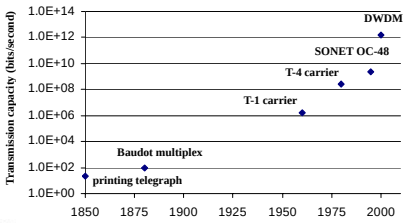
Long-Term Trends



- *For many complex technologies, a long-term trend can be plotted as a smooth curve in spite of "surprises" in technology*
- As a given class of technology saturates, another class supersedes it
- Computer MIPs, RAM
- Bandwidth
- 20 year lead time for telecom innovations

Example

- Advances in optical transmission technology are accelerating and will soon cause a major change in network architecture



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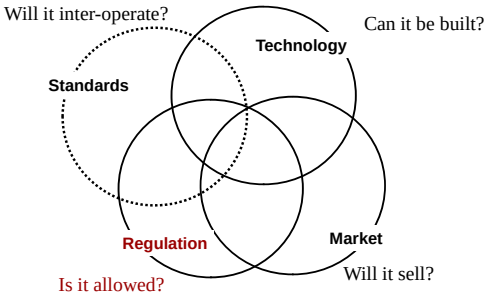
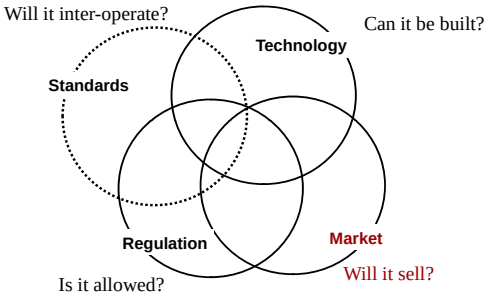


Regulation

- Telegraph & Telephone originally monopolies
  - Arose due to extremely high cost of infrastructure
  - Profitable, predictable, slow to innovate
- Deregulation and breakup of monopolies
  - competition in long distance telephone
  - opening up of the local telephone service
  - cable television and satellite broadcasting
- New radio spectrum allocations
  - cellular phone service (900 MHz)
  - personal communication services (2.4 GHz)
  - local multipoint distribution service (28 GHz)
  - NII/Supernet (5 GHz)

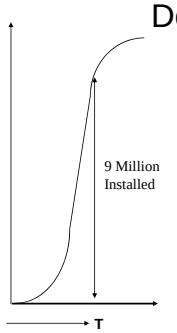
Economics for Success of a Network Service



Market

- New applications & services must have a market
  - cellular telephony
  - fax transmission
  - Web browsing
  - electronic commerce
- *The network effect*: usefulness of a service increases with size of community
  - Metcalfe's Law: usefulness is proportional to the square of the number of users
  - Phone, fax, email, …
- *Economies of scale*: per-user cost drops with increased volume
  - Cell phones, PDAs, PCs
  - Efficiencies from multiplexing

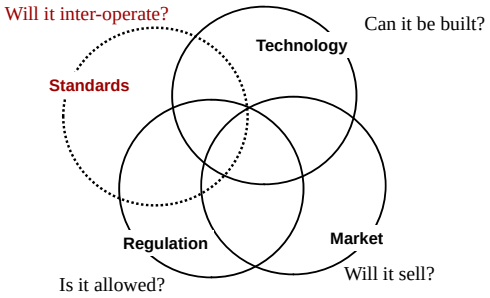
Deployment Rate



Certain conditions required before new services take off:

- Telephone: T=30 years
  - city-wide & inter-city links
- Automobile: T=30 years
  - roads
- Television: T=20, 11, or 5 years
  - extremely steep rise 1945-1950
- CATV: T=20 years
  - cable plant, programming
- What about fax, cellular & cordless phones, PC's, internet & www, direct broadcast satellite?

Economics for Success of a Network Service



Standards

- New technologies very costly and risky
- Standards allow players to share risk and benefits of a new market
  - Reduced cost of entry
  - Interoperability and network effect
  - Compete on innovation
- Example
  - 802.11 wireless LAN products

Standards Bodies

- Internet Engineering Task Force
  - Internet standards development
  - Request for Comments (RFCs): www.ietf.org
- International Telecommunications Union
  - International telecom standards
- IEEE 802 Committee
  - Local area and metropolitan area network standards
- Industry Organizations
  - MPLS Forum, WiFi Alliance, World Wide Web Consortium