

CSE/EE 461 Introduction to Computer-Communication Networks

David Wetherall
djw@cs.washington.edu

Winter 2000.

This Lecture

1. Administrivia
2. Course Intro
3. A Brief Look at the Internet
4. Protocols and Layering

djw // CSEEE 461, Winter 2000

L1.2

1. Administrivia – People

- David Wetherall (Instructor)
 - djw@cs.washington.edu
 - Sieg 210, Th 11 → 12
- Eric Hoffman (TA, Labs)
 - hoffman@cs.washington.edu
 - Tu 1 → 2
- Ratul Mahajan (TA, Homeworks)
 - ratul@cs.washington.edu
 - M 10 → 11

djw // CSEEE 461, Winter 2000

L1.3

Materials

- Course Web page
 - www.cs.washington.edu/education/course/461/00wi
- Mailing list
 - Important - make sure you join!
- Textbook
 - S. Keshav, "An Engineering Approach to Computer Networking", Addison-Wesley, 1997.

djw // CSEEE 461, Winter 2000

L1.4

Work and Grading

- 4 homeworks 20%
 - 4 projects 40%
 - Midterm 15%
 - Final 25%
-
- Late Policy
 - Collaboration/Cheating Policy

djw // CSEEE 461, Winter 2000

L1.5

Programming Projects

- You will add forwarding, routing, reliability and congestion control to an emulated network.
 - 4 projects, progressively more difficult
- Developed by Eric Hoffman
- Computer lab or do-it-yourself
 - Grab a partner
 - Get an account!

djw // CSEEE 461, Winter 2000

L1.6

Timeline

- **Homeworks**
 - Due at end of weeks 3, 5, 7, and 9 (tentative)
- **Projects**
 - Due at end of weeks 4, 6, 8, and 10 (tentative)
- **Midterm**
 - Monday 2/7, in class
- **Final**
 - Monday 3/13, at 4:30

djw // CSEEE 461, Winter 2000

L1.7

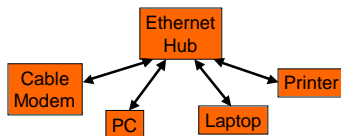
2. Intro – What is a Network?

- **Links carry information (bits)**
 - Wire, wireless, fiber optic, smoke signals ...
 - May be point-to-point or broadcast
- **Switches move bits between links**
 - Routers, gateways, bridges, CATV headend, PABXs, ...
- **Hosts are the communication endpoints**
 - PC, PDA, cell phone, tank, toaster, ...
- **Also called channels, nodes, intermediate systems, end systems, and much more.**

djw // CSEEE 461, Winter 2000

L1.8

Example – Local Area Network

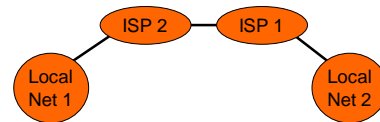


- **Your home network**
 - Ethernet is a broadcast-capable multi-access LAN

djw // CSEEE 461, Winter 2000

L1.9

Example – An Internetwork



- **Internetwork is a network of networks**
- **The Internet is a global internetwork in which all participants speak a common language**
 - IP, the Internet Protocol

djw // CSEEE 461, Winter 2000

L1.10

Other Networks

- **You've all used networks:**
 - Telephone, Cable TV,
 - ATMs, Processor Interconnects
- **We are interested in networks that are:**
 - Distributed
 - Large scale
 - Multi-purpose

djw // CSEEE 461, Winter 2000

L1.11

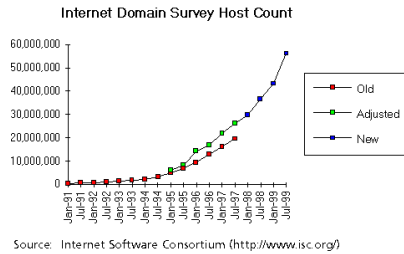
The meaning of "Distributed"

- **There are distributed and parallel networks:**
 - Cash machines versus a parallel computer
- **What is the essential difference?**
 - Tolerance of failed components
 - Decentralized operation
 - Heterogeneity
- **Hard to get it right**
 - "A distributed system is a system in which I can't do my work because some computer has failed that I've never even heard of." - Lamport

djw // CSEEE 461, Winter 2000

L1.12

The meaning of "Large-scale"



djw // CSEEE 461, Winter 2000

L1.13

The meaning of "Multi-purpose"

- Telephone network
 - Designed for telephone calls
- Internet
 - Web, email, Quake, e-commerce, audio/ video, ...
 - But evolution was at work: Web/email a "surprise"
- Computer networks
 - Carry digital information and support a rich variety of distributed applications

djw // CSEEE 461, Winter 2000

L1.14

Why Build Networks?

- Communication at a distance
 - Want performance sufficient to given task
 - Video conference, etc.
- Resource sharing
 - Networks are shared among users
 - Fundamental issues concern the effective sharing of distributed resources
 - Effective = cost, control, secure, reliable, ...

djw // CSEEE 461, Winter 2000

L1.15

Goal of this Course

- For you to understand the design of *large-scale computer networks*.
- Fundamental problems in building networks
 - That are fast, efficient, secure and robust
- Design principles of proven value
 - Networking is young and there are few!
- Common implementation technologies
 - These will change of course ...

djw // CSEEE 461, Winter 2000

L1.16

Lecture Topics

- | | |
|----------------------------|--------------------------|
| • Multi-access (Ethernet) | • Coordination |
| • Routing (IP) | • Robust operation |
| • Transport (TCP) | • Reliable delivery |
| • Congestion control (TCP) | • Resource allocation |
| • Multicast (Mbone) | • Efficient delivery |
| • Real time (DiffServ) | • Multimedia |
| • Naming (DNS) | • Distributed state |
| • Security (IPSEC) | • Authentication/Privacy |

djw // CSEEE 461, Winter 2000

L1.17

Lecture Emphasis

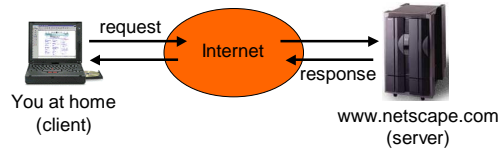
- What we do cover:
 - Communications
 - Internetworking ← We focus here
 - Distributed systems
- What we don't cover:
 - Design of communications hardware
 - Queuing theory
 - Protocol standards

djw // CSEEE 461, Winter 2000

L1.18

3. A Brief Tour of the Internet

- What happens when you "click" on a web link?



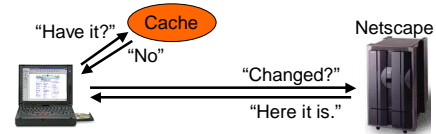
- This is the view from 10,000 ft ...

djw // CSEEE 461, Winter 2000

L1.19

9,000 ft: Scalability

- Caching improves scalability



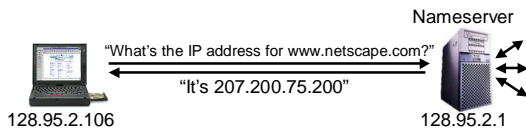
- We cut down on transfers:
 - Check cache (local or proxy) for a copy
 - Check with server for a new version

djw // CSEEE 461, Winter 2000

L1.20

8,000 ft: Naming (DNS)

- Map domain names to IP network addresses



- All messages are sent using IP addresses
 - So we have to translate names to addresses first
 - But we cache translations to avoid next time

djw // CSEEE 461, Winter 2000

L1.21

7,000 ft: Sessions (HTTP)

- A single web page can be multiple "objects"



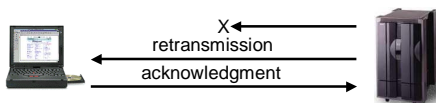
- Fetch each "object"
 - either sequentially or in parallel

djw // CSEEE 461, Winter 2000

L1.22

6,000 ft: Reliability (TCP)

- Messages can get lost



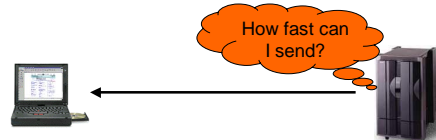
- We acknowledge successful receipt and detect and retransmit lost messages (e.g., timeouts)

djw // CSEEE 461, Winter 2000

L1.23

5,000 ft: Congestion (TCP)

- Need to allocate bandwidth between users



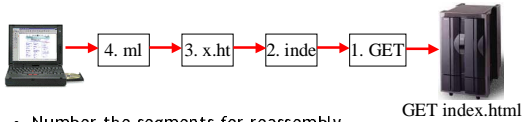
- Senders balance available and required bandwidths by probing network path and observing the response

djw // CSEEE 461, Winter 2000

L1.24

4,000 ft: Packets (TCP/IP)

- Long messages are broken into packets
 - Maximum Ethernet packet is 1.5 Kbytes
 - Typical web page is 10 Kbytes



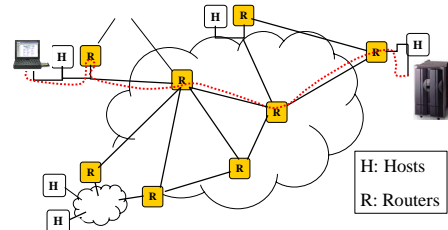
- Number the segments for reassembly

djw // CSEEE 461, Winter 2000

L1.25

3,000 ft: Routing (IP)

- Packets are directed through many routers

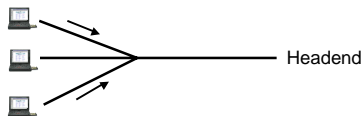


djw // CSEEE 461, Winter 2000

L1.26

2,000 ft: Multi-access (Cable)

- May need to coordinate packet transmissions



- Poll headend to receive a timeslot to send upstream
 - Headend controls all downstream transmissions
 - A lower level of addressing is used ...

djw // CSEEE 461, Winter 2000

L1.27

1,000 ft: Framing/Modulation

- Protect, delimit and modulate payload

Sync / Unique Header Payload w/ error correcting code

- Take payload, add error protection (Reed-Solomon), header and framing, and then turn into a signal
 - Modulate data to assigned channel and time (upstream)
 - Downstream, 6 MHz (~30 Mbps), Upstream ~2 MHz (~3 Mbps)

djw // CSEEE 461, Winter 2000

L1.28

4. Protocols and Layering

- Need abstractions to handle complexity
 - Protocols and layering
- Protocol
 - Agreement dictating the form and function of data exchanged between parties to effect communication
 - Two parts:
 - Syntax: where the bits go
 - Semantics: what they mean, what to do with them
 - Examples:
 - IP, the Internet protocol
 - TCP and HTTP, for the Web

djw // CSEEE 461, Winter 2000

L1.29

Protocol Standards

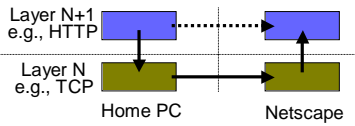
- Different functions require different protocols
- Thus there are many protocol standards
 - E.g., IP, TCP, UDP, HTTP, DNS, FTP, SMTP, NNTP, ARP, Ethernet/802.3, 802.11, RIP, OSPF, 802.1D, NFS, ICMP, IGMP, DVMRP, IPSEC, PIM-SM, BGP, ...
- Organizations: IETF, IEEE, ITU
- IETF specifies Internet-related protocols
 - RFCs (Requests for Comments)
 - "We reject kings, presidents and voting. We believe in rough consensus and running code." - Dave Clark.

djw // CSEEE 461, Winter 2000

L1.30

Protocol Layering

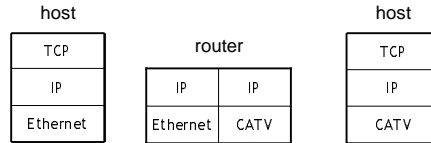
- Layering
 - Higher level protocols build on services provided by lower levels
 - Peer layers communicate with each other



djw // CSEEE 461, Winter 2000

L1.31

Example – Layering at work



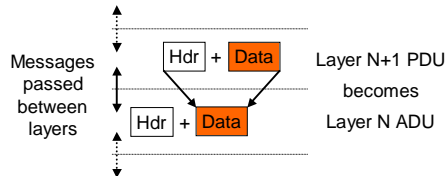
- We can connect different systems

djw // CSEEE 461, Winter 2000

L1.32

Layering Mechanics

- Encapsulation and decapsulation

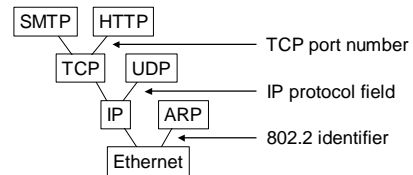


djw // CSEEE 461, Winter 2000

L1.33

More Layering Mechanics

- Multiplexing and demultiplexing in a protocol graph

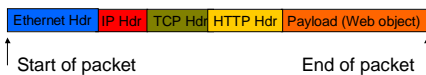


djw // CSEEE 461, Winter 2000

L1.34

A Packet on the Wire

- Starts looking like an onion!

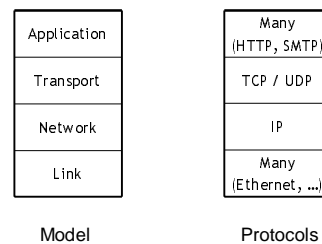


- This isn't entirely accurate
 - ignores segmentation and reassembly, Ethernet trailers, etc.
- But you can see that layering adds overhead

djw // CSEEE 461, Winter 2000

L1.35

Internet Protocol Stacks



djw // CSEEE 461, Winter 2000

L1.36

OSI Reference Model

- Seven Layers

Application
Presentation
Session
Transport
Network
Link
Physical

Their functions:

- Your call
- Encode/decode messages
- Manage connections
- Reliability, congestion control
- Routing
- Framing, multiple access
- Symbol coding, modulation

Key Concepts

- Networks are used to share distributed resources
- Protocol layers are used to handle complexity
- The Internet/OSI models give us a roadmap

- Next time: We start working our way up the layers from the bottom, beginning with how to send bits.