Lecture 34: How does a computer send messages over the Internet?

Brief History of Networking

1989: World Wide Web

Caveat: Internet ≠ Web

Internet:
- Collection of computers connected on network
- Communicate with TCP/IP protocol

Web (WWW):
- Hyperlinked content (web pages) stored on servers
- Request and serve pages using HTTP protocol
- Built on top of the internet

Modern Internet

Simple to connect and use

Need:
- Device capable of speaking right protocol (TCP/IP)
- IP "address" given by an Internet provider
- Connection to provider’s servers (via modem, DSL, wireless, etc.)

Able to access any other machine on Internet!

Internet

Web

Your PC

IP Address: 128.156.16.201
Today’s Challenges

Interesting example of large, heterogeneous system

Challenge 1:
How to find someone when no one knows everybody?

Challenge 2:
How to build reliability on top of unreliable protocols?

Challenge 3:
How to cooperate when not in your selfish best interest?

First Challenge

Challenge 1:
How to find someone when no one knows everybody?

Scenario: Imagine you’re royal leader with 10,000 peasants in your kingdom

- You need to deliver message to all of them
- “We are being attacked! Come fight for me!”

How might you do that?

Solution: Hierarchy

Deliver orders by broadcasting message down tree

How can peasant send msg to nearby peasant?
How can peasant send msg to faraway peasant?

What if knight leaves army? What must happen?

Summary of Hierarchies

Advantages

- Manages complexity
- Decentralized
  - No single entity knows or controls everything
- Boss doesn't know all employees
  - Manager filters info; only propagate relevant info up
- Managers/employees don’t know about other branches

Disadvantages

- Can be tricky to handle new entities leaving/entering system
- Can be bad if too much info is passed up to boss (overworked if micromanage)
2nd Type of Hierarchy: Domain Name System (DNS)

How to find machine?

Scenario: Want to send a message to www.cs.wisc.edu

Must translate www.cs.wisc.edu to IP address

Ask appropriate DNS server in hierarchy
- Contact DNS server managing "edu" namespace
- Contact DNS server managing wisc.edu
- Get IP address: 128.105.7.31

Use IP address for routing messages thru physical network hierarchy based upon address

Challenge 2

How to send message reliably when medium might not deliver your message?

Is there some unreliable communication device you use everyday?

What problems do you experience w/ cellphones?

How do you deal with them?

Reliability Problems and Solutions

Can’t quite understand message?
- "Could you say that again?"
- Retransmit message

Don’t hear anything at all?
- "Can you hear me??" <wait> "Can you hear me??"
- Timeout and retry

Sick of listening to other person repeating themselves?
- "I heard you. Go on."
- Acknowledgements
Reliability on Unreliable Protocol

TCP/IP Protocol
IP: Internet Protocol
  • Makes best-effort to get your message to destination
TCP: Transmission Control Protocol
  • Builds on top of IP
  • Ensures message gets there

All messages broken up into packets

IP: Delivering Messages

Internet contains connected computers called routers
Message divided into multiple packets (Example: 3)
Packets hop from router to router to destination
  • Each packet can use different routers!

Basic TCP Protocol

Concerns:
  • Packets may arrive out of order
  • Packet may be dropped and never arrive

Don’t have human hearing if message makes sense!

What should be in book-keeping info to help?
Out of order?
Sender:
  • Associate unique sequence number w/ each packet
Receiver
  • Sort packets by sequence number

What can go wrong?

Two problems for today
  • Packets may arrive out of order
  • Packet may be dropped and never arrive
How can TCP over IP fix these problems?
Basic TCP Protocol

Concerns:
• Packets may arrive out of order
• Packet may be dropped and never arrive

Don’t have human hearing if message makes sense!

What should be in book-keeping info to help?
Packet dropped?
Receiver
• Acknowledge packets that arrived (by sequence number)
Sender
• Resends packet if no acknowledgment in some time-out interval

Challenge 3

How to cooperate when not in your selfish best interest?

Must avoid network congestion
Queue (Fixed amount of memory) full
→ packets are dropped
How can we avoid this problem (happening too often)?

How should good sender react?

Packets getting dropped?
• → Halve the transmission rate
• How do you know your packets are being dropped?
  - Don’t receive acknowledgements

All packets getting through?
• → Increase transmission rate a little

Desired behavior included in TCP/IP software
• “Congestion control”

No enforcement mechanism in Internet!
• Allows cheating, VoIP Telephony, streaming media

How does WWW work?

User-level apps run HTTP protocol on TCP/IP
Client (web browser): Sends requests to server
• Use TCP/IP to find server and ensure requests arrive
• HTTP protocol: “GET filename”
Server: Replies with requested file
• Reads file from file system; sends over network
  – Doesn’t know anything about contents of file
• Easy to make your own web server!
• Implementation Issue: Speed
Client: Does work to interpret .html file, display in browser
Today’s Summary

Internet: Built using TCP/IP to send packets
- Use hierarchy for decentralized control
- Build reliability (TCP) on top of unreliable layer (IP)
- Congestion control: Slow down when you see problems

Reading
- Section 7.1 - 7.3

Announcements
- Exam 2: Return Monday after Thanksgiving
- Project 2: Create Trivia Game with Lists
  - Due Monday 12/13 (In class demo)
- Wed before Thanksgiving: Video outside lecture (no lecture)
- Bio 375-004: Spring Service-Learning Course for teaching Scratch to Kids in Madison Afterschool
  - Wed 5:30 - 7:00