CSE/EE 461 – Lecture 11
Heterogeneity & Layering

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Reading:
– Peterson 3.1 & 4.1.1
– Clark (focus on sections 1-7)

Where are we?

• The last three weeks...
  – Reliability
  – How can we build a network out of unreliable, distributed components?
• The next week…
  – Heterogeneity
  – How can we support a range of media and applications?

Flashback to 1973…

ARPAnet
Satellite Packet Network
ALOHAnet

Fundamental Goal (Clark 1988)

• Connect these networks together
  – (And others in the future)
• Approaches?
The Internet, 1977

Source: Janet Abate, Inventing the Internet. 1999.

IP Basics

- IP =

- Gateways forward IP packets.
- Everything on the Internet speaks IP.

Layering and Protocol Stacks, redux

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

Example – Layering at work
Layering Mechanics

Messages passed between layers

A Packet on the Wire

Start of packet  End of packet

More Layering Mechanics

• Multiplexing and demultiplexing in a protocol graph

Internet Protocol Framework

Model  Protocols
Another view of layering...

OSI “Seven Layer” Reference Model

- Seven Layers:
  - Seven Layers: Their functions:
    - Application
    - Presentation
    - Session
    - Transport
    - Network
    - Link
    - Physical
    - Your call
    - Encode/decode messages
    - Connections
    - Reliability, flow control
    - Routing
    - Framing, multiple access
    - Coding, signaling

“Ten Layer” Reference Model

Other goals (Clark 1988)

1. Survivability
2. Multiple types of service
3. Multiple types of network
4. Distributed management
5. Cost effectiveness
6. Ease of attaching new hosts
7. Resource accounting
Survivability

• The Internet should keep working, even when networks or gateways fail.

Multiple types of service

• Not only reliable byte stream (TCP)
  – Useful for

• But also other models such as unreliable datagram (UDP)
  – Useful for

Multiple types at network

• Use a variety of network technologies
  – Make minimal assumptions about network capabilities
  – Don’t assume
  •
  •
  •
  •

Other goals

• Less well supported…
• In particular, little accountability for resource use!
• If the Internet was designed for commercial interests, this would have been a requirement.
Question

- How do layering & the IP protocol help us with heterogeneity?

Hourglass Analogy 1

- Washing machines
- Lights
- Ovens
- Oil
- Dams
- Natural Gas

Hourglass Analogy 2

- Jackets
- Dresses
- Shirts
- Pants
- Wool
- Linen
- Silk
- Cotton

Internet Hourglass

- File transfer
- Email
- Telnet
- ARPA
- ALOHA
- Satellite network
Key concepts

- We want to connect many different networks and run many different applications.
- IP provides the layer of indirection that makes this feasible.

Next time:
More on IP and the network layer