Today

Announcements

A few more project ideas

Cerf and Kahn: TCP / IP

Clark: TCP / IP design philosophy
Announcements

• Project proposals due Sept 15
  • Find partner and chat with me before then
  • Submit half-page description of your plan and roughly what each group member will do
• Readings through Sept 15 on web site
• Thursday:
Upcoming presentations

• Soliciting volunteers to present Tuesday Sept 8 (and later):
  
  
Paper reviews

• Preferred format: plain text pasted into email. No attachments necessary.
• No summary necessary. Just criticism.
• One paragraph is sufficient. Longer is not better. :-)


Today

Announcements

A few more project ideas

Cerf and Kahn: TCP / IP

Clark: TCP / IP design philosophy
Optimally hierarchical distributed systems

- Distributed systems frequently hierarchical: some set of nodes are picked for greater responsibilities (e.g., content distribution systems, Skype, distributed hash tables)

- Larger set of these “superpeers” brings more capacity (good) but potentially greater overhead and worse service quality (bad!)

- How do you balance these tradeoffs optimally? (e.g., if $n$ superpeers incur $\log(n)$ overhead factor, and you know the distribution of node capacities, what is the optimal set of superpeers?)
emailfs

- We use email a lot like a filesystem
- Admit it, and design an email system that has the best of both worlds. Compared with email,
  - avoid explicit duplication of content
  - integrated versioning of files?
  - ideas from distributed filesystems to deal with large files?
Incentive compatibility of congestion control

• What congestion control schemes are both efficient and incentive compatible?

• Intermediate problem: convergence with feedback effects

• Simulate these effects using ns2 or similar packet-level evaluation, working with Brighten and coauthors
Today

Announcements

A few more project ideas

Cerf and Kahn: TCP / IP

Clark: TCP / IP design philosophy
Interconnection challenges

- Different ways of addressing, supported packet lengths, latency, status information, routing
- Must let each network operate independently
- Solution: "unacceptable alternative"

Hosts

Protocols

IP

"unacceptable alternative"
Gateways and IP

- Gateways sit at interface between networks

![Diagram showing three networks interconnected by two Gateways](image)

Fig. 2. Three networks interconnected by two Gateways.

- ...and speak an Internetworking protocol

![Internetwork packet format diagram](image)

Fig. 3. Internetwork packet format (fields not shown to scale).
IP packet fragmentation

- Allow maximum packet size to evolve
- Protocol mechanisms to split packets in-transit (byte-level sequence numbers)
- Reassemble at end-hosts
  - Why not gateways?
Unreliable datagrams

• No need for reliability support from underlying network

• Greatly simplifies design
  • Exception handling always adds complexity
  • Any problem? Just drop the packet.

• What’s not a stated reason for datagrams?
  • Statistical multiplexing.
Addressing & routing

- Unspecified—but not unconstrained!
  - Picks address format
  - Hierarchical (network, host)
  - Route computed within network
  - 8 bits for network. "This size seems sufficient for the foreseeable future." Later: 32 bits in three size classes (A,B,C), and then CIDR.

- Just about every new routing algorithm we’ll see needs to change the packet’s address format.
Ports

• Associated with a process on a host
• Identify endpoints of a connection ("association")
• Rejected design: connection at host level; packet may include bytes for multiple processes
What we now call TCP

• Window-based scheme

• Provides reliability, ordering, flow control

• And now, congestion control too

• Note you might want only some of these

• Not in this version: 3-way handshaking, congestion control (next section of course!)

![Window Concept Diagram](image-url)
Today

Announcements

A few more project ideas

Cerf and Kahn: TCP / IP

Clark: TCP / IP design philosophy
Goals of the architecture

0. Interconnect existing networks
1. Survivability
2. Multiple communication services
3. Variety of networks
4. Distributed management
5. Cost effective
6. Easy host attachment
7. Resource usage accountability
0. Interconnect networks

- Assumption: One common architecture
- Technique: packet switching
  - Met target application needs
- Already used in ARPANET, ARPA packet radio network
- Interconnect with layer of gateways (packet switches)
1. Survivability

- Definition: even with failures, endpoints can continue communicating without resetting high-level end-to-end conversation
  - Except when?

- Did this work?
I. Survivability

Key question for survivability:
Where is connection state stored?

In network
So, must replicate
- Complicated
- Does not protect against all failures

On end hosts
Shared fate
- Simpler
- If state lost, then it doesn’t matter

Conclusion: stateless network — datagram packet switching
2. Multiple types of service

- Initially, just TCP
- But some apps do not want reliability!
  (VoIP, XNET)
2. Multiple types of service

- So, TCP/IP split: **datagram** basic building block for many types of service
- Still difficult to support low latency across all networks
- Hard to remove reliability if underlying network provides it
- For what services is IP **not sufficient?**
3. Variety of networks

- Datagram is simple building block
- Few requirements from underlying network technology
4. Distributed management

“...some of the most significant problems with the Internet today relate to lack of sufficient tools for distributed management, especially in the area of routing.”

— David Clark, 1988

Still a problem 20 years later!

Later in this course: new easier-to-manage architectures (Ethane, OpenFlow, SEATTLE)
5. Cost effective

- Inefficiencies:
  - 40 byte header
  - retransmission of lost packets

- How much does it matter now?
6. Easy host attachment

- End-hosts must implement net services
- once caused concern to some people
- problems if host misbehaves!
7. Accountability

• Difficult to account for who uses what resources
  
• How is this done today? Why is it only an approximation?
  
• Both an economic and security issue
  
• Later in this course: Anderson et al., Accountable Internet Protocol, SIGCOMM 2008.
What it doesn’t do

• “The architecture tried very hard not to constrain the range of service which the Internet could be engineered to provide.” Extremely successful! But:
  
  • Hard for network to report that it failed (“potential for slower and less specific error detection”)
  
  • Resource management (coming soon: fair queueing)
  
  • Multipath
  
  • Full illusion of reliability during failures
  
  • Security: Clark discusses host misbehavior (briefly) and accountability, but other aspects missing
Clark’s new terms

fate-sharing

flow

soft state
What if the Internet were commercial?

• Different priorities: accountability first, survivability last

• Example: Videotex networks

• e.g., France Telecom’s Minitel
  • Centralized
  • Reliable
  • Banking, news, stock transactions, ...

(photo: wikimedia)
What’s next

• Thursday:
  
  

• Tuesday: *congestion control* begins
Volunteers?

- Soliciting volunteers to present Tuesday Sept 8 (and later):