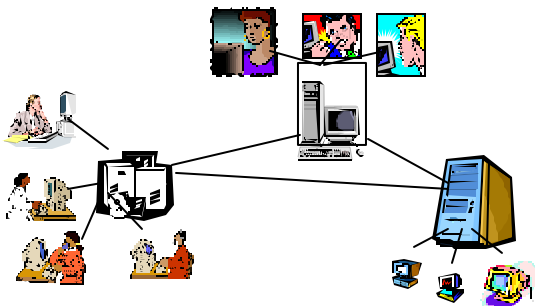

Internet Structure & Protocols

Emin Gun Sirer

Internetworking Origins

- Expensive supercomputers scattered throughout the US
- Researchers scattered differently throughout the US
- Need way to connect researchers to expensive machinery
- Point-to-point connections might have sufficed

Point to point connections



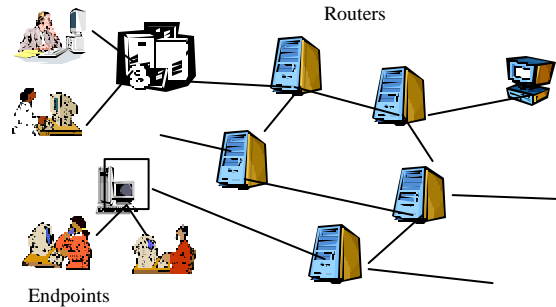
Internetworking Origins

- Department of Defense initiated studies on how to build a resilient global network
 - How do you coordinate a nuclear attack ?
 - Especially, how do you tell people to stop firing missiles during a nuclear war ?
- Interoperability and dynamic routing are a must
 - Along with a lot of other properties
- Result: Internet
- A complex system with simple components

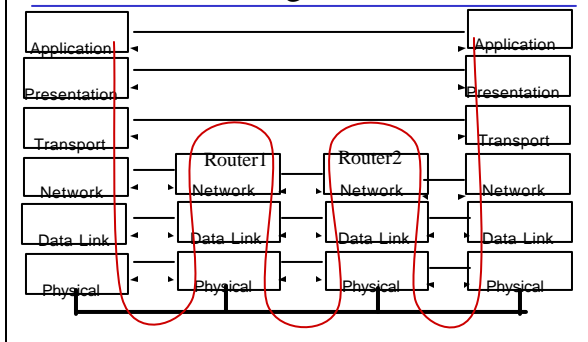
Internet Overview

- Every host is assigned, and identified by, an IP address
- Each packet contains a header that specifies the destination address
- The network routes the packets from the source to the destination
- Question: What kinds of properties should the network provide?

Internet, The Big Picture



The Big Picture



End-to-End Example

- Should the network guarantee packet delivery ?
 - Think about a file transfer program
 - Read file from disk, send it, the receiver reads packets and writes them to the disk
- If the network guaranteed packet delivery, one might think that the applications would be simpler
 - No need to worry about retransmits
 - But still need to check that the file was written to the remote disk intact
- A check is necessary if nodes can fail
 - Consequently, applications need to be written to perform their own retransmits
 - No need to burden the internals of the network with properties that can, and must, be implemented at the periphery

End-to-End Argument

- An Occam's Razor for Internet architecture
- Application-specific properties are best provided by the applications, not the network
 - Guaranteed, or ordered, packet delivery, duplicate suppression, security, etc.
- The internet performs the simplest packet routing and delivery service it can
 - Packets are sent on a best-effort basis
 - Higher-level applications do the rest

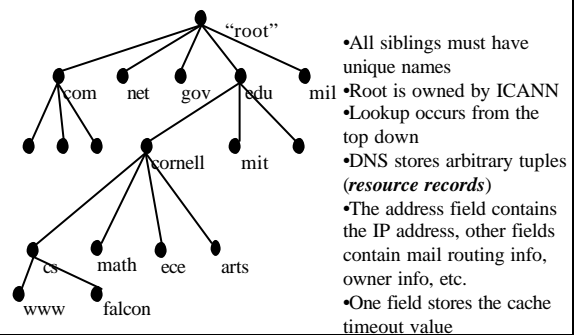
Naming

- Every host on the Internet is identified by an IP address
 - For now, 32-bit descriptor, like a phone number
 - Plans underway to change the underlying protocols to use longer addresses
- IP addresses are assigned to hosts by their internet service providers
 - Not physical addresses: IP address does not identify a single node, can swap machines and reuse the same IP address
 - Not entirely virtual: the IP address determines how packets get to you, and changes when you change your ISP
- Need completely virtual names
 - No one wants to remember a bunch of numbers

DNS

- Protocol for converting textual names to IP addresses
 - www.cnn.com = 207.25.71.25
- Namespace is hierarchical, i.e. a tree.
- Names are separated by dots into components
- Components are looked up from the right to the left

DNS Tree



DNS Lookup

1. the client asks its local nameserver
2. the local nameserver asks one of the *root nameservers*
3. the root nameserver replies with the address of the authoritative nameserver
4. the server then queries that nameserver
5. repeat until host is reached, cache result.

DNS Lessons

- Simple, hierarchical namespace works well
 - Can name anything, can share names
- Scales OK
 - Caching
 - Even though it was meant to be hierarchical, people like short names, and use it like a flat namespace
- Arbitrary tuple database
 - Can delegate selected services to other hosts
- No security!
- Namespace = money
 - Innovations in this space are met with resistance from people who control name resolution

IP

- Internetworking protocol
 - Network layer
- Common packet format for the Internet
 - Specifies what packets look like
 - *Fragments* long packets into shorter packets
 - *Reassembles* fragments into original shape
- Some parts are fundamental, and some are arbitrary
 - IPv4 is what most people use
 - IPv6 clears up some of the messy parts, but is not yet in wide use

IPv4 packet layout



IPv4 packet layout

Version	IHL	TOS	Total Length	
Identification		Flags	Fragment Offset	
TTI	Protocol	Header Checksum		
Source Address				
Destination Address				
Options				
Data				