CS155b: E-Commerce

Lecture 3: Jan 16, 2001

How Does the Internet Work?

Acknowledgements: S. Bradner and R. Wang

Internet Protocols Design Philosophy

- ordered set of goals
  1. multiplexed utilization of **existing networks**
  2. survivability in the face of failure
  3. support multiple types of communications service
  4. accommodate a variety of network types
  5. permit distributed management of resources
  6. cost effective
  7. low effort to attach a host
  8. account for resources
- not all goals have been met

Packets!

- basic decision: use packets not circuits
  - Kleinrock’s work showed packet switching to be a more efficient switching method
- packet (a.k.a. datagram)

Dest Addr	Src Addr	payload

  - self contained
  - handled independently of preceding or following packets
  - contains destination and source **internetwork** address
  - may contain processing hints (e.g. QoS tag)
  - **no delivery guarantees**
  - net may drop, duplicate, or deliver out of order
  - reliability (where needed) done at higher levels

Telephone Network	**Internet**
• Connection-based	• Packet-based
• Admission control	• Best effort
• Intelligence is “in the network”	• Intelligence is “at the endpoints”
• Traffic carried by relatively few, “well-known,” communications companies	• Traffic carried by many routers, operated by a changing set of “unknown” parties

Review: Technology Advances

	1981	1999	Factor
MIPS	1	1000	1,000
$/MIPS	$100K	$5	20,000
DRAM Capacity	128KB	256MB	2,000
Disk Capacity	10MB	50GB	5,000
Network B/W	9600b/s	155Mb/s	15,000
Address Bits	16	64	4
Users/Machine	10s	<=1	<0.1

- Expensive machines, cheap humans
- Cheap machines, expensive humans
- (Almost) free machines, really expensive humans, and communities

The Network *is* the Computer

- Relentless decentralization
  - "Smaller, cheaper, more numerous"
    mainframe → mini → PC → palms → ubiquitous/embedded
  - More computers → more data communication
- (Shifting) reasons computers talk to each other
  - Efficient sharing of machine resources
  - Sharing of data
  - Parallel computing
  - *Human* communication

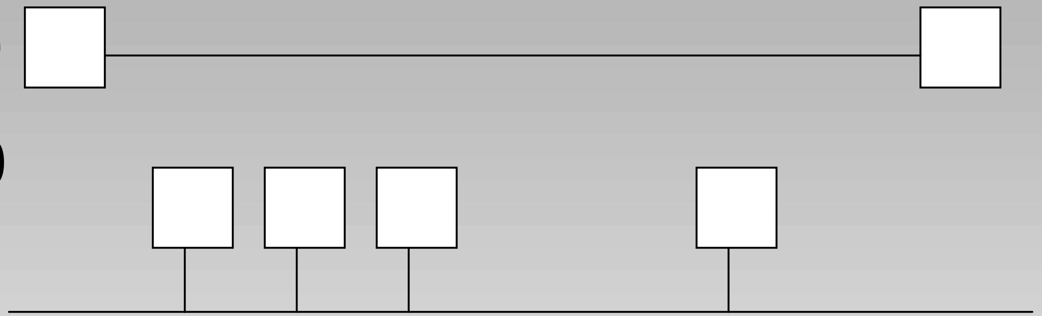
The Network *is* the computer (con’t)

- Networks are everywhere and they are converging
  - SAN, LAN, MAN, WAN
  - All converging towards a similar switched technology
- New chapter of every aspect of computer science
  - Re-examine virtually all the issues in the context of distributed systems or parallel systems
- This is only the beginning.

Directly Connected

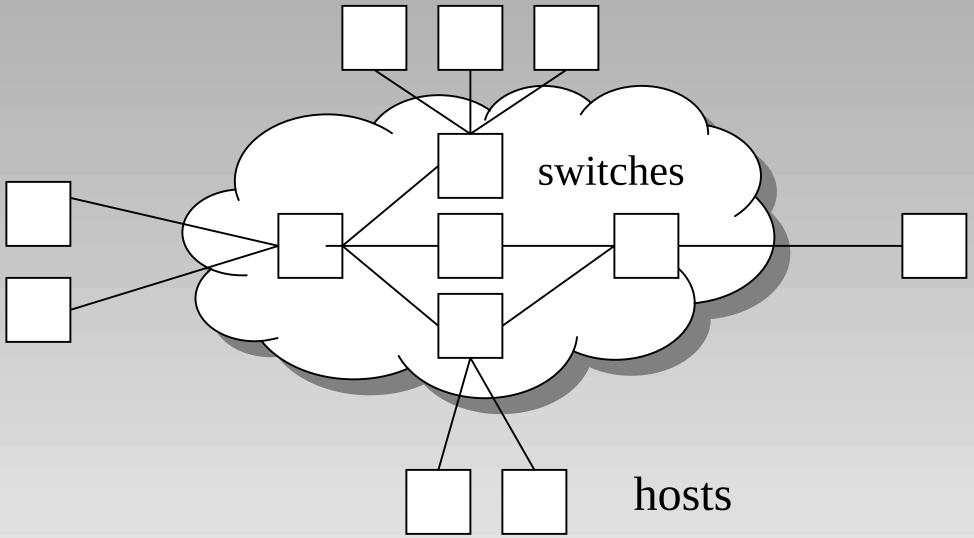
(a)

(b)



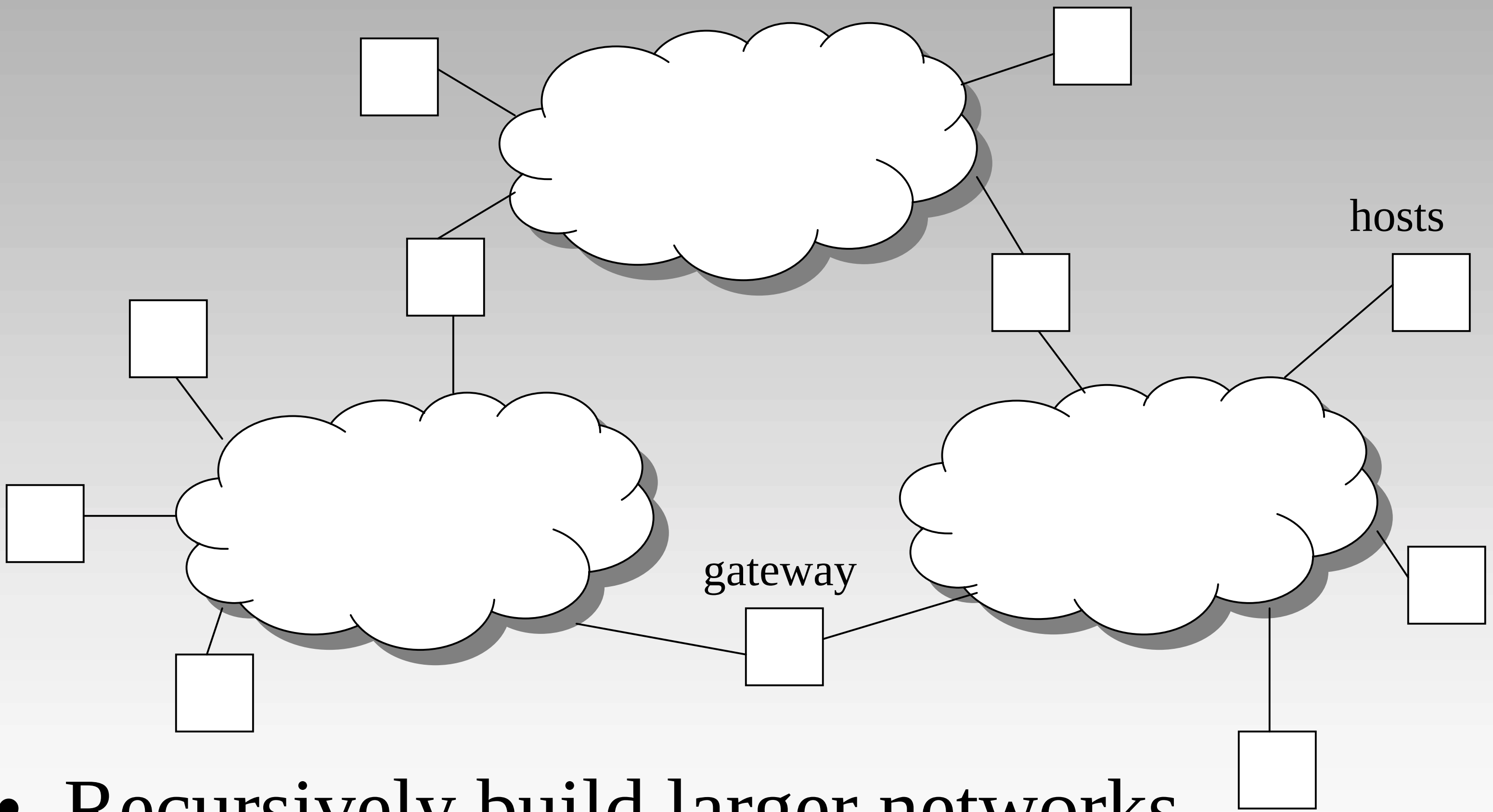
- (a) point-to-point: ATM
- (b) multiple-access: ethernet, FDDI
- Can’t build a network by requiring *all* nodes to be directly connected to each other: scalability in terms of the number of wires or the number of nodes that can attach to a shared media

Switched Network



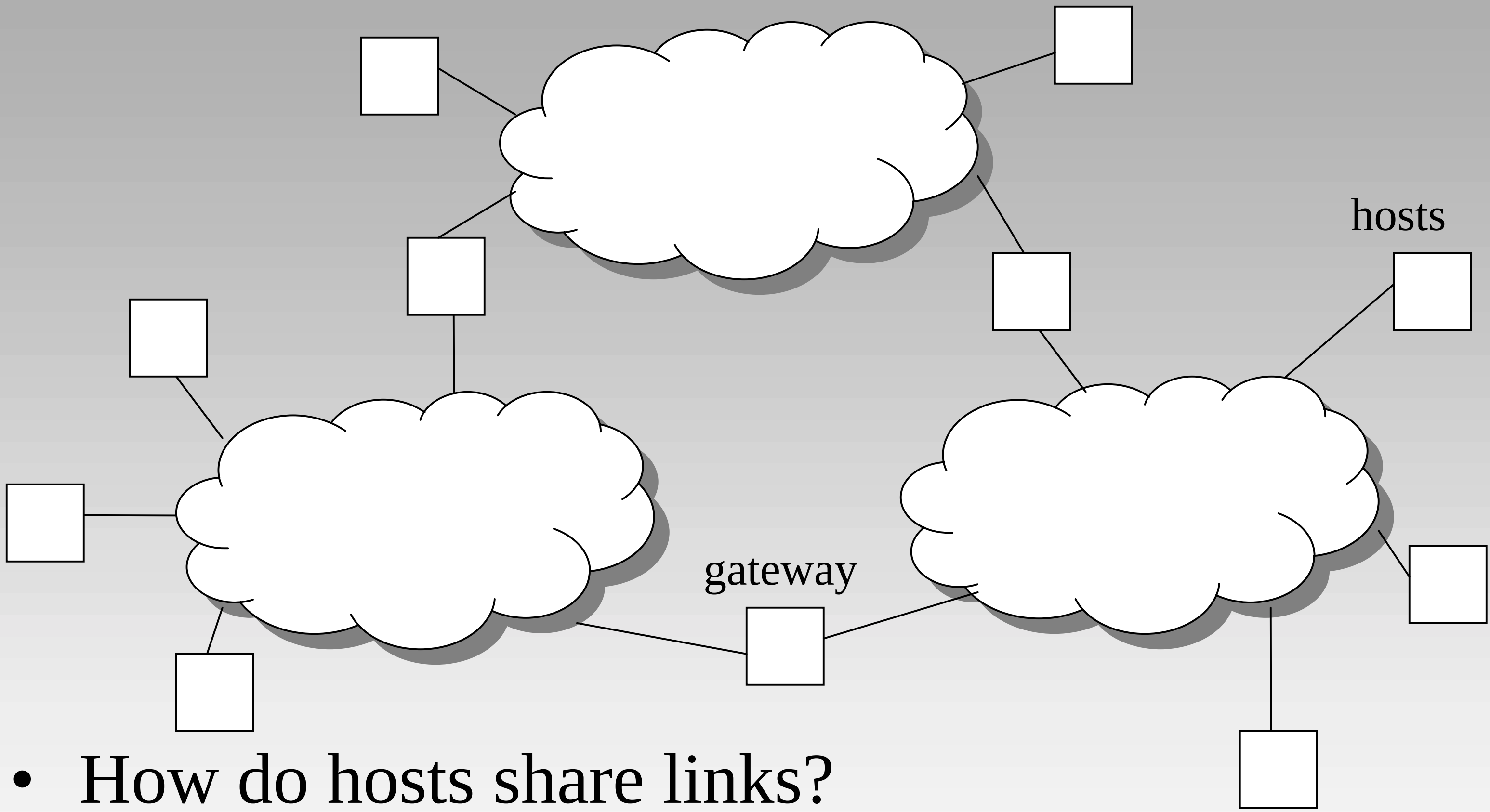
- Circuit switching vs. packet switching
- Hosts vs. “the network,” which is made of switches
- Nice property: scalable aggregate throughput

Interconnection of Networks



- Recursively build larger networks

Some Hard Questions

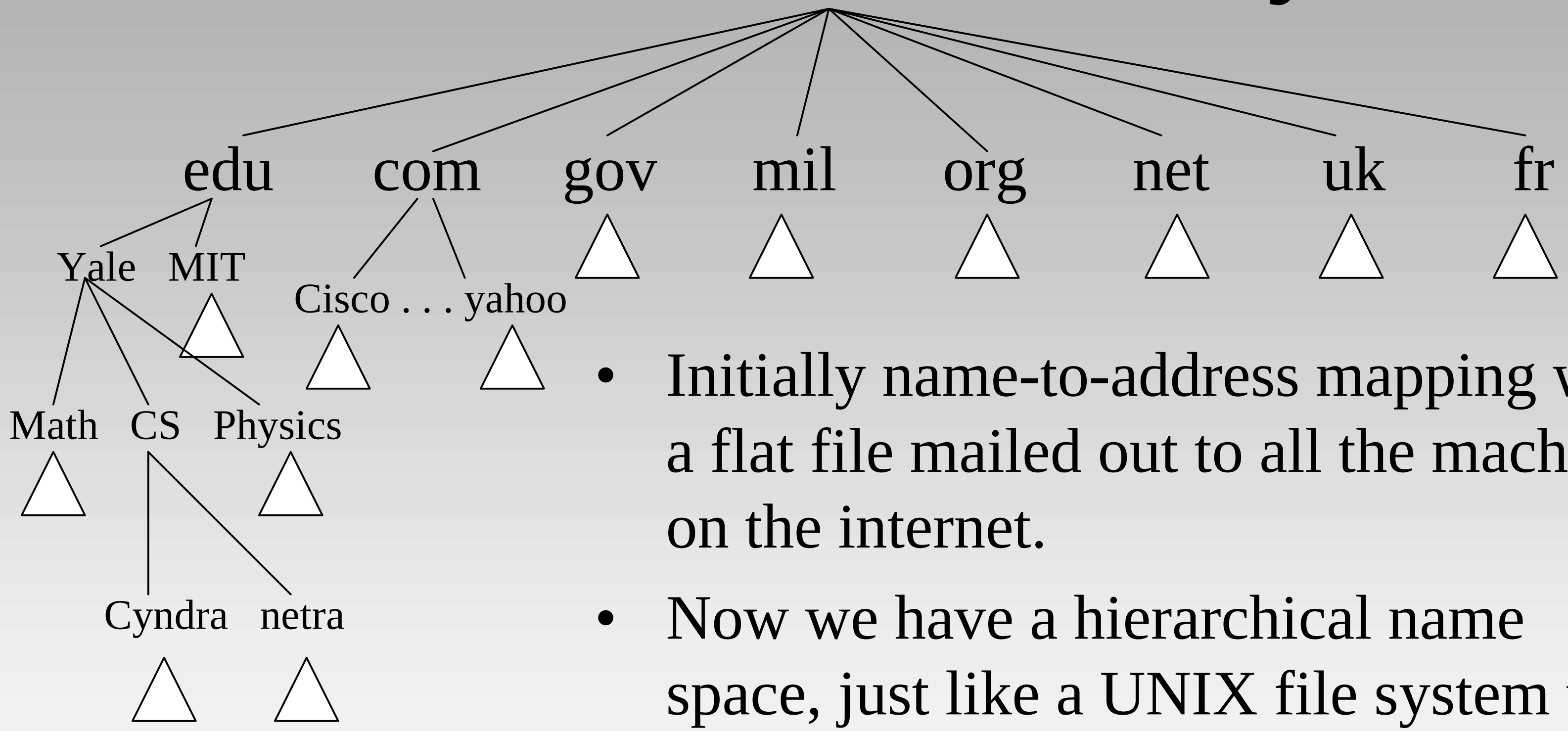


- How do hosts share links?
- How do you name and address hosts?
- Routing: given a destination address, how do you get to it?

IP addresses and Hosts Names

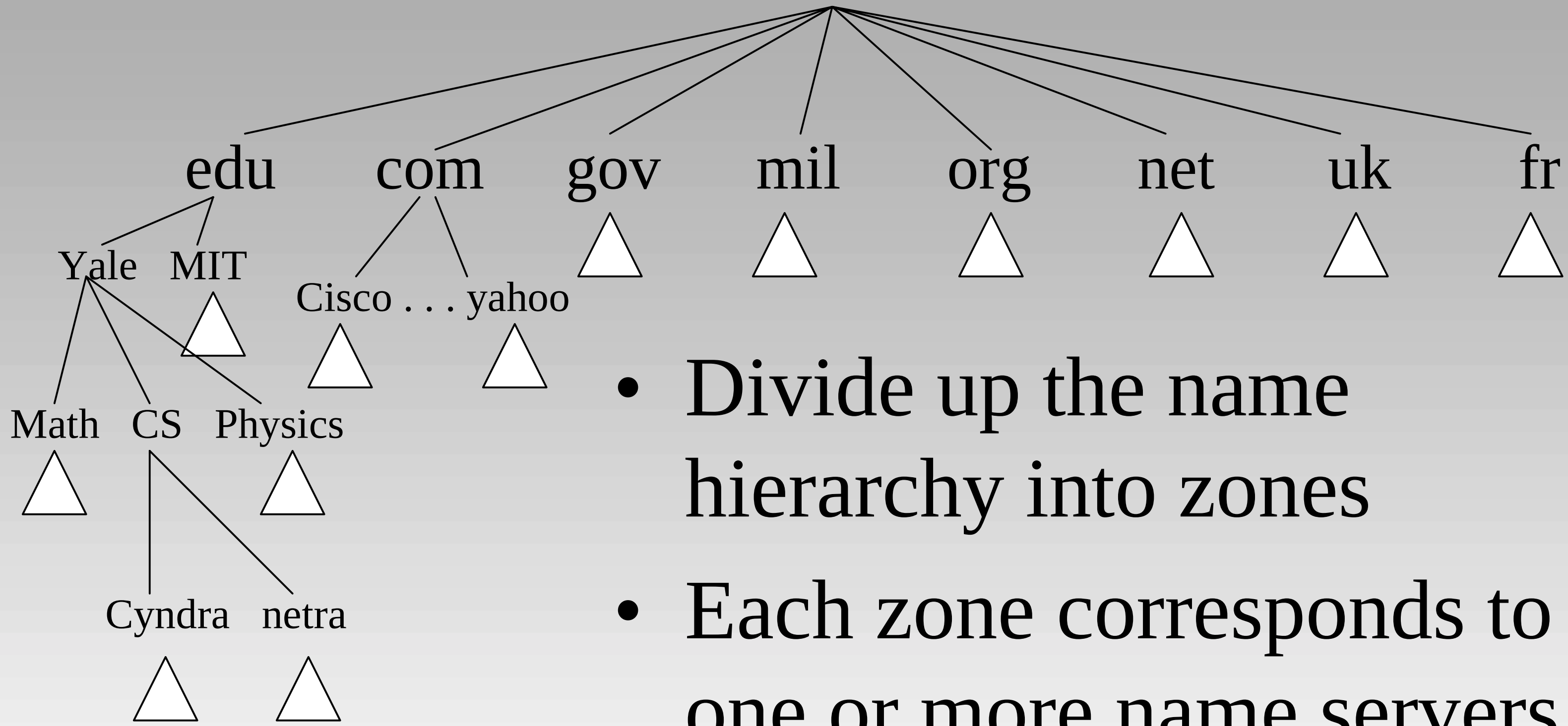
- Each machine is addressed by a 32-bit integer: IP address
  - We will tell you what "IP" is later
  - Ran out of numbers and there are schemes to extend
- An IP address is:
  - Written down in a "dot notation" for "ease" of readings such as `128.36.229.231`
  - Consists of a network address and a host ID
- IP addresses are the universal IDs that are used to name everything
- For convenience, each host also has a human-friendly host name: for example "`128.36.229.231`" is "concave.cs.yale.edu"
- Question: how do you translate names into IP addresses?

Domain Hierarchy



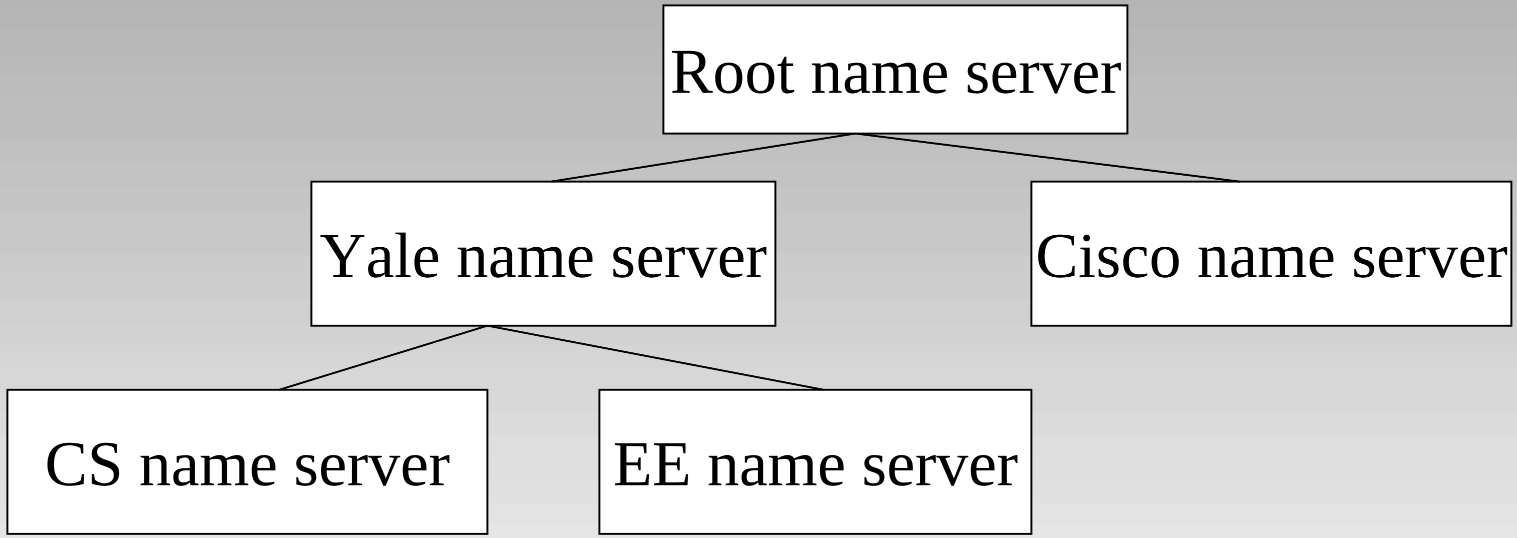
- Initially name-to-address mapping was a flat file mailed out to all the machines on the internet.
- Now we have a hierarchical name space, just like a UNIX file system tree.
- Top level names: historical influence: heavily US centric, government centric, and military centric view of the world.

DNS Zones and Name Servers



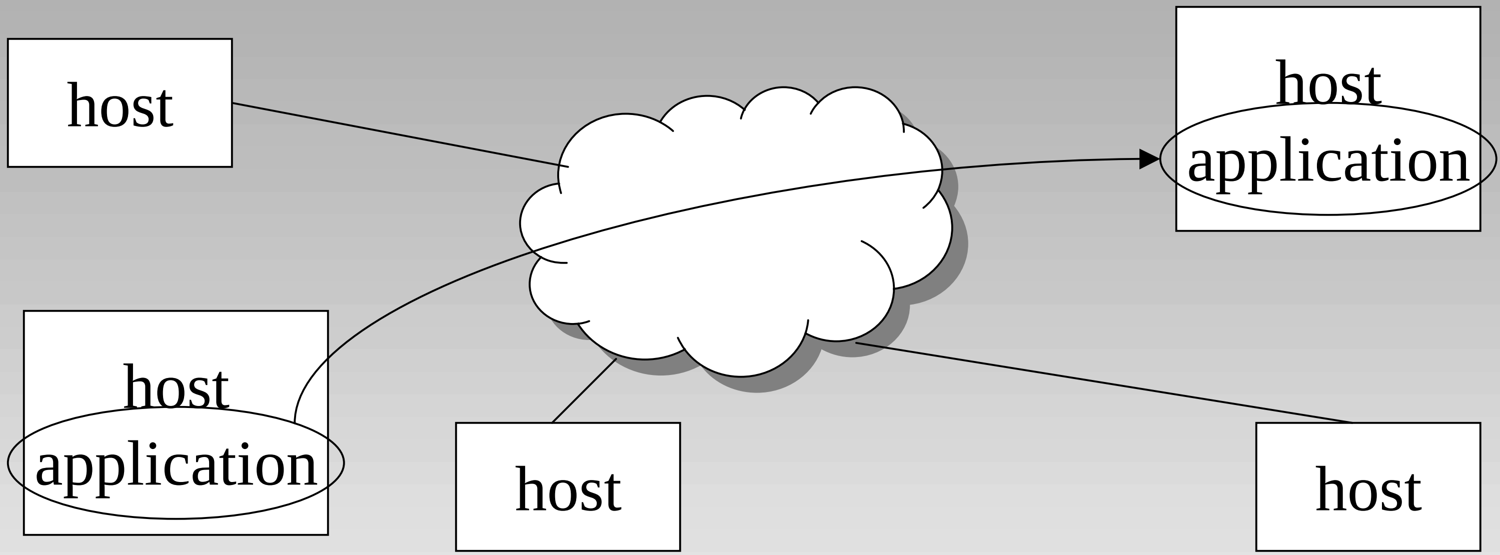
- Divide up the name hierarchy into zones
- Each zone corresponds to one or more name servers under a single administrative control

Hierarchy of Name Servers



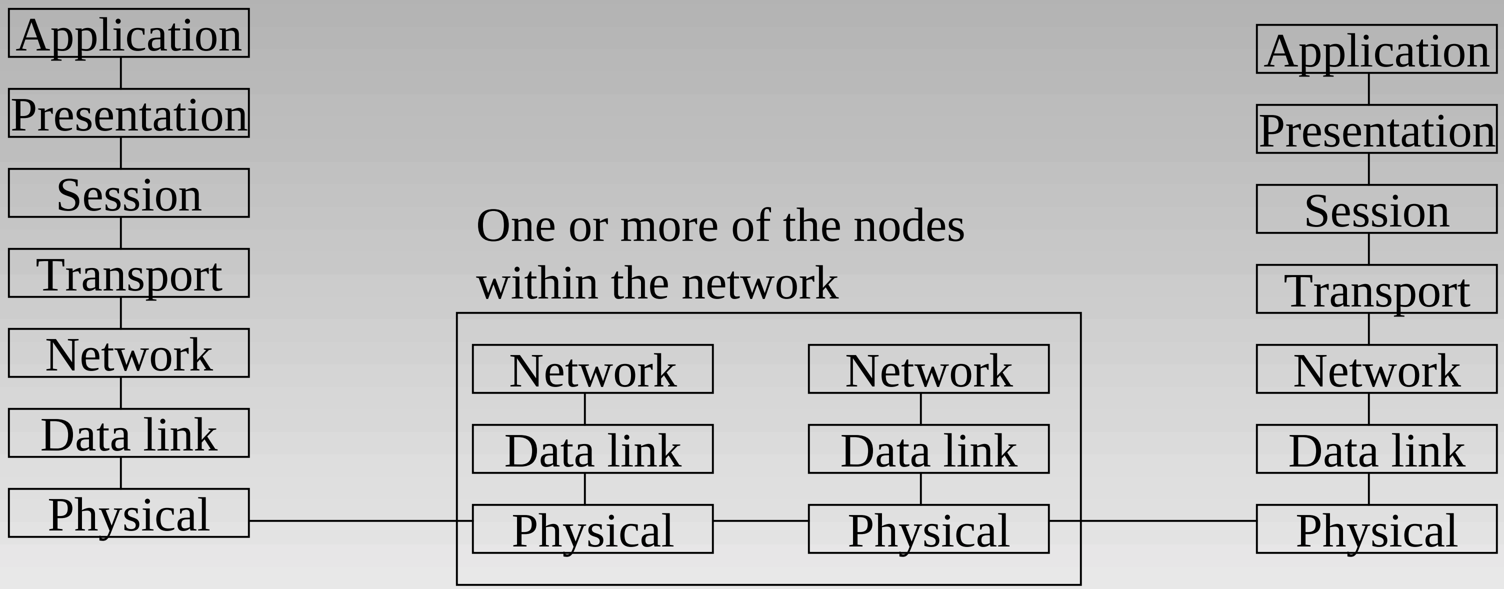
- Clients send queries to name servers
- Name servers reply with answers or forward request to other name servers
- Most name servers also perform lookup caching

Application-Level Abstraction



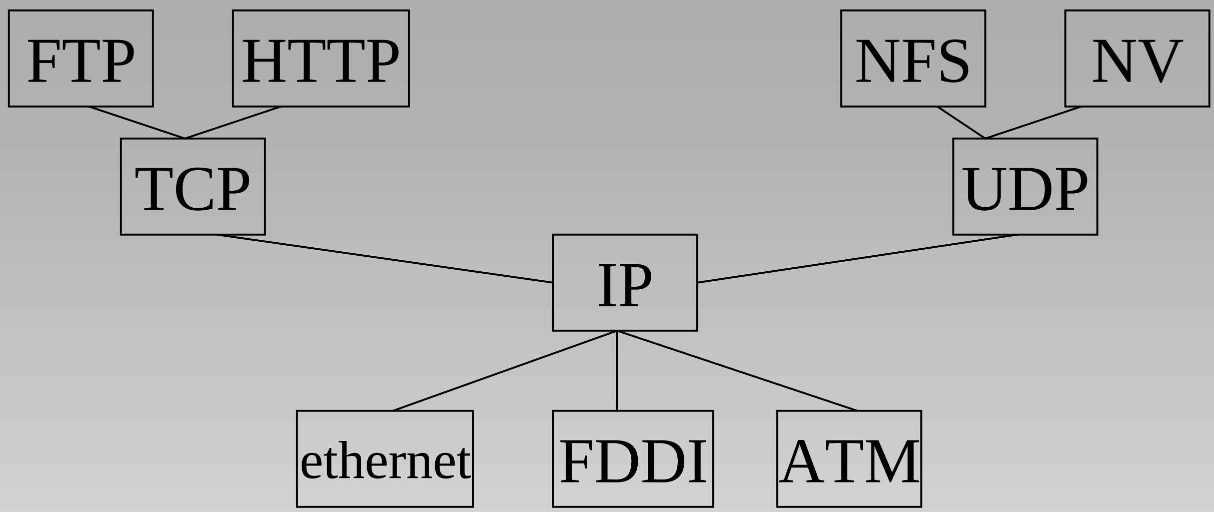
- What you have: hop-to-hop links, multiple routes, packets, can be potentially lost, can be potentially delivered out-of-order
- What you may want: application-to-application (end-to-end) channel, communication stream, reliable, in-order delivery

OSI Architecture



- Physical: handles *bits*
- Data link: provides "*frames*" abstraction
- Network:
  handles hop-to-hop routing, at the unit of *packets*
- Transport: provides process-to-process semantics such as in-order-delivery and reliability, at the unit of *messages*
- Top three layers are not well-defined, all have to do with application level abstractions such as transformation of different data formats

Reality: the "Internet" Architecture



- Protocols: abstract objects that makeup a layer
- Lowest level: hardware specific, implemented by a combination of network adaptors and OS device drivers
- IP (Internet Protocol): focal point of the architecture, provides host-to-host connection, defines common methods of exchanging packets
- TCP (transmission Control Protocol): reliable, in-order stream
- UDP (User Datagram Protocol): unreliable messages (maybe faster)
- On top of those are the application protocols
- Not strictly layered, "hour-glass shape," implementation-centric