What Is Internetworking?

- Primarily software, not hardware
- Provides (attempts) universal interconnection
- Consists of common protocol standards for the exchange of information
- Services
  - Application layer
    - Email, WWW
  - Transport layer
    - TCP, UDP
  - Internetwork layer
    - IP
  - Network layer
    - What IP looks like running over Ethernet

What is an Internetwork? (Internet)

- An internet
  - Collection of interconnected, cooperative networks
  - Uses common protocols
  - Acts like a single network system
- *The* Internet
  - The connected TCP/IP internetwork

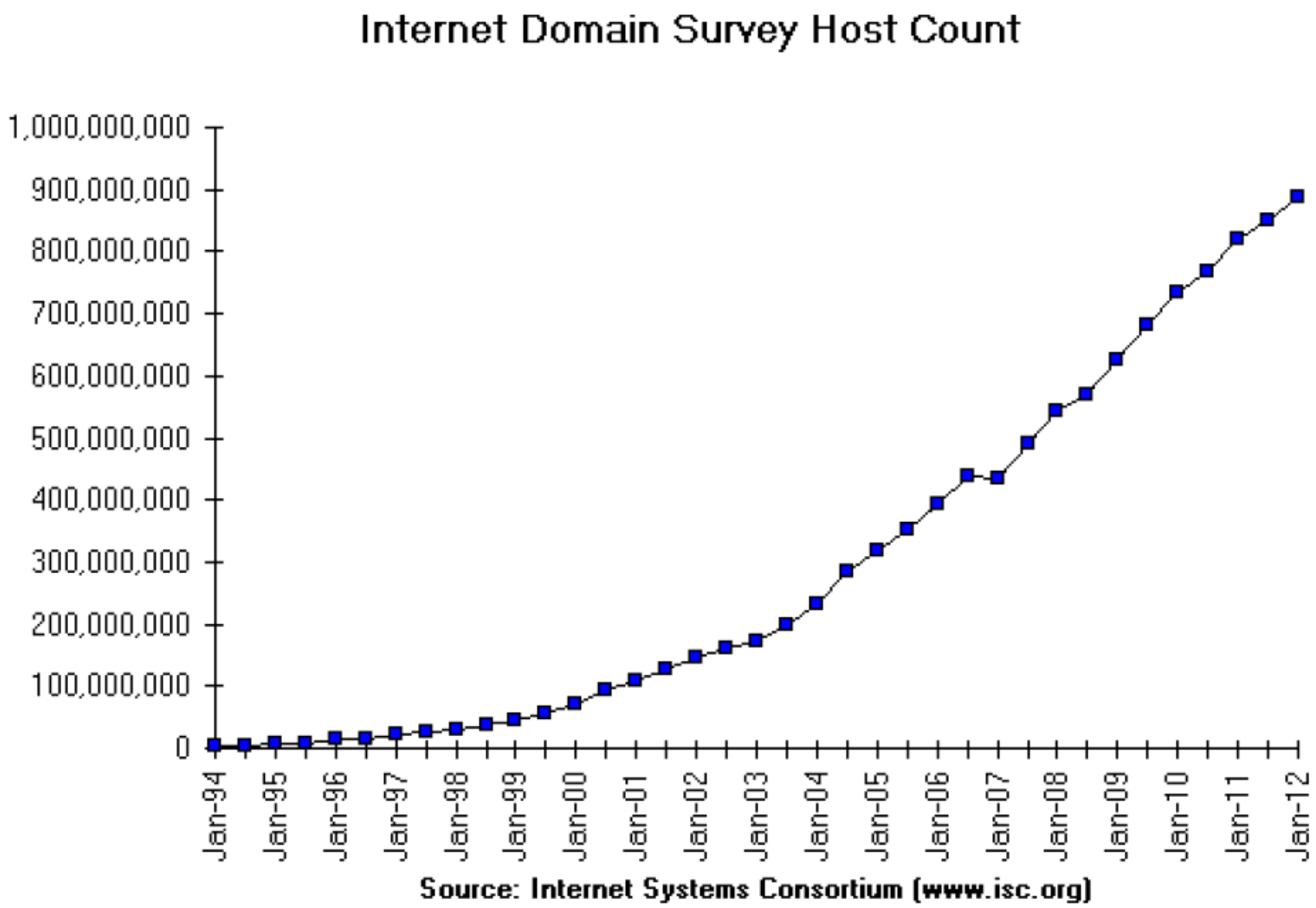
Origins of the TCP/IP Internet

- Originally spanned
  - University campuses
  - Industrial sites
  - Government laboratories
  - Military installations
- Original R&D funded by U.S. Defense Advanced Research Projects Agency (DARPA, formerly ARPA, formerly DARPA)
- Later R&D support from DARPA, NSF, NASA, DOE, DOD
  - Support diminished as commercial entities took over

Growth Of The TCP/IP Internet

- Over 888,239,420 host names registered (as of January 2012)
- 4,632,085 second-level domains registered (foo.com, bar.info, etc.) (as of 4/5/2011)
  - 2,822,456 are `.com`
- 3,484,977,153 IPv4 Addresses Owned (as of 4/1/2012)
  - 1,536,254,577 - US - 1
  - 329,842,729 - China - 2
  - 203,754,516 - UK - 3
  - 200,245,966 - Japan - 4
  - ...
  - 10 - Heard Island and McDonald Islands
  - 5 - Saint Helena, Ascension and Tristan da Cunha
  - 5 - Pitcairn Island (unlisted last year, had 8 two years ago)

Graph Over Time



Most Popular Host Names (As of April 2011)

- 1 - **www** - 1,012,884
- 2 - **mail** - 957,477
- 3 - **dsl** - 510,674 (reduced)

other interesting entries

- **ftp** - 49,049
- **server** - 39,285
- **host2** - 12,623
- **host1** - 11,841
- **a** - 8,714

Services TCP/IP Provides

APPLICATION SERVICES

RELIABLE TRANSPORT SERVICE

CONNECTIONLESS PACKET DELIVERY SERVICE

Network-Level TCP/IP Services

- Lowest Level (packet delivery)
  - Connectionless
  - Best-effort delivery
- Transport Level (stream transport)
  - Uses virtual circuit connections
  - Reliable delivery
  - Flow control

Application-Level TCP/IP Services

- World Wide Web
- Electronic mail
- Network news
- File access and transfer
- Remote login
- Remote execution
- Remote file access

Use Of Hardware

- TCP/IP was designed to run over a wide variety of underlying network hardware
- TCP/IP can use the two basic types of network hardware
  - Circuit switched
  - Packet switched

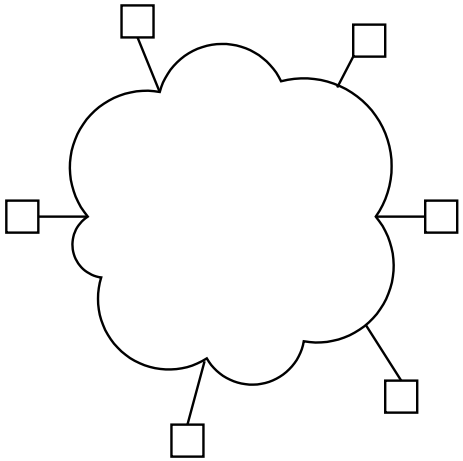
Internetworking Model

- Goal
  - *To maximize interoperability of distributed computations across vendors and products*
- To Achieve Our Goal We Need
  - Universal connectivity
  - Agreement on procedures and formats for exchanging information
  - Agreement on names and addresses for services, machines, etc.

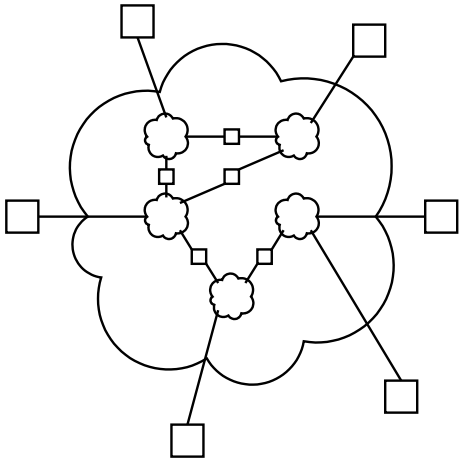
The TCP/IP Internet Idea

- Use standard network hardware
- Interconnect physical networks
- Devise abstractions to hide the details of network hardware, physical addresses, and routing

Conceptual View Of A TCP/IP Internet



user's view



actual connections

Architectural Model

- Hosts connect to physical networks
- Dedicated computers called *gateways* or *routers* interconnect networks

Addressing Model

- Abstract Internet addresses (IP addresses) assigned to every host or gateway that connects to an Internet
- Application software on hosts and gateways uses Internet addresses when sending and delivering packets
- Software in the operating system maps Internet addresses into physical hardware addresses automatically

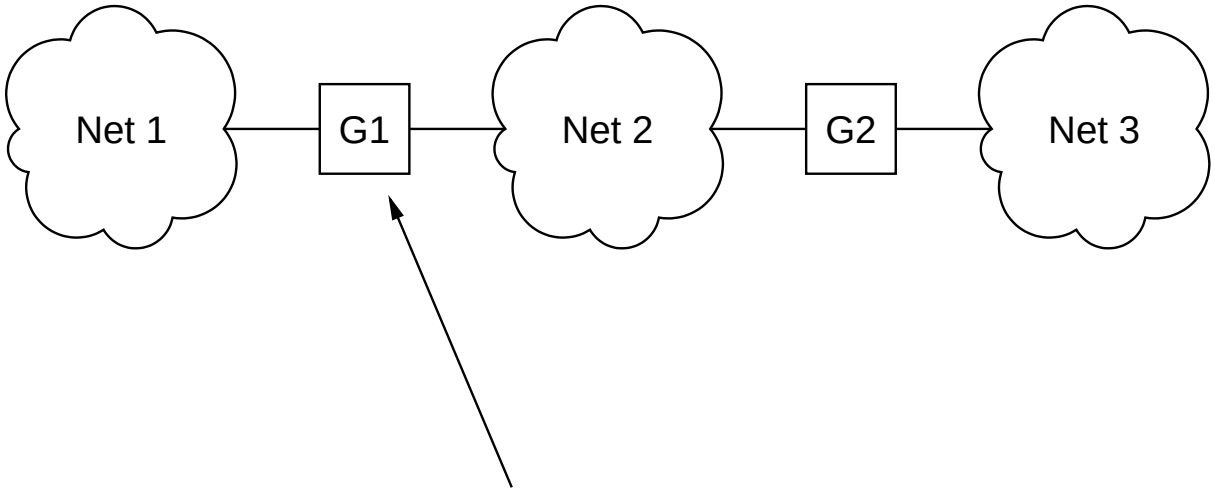
How Hosts Transmit Packets On A TCP/IP Internet

- Host forms a packet to be sent including the destination Internet address
- If host can reach the destination directly, it sends the packet over the physical network to its destination
- If host cannot reach the destination directly, it sends the packet to the nearest gateway

How Gateways Handle Packets

- If gateway can reach the destination directly, it sends the packet over the physical network to its destination
- If gateway cannot reach the destination directly, it chooses another gateway that it can reach directly and sends the packet to that gateway

Illustration Of Gateway Routing



Routing Table

Net 1	direct
Net 2	direct
Net 3	G2
OTHER	Error