Internetworking

COMP476
Networked Computer Systems

Goals

- Understand the differences and advantages of connectionless and connection oriented networks.
- Understand how to create a universal network.

Making a Connection

- Some networking systems are connection oriented. They require the sender and receiver to agree to communicate before sending any data.
- Different layers of the OSI stack may be connection oriented or connectionless.
- A protocol may be connection oriented even if the underlying network is not connection oriented.

Connectionless Networks

- When communicating over a connectionless network, the sender just transmits the data. No setup or connection is required.

Connection oriented and connectionless systems

Issue	Connection oriented	Connectionless
Initial setup	required	not necessary
Destination address	only needed during initial setup	needed every packet
Network failure detection	detected	not detected
Option negotiation	possible at setup	not available
Overhead	moderate	low

Analogy

- A telephone call is connection oriented
  - You have to connect (dial) before you can talk.
  - Once you connect, you don't have to specify the receiver again.
- A letter is connectionless
  - Each letter has the full address
  - Each letter is sent separately
  - Letters may arrive out of order

Example Networks

Connectionless Examples

- Ethernet
- Token Ring
- Internet Protocol
- User Datagram Protocol (UDP)

Connection Oriented Examples

- Asynchronous Transfer Mode (ATM)
- Transmission Control Protocol (TCP)

TCP connection

- TCP is connection oriented while IP is connectionless.
- The TCP protocol sends three messages to establish a connection.

1. A → B I want to talk with you
2. B → A OK, here are some parameters
3. A → B OK, here are my parameters

Universal Service Concept

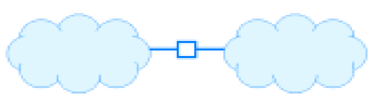
- Any computer can communicate with any other computer in the world.
- Multiple independently owned and operated networks can be interconnected to provide universal service.

Internetworking

- Scheme that uses both hardware and software to provide universal service among heterogeneous networks.
- Everybody can connect even with different equipment.

Physical Network Connection

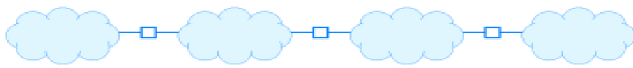
- Routers are used to connect heterogeneous networks together.



Two physical networks connected by a router, which has a separate interface for each network connection.

Internet Architecture

- An internet consists of a set of networks interconnected by routers. The internet scheme allows each organization to choose the number and type of networks, the number of routers to use to interconnect them, and the exact interconnection topology.



An internet formed by using three routers to interconnect four physical networks. Each network can be a LAN or a WAN.

Internet Protocol

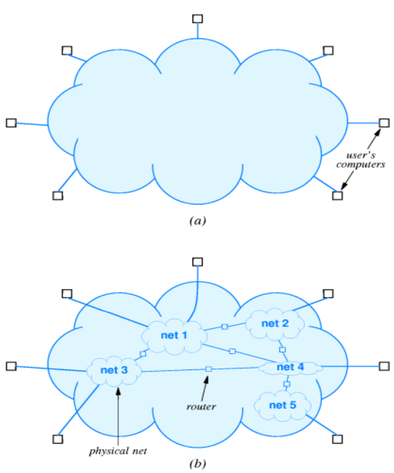
- To achieve universal service among all computers on an internet, routers must agree to forward information from a source on one network to a destination on another.
- A common protocol is needed on computers and routers to overcome the differing frame formats and addressing schemes used within each network.
- Because each network uses an different and incompatible addressing system, an independent addressing system is needed.

Virtual Network

- The Internet is a virtual network. We say this because the communication system is an abstraction. It provides the illusion of a seamless network where:

1. *Each computer is assigned an address.*
2. *Any computer can send a packet to any other computer.*
3. *Internet protocol software hides the details of the network.*

The Internet Concept



- The illusion of a single network
- Underlying physical structure in which routers interconnect the networks.

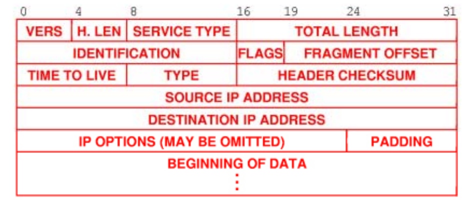
Virtual Packets

- Because routers can connect heterogeneous networks, they cannot just transmit an exact copy of the frame that arrives on one network across another.
- To accommodate heterogeneity, an internet must define a hardware-independent packet format.

IP Datagrams

- A packet sent across a TCP/IP internet is called an IP datagram. Each datagram consists of a header followed by data. Source and destination addresses in the datagram header are IP addresses.
- The size of a datagram is determined by the application that sends data. Allowing the size of datagrams to vary makes IP adaptable to a variety of applications.

The IP Datagram Header Format



VERS – 4-bit protocol version number
H.LEN – 4-bit header length (specifies # of 32-bit quantities)
SERVICE TYPE – specifies sender preference of min. delay or max. throughput
TOTAL LENGTH – 16-bit integer that specifies # of octets
IDENTIFICATION, FLAGS, & FRAGMENT OFFSET – covered later
TIME TO LIVE – used to prevent a forever loop
HEADER CHECKSUM – ensures that bits of the header are not changed in transit
DESTINATION IP ADDRESS – IP address of the final destination
PADDING – ensures that the header length is a complete 32-bit multiple
IP SOURCE ADDRESS – contains the internet address of the sender.
TYPE – specifies the type of data.

IP Encapsulation

- A datagram is encapsulated in a frame for transmission across a physical network.
- The destination address in the frame is the address of the next hop to which the datagram should be sent.

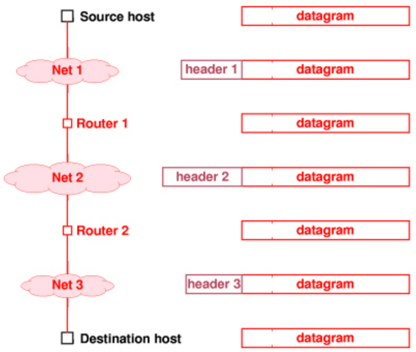
An IP datagram encapsulated in a hardware frame. The entire datagram resides in the frame data area.

Data Envelopes

- Each network hardware defines its own data envelope.
- The Internet packet is put inside the data envelope of the Data Link network. The envelope (with the IP packet) is sent to a router.
- The router takes the IP packet out of the envelope. If the packet has to go further, it puts the packet into an envelope of the next network and sends it.

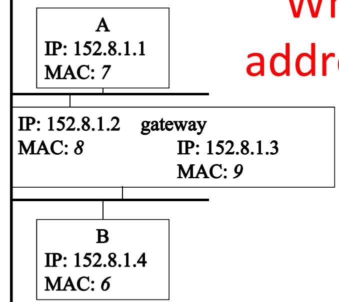
Internet Transmission

- When a datagram arrives in a network frame, the receiver extracts the datagram from the frame data area and discards the frame header.

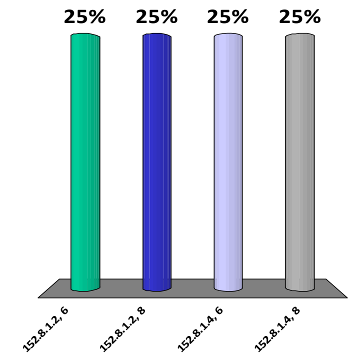


An IP datagram as it appears at each step during a trip across an internet. Whenever it travels across a physical network, the datagram is encapsulated in a frame appropriate to the network.

What IP and Ethernet address will be in a frame sent by A for B?



1. 152.8.1.2, *6*
2. 152.8.1.2, *8*
3. 152.8.1.4, *6*
4. 152.8.1.4, *8*



Destination & Next-Hop Address

- The destination address in an IP datagram header always refers to the ultimate destination.
- When a router forwards the datagram to another router, the address of the next hop does not appear in the IP datagram header.
- The address in the MAC layer frame is always the address of the next hop.

Network Identifiers

Computers on the Internet are referred to as hosts. Each host as at least three identifiers:

- **Internet name** for humans to use (i.e. garfield.ncat.edu)
- **Internet address**, a 32 bit binary number written in decimal as four bytes (i.e.152.8.240.16)
- **hardware address**, such as an Ethernet address (i.e. 00-e0-63-03-76-c0 for garfield)