INTERNET SYSTEM

NETWORK SOFTWARE

• Protocols & Layers
• Internetworking
• IP/TCP

Protocols

• All parties involved in a communication must agree on a set of rules to be used when exchanging messages. Diplomats call it protocol.
• Tom Merill:
  - connected two computers (Lincoln Lab’s TX-2 and the SDC-Q-32 at Santa Monica) with a 2000 bps crude modem, which he called an automatic dialer, and was able to send message back and forth.
  - Merill set up a procedure for grouping characters into messages, sending them across links, and checking to see if message has arrived. If not, message was retransmitted.
  - Merill called his procedure Protocol.

Protocols Suits & Layering

• Making communication happen is complex.
• Thus instead of having a single giant protocol taking care of everything, it is better if the communication problems can be divided into small pieces each focused on a small manageable sub-problem.

Layering Approach

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Layering Approach

- Physical:
  - example RS-232 specs.
- Data Link:
  - frame generation, byte stuffing, checksum etc.
- Network:
  - addressing, forwarding.
- Transport:
  - reliable transfer.
- Session:
  - login, security etc.
- Presentation:
  - data translation, representation.
- Application:

Protocol Stack

Stack-to-Stack Communication

Some Important Protocol Functions

- Sequencing Out-of-Order Packets
  - A connectionless protocol may route different packets to be routed through different paths.
  - How to handle?
    - Sender inserts a field called sequence number. Receiver maintains a buffer. If a new packet arrives inserts it in the buffer in right location. If all previous packets are there, it is delivered. If delivered, also checks for additional packets in buffer.

- Eliminate Duplicate Packets
  - Can duplication occur in CSMA/CD?
  - Combine with sequencing, check if it has already been received, or in the buffer discard it.

Protocol Functions (contd..)

- Retransmission of Lost Packets
  - transmission error makes packet loss a part of digital communication.
  - Create some form of ACK/ buffer.

- Avoiding Replay
  - example: packet-3 of last transmission arrives late as a packet-3 of a later transmission, resulting in drop of the actual packet-3.
  - Solution: unique ID for each session.
Flow Control to Prevent Data Overrun

- Computers do not operate at all same speed.
- Solution: Stop-and-go

### Diagram

- Stop-and-go can be inefficient.
- Allow more than 1 packet to be transmitted without wait for acknowledgement.

### Efficiency & Flow Control

- How much improvement?
- $T_p = \min (B, T_{\text{stop-and-go}} \times W)$

### Congestion Control

- Let all the links are 1.5Mbps. What if 1 & 2 both are sending at 15 Mbps rate?
- Solution:
  - Drop or delay packet
  - Management:
    - Let the switch send back warning to senders.
    - Send back to sender, or mark in message via receiver.
    - Let senders count packet loss and adjust.

### Protocol Design

- A delicate task!
- Examples:
  - sequence number size big or small?
  - Congestion control or flow control?
  - Message size?

### Internet Protocol

- Objective: Universal Service.
- Can we have one single network technology serving all?
- Why networks cannot communicate?
  - What are the two main sources of incompatibility?
  - What is internet and Internet?
The Main Hardware Component

- Routers:
  - Like bridge connects two networks.
  - Performs filtered frame forwarding.
  - But, also understands packet format.
  - Two sides can be two technologies.

Internet Architecture

Why Routers are Bridge like, but not Switch like?

Protocols for Internetworking

- A number of attempts were made to make internetworking possible. However, the most successful one is the protocol suite known as TCP/IP. Its development begun in the 1970s by DARPA.
- Now Internet connects more than 80 million computers across more than 107 countries.

TCP/IP Protocol Stack

- Application
  - Same as ISO
- Transport
  - Reliability: ordering, missing data handling
- Internet
  - Format consistency
  - Routing
- Network Interface
  - Same as ISO
- Physical
  - Same as ISO

Host have all 5 layers. How many layers routers need?

IP Addressing Scheme

- To achieve an illusion of single network, all computers, despite their differences in physical technology, should have a uniform addressing scheme.
- This is done as a software address.
- In this abstraction, each host in internet is assigned an unique 32 bit address called IP address.

- IP - Internet Protocol
  - Global Addressing Scheme
  - Local Address Resolution
  - Datagram Forwarding
  - Encapsulation, Fragmentation & Reassembly

- TCP - Transmission Control Protocol
  - Connection startup & shutdown
  - Reliability: ordering, missing data handling
IP Addressing Format

\[ \text{IP address} = \text{Network number} + \text{host number} \]

If \( n \) bits are for network than how many networks can be there?

How many hosts can be in those networks?

The hierarchy allows host addresses to be assigned independently. What is the right allocation for bits for each part?

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IP Addressing Classes

- IP divides the addresses into 5 classes to accommodate networks of varying sizes.

Class Computation

- Determination of address class is crucial. Generally a machine reads 4 leading bits and determines the class from a table.

Dotted Decimal Notation

- IANA assigns network numbers or blocks of network numbers to ISPs.
- Big ISPs further distribute the network numbers to smaller ISPs connected to them.
- Network administrators assigns the host numbers to individual computers.
An Example Private TCP/IP Network

Can you determine the network classes?

Special Addresses

- Network Address (n.n.n.0, n.0.0.0, etc)
  - Never appears as the destination in an IP packet.
- Direct Broadcast (n.n.n.255, n.0.0.0, etc)
  - All computers in the logical network.
- Limited Broadcast (255.255.255.255)
  - All computers in physical network.
- This computer (0.0.0.0)
  - used during booting.
- Loopback (127.any)
  - used for testing.

Router Addresses

Routers have more than one IP addresses.
Some computers may also be in more than one network.