Chapter 5: The Network Layer

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Overview

- 5.1.2 Datagram vs virtual circuit
- 5.2.3 Flooding
- 5.2.5 Distance vector routing
- 5.2.6 Link state routing
- 5.5.1 IP
- 5.5.2 IP Addresses
### Datagram vs Virtual Circuit

<table>
<thead>
<tr>
<th>Issue</th>
<th>Datagram</th>
<th>Virtual Ckt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connection</td>
<td>N/A</td>
<td>Required</td>
</tr>
<tr>
<td>State</td>
<td>In packet</td>
<td>In switches</td>
</tr>
<tr>
<td>Routing</td>
<td>Per packet</td>
<td>At connection setup</td>
</tr>
<tr>
<td>Faults</td>
<td>Few packets lost</td>
<td>All Vcs terminated</td>
</tr>
<tr>
<td>Congestion control</td>
<td>Difficult</td>
<td>By reservation</td>
</tr>
</tbody>
</table>

### Transport vs Network Layer

<table>
<thead>
<tr>
<th>Transport</th>
<th>Network</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Datagram</td>
</tr>
<tr>
<td>Connectionless</td>
<td>UDP over IP</td>
</tr>
<tr>
<td>Connection-oriented</td>
<td>TCP over IP</td>
</tr>
</tbody>
</table>
Rooting or Routing

- *Rooting* is what fans do at football games, what pigs do for truffles under oak trees in the Vaucluse, and what nursery workers intent on propagation do to cuttings from plants.

- *Routing* is how one creates a beveled edge on a table top or sends a corps of infantrymen into full scale, disorganized retreat

Ref: Piscitello and Chapin, p413
Routeing or Routing

- Routeing: British
- Routing: American

Since Oxford English Dictionary is much heavier than any other dictionary of American English, British English generally prevails in the documents produced by ISO and CCITT; wherefore, most of the international standards for routing standards use the routeing spelling.

Ref: Piscitello and Chapin, p413

Flooding

- Uses all possible paths
- Uses minimum hop path Used for source routing

Fig 8.11b
Routing Techniques Elements

- **Performance criterion**: Hops, Distance, Speed, Delay, Cost
- **Decision time**: Packet, session
- **Decision place**: Distributed, centralized, Source
- **Network information source**: None, local, adjacent nodes, nodes along route, all nodes
- **Routing strategy**: Fixed, adaptive, random, flooding
- **Adaptive routing update time**: Continuous, periodic, topology change, major load change

Distance Vector vs Link State

- **Distance Vector**: Each router sends a vector of distances to its neighbors. The vector contains distances to all nodes in the network. Older method. Count to infinity problem.
- **Link State**: Each router sends a vector of distances to all nodes. The vector contains only distances to neighbors. Newer method. Used currently in internet.
**Internetworking Terms**
- **End-system**: Host
- **Network**: Provides data transfer between end-systems
- **Internet**: A collection of networks
- **Subnetwork**: Each component of an internet
- **Port**: Application processes in the host

The diagram shows a network topology with hosts, routers, and subnets. Hosts A and B communicate through a router. The routers are connected to subnets 1 and 2.

**Internet Protocol (IP)**
- **IP Header**

The IP header structure includes fields such as version, header length, type of service, total length, identification, flags, fragment offset, time to live, protocol, header checksum, source address, destination address, options + padding, and data.
## IP Header

- **Version (4 bits)**
- **Internet header length (4 bits):** in 32-bit words. Min header is 5 words or 20 bytes.
- **Type of service (8 bits):** Reliability, precedence, delay, and throughput
- **Total length (16 bits):** header+data in bytes
- **Identifier (16 bits):** Helps uniquely identify the datagram during its life for a given source, destination address
- **Flags (3 bits):**
  - More flag - used for fragmentation
  - No-fragmentation
  - Reserved
- **Fragment offset (13 bits):** In units of 8 bytes
- **Time to live (8 bits):** Specified in router hops
- **Protocol (8 bits):** Next level protocol to receive the data
- **Header checksum (16 bits):** 1’s complement sum of all 16-bit words in the header
- **Source Address (32 bits)**
- Destination Address (32 bits)
- Options (variable): Security, source route, record route, stream id (used for voice) for reserved resources, timestamp recording
- Padding (variable): Makes header length a multiple of 4
- Data (variable): Data + header ≤ 65,535 bytes

### IP Address

- **Class A:**
  - Network: 0
  - Local: 7, 24 bits

- **Class B:**
  - Network: 10
  - Local: 2, 14, 16 bits

- **Class C:**
  - Network: 110
  - Local: 3, 21, 8 bits

- **Class D:**
  - Network: 1110
  - Host Group (Multicast): 4, 28 bits

- **Local = Subnet + Host** (Variable length)
Summary

- Datagram vs virtual circuits
- Distance vector vs link state routing
- IP header and addresses
- subnetworks and ports

Homework

- Read sections 5.1.3, 5.2.2, 5.2.3, 5.2.5, 5.2.6, 5.5.1, 5.5.2, 5.5.3
- Problems: 8, 9, 26, 27, 28