Network Layer (I)

Network-layer Functions, Data Plane and Control Plane

- **Forwarding:**
  - Task of the **data plane**
  - Data plane: move packets from router’s input to appropriate router output

- **Routing:**
  - Task of the **control plane**
  - Control plane: determine route taken by packets from source to destination

- **Two approaches** to structuring network control plane:
  - **per-router control** (traditional)
    - Individual routing algorithm components in each and every router interact in the control plane
  - **logically centralized control** (software defined networking)
    - A distinct (typically remote) controller interacts with local control agents (CAs)
    - The routing path is computed by the remote controller
Network Layer General Functions

- Addressing: IP address
- Error control: rerouting, ICMP (Internet Control Message Protocol)
- QoS: TOS (Type of Service) field and Differentiated Services

ICMP

- Internet Control Message Protocol
  - used by hosts & routers to communicate network-level information
  - typically used for diagnostic/control purpose/generated in response to errors in IP
  - Runs on top of IP but still within the network layer

- Examples:
  - ping (Echo Request/Reply)
    - uses ICMP to send requests to the destination and replies to the source
  - traceroute (Time-to-live Exceeded, Destination Unreachable)
    - every node on the path sends three responses to measure the RTT using ICMP or to tell the destination is unreachable.
  - “TTL is 0” (Packet Drop)
    - a router uses ICMP packet to indicate the source of a packet that the lifetime exceeded and the packet is dropped.

- ICMP messages use its type and code fields to specify its purposes. These values are well defined in the protocol. The list below shows a subset of the values as an example.

<table>
<thead>
<tr>
<th>Type</th>
<th>Code</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>echo reply (ping)</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>dest. network unreachable</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>dest host unreachable</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>dest protocol unreachable</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>dest port unreachable</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>dest network unknown</td>
</tr>
<tr>
<td>3</td>
<td>7</td>
<td>dest host unknown</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>source quench (congestion control - not used)</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
<td>echo request (ping)</td>
</tr>
<tr>
<td>9</td>
<td>0</td>
<td>route advertisement</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
<td>router discovery</td>
</tr>
<tr>
<td>11</td>
<td>0</td>
<td>TTL expired</td>
</tr>
<tr>
<td>12</td>
<td>0</td>
<td>bad IP header</td>
</tr>
</tbody>
</table>
Ping
- ping 137.146.213.6 and open Wireshark filter on ip.src == 137.146.103.160 & icmp

- ping is a network tool to check the status of the network
- It uses ICMP and the client-server model
- The client sends an ICMP request (type 0 code 0), and the server sends an ICMP response (type 8 code 0) back to the client after receiving the request.
- The ping program calculates the RRT for each ping packet based on the request and response messages
- After ctrl-c, the ping program calculates the statistics based on the RTT of all ping packets
- Then, we can use the statistics to tell the status of the network. (packet loss and RRT).

Disclaimer: Notes adapted from the textbook and online resources.