ICMP: Internet Control Message Protocol

- used by hosts, routers, gateways to communicate network-level information
  - error reporting:
    - unreachable host, network, port, protocol
    - echo request/reply (used by ping)
  - network-layer "above" IP:
    - ICMP msgs carried in IP datagrams
  - ICMP message: type, code plus first 8 bytes of IP datagram causing error

<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>4</td>
<td>dest network unknown</td>
</tr>
<tr>
<td>3</td>
<td>5</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>

DHCP: Dynamic Host Configuration Protocol

**Goal:** allow host to *dynamically* obtain its IP address from network server when it joins network

- Can renew its lease on address in use
- Allows reuse of addresses (only hold address while connected an "on")
- Support for mobile users who want to join network (more shortly)

**DHCP overview:**
- host broadcasts "DHCP discover" msg
- DHCP server responds with "DHCP offer" msg

DHCP Client-Server Scenario

DHCP client-server scenario

DHCP client-server scenario

What is mobility?

- spectrum of mobility, from the network perspective:

  no mobility
  mobile user, using same access point
  mobile user, connecting/disconnecting from network using DHCP.
  mobile user, passing through multiple access points while maintaining ongoing connections (like cell phone)

  high mobility
Mobility: more vocabulary

- **Care-of-address**: address in visited network (e.g., 79.129.13/24)
- **Permanent address**: remains constant (e.g., 128.119.40.186)
- **Visited network**: network in which mobile currently resides (e.g., 79.129.13/24)
- **Home agent**: entity in visited network that performs mobility functions on behalf of mobile
- **Correspondent**: wants to communicate with mobile

How do you contact a mobile friend:

Consider friend frequently changing addresses, how do

- *your friend* keep phone books?
- call her parents?
- expect her to let you know where he/she is?

I wonder where Alice moved to?

Mobility: approaches

- **Let routing handle it**: routers advertise permanent address of mobile-nodes in residence via usual routing table exchange.
  - routing tables indicate where each mobile located
  - no changes to end systems
- **Let end-systems handle it**:
  - *indirect routing*: communication from correspondent to mobile goes through home agent, then forwarded to remote
  - *direct routing*: correspondent gets foreign

Mobility: registration

End result:

- Foreign agent knows about mobile
- Home agent knows location of mobile

Mobility via Indirect Routing

- *Let routing handle it*: routers advertise permanent address of mobile-nodes in residence via usual routing table exchange.
  - routing tables indicate where each mobile located
  - no changes to end systems
- *Let end-systems handle it*:
  - *indirect routing*: communication from correspondent to mobile goes through home agent, then forwarded to remote
  - *direct routing*: correspondent gets foreign
Indirect Routing: comments

- Mobile uses two addresses:
  - permanent address: used by correspondent (hence mobile location is transparent to correspondent)
  - care-of address: used by home agent to forward datagrams to mobile

- foreign agent functions may be done by mobile itself

- triangle routing: correspondent—home network—mobile
  - inefficient when correspondent mobile

Forwarding datagrams to remote mobile

- correspondent forwards to foreign agent
- foreign agent receives packets, forwards to mobile
- mobile replies directly to correspondent

Indirect Routing: moving between networks

- suppose mobile user moves to another network
  - registers with new foreign agent
  - new foreign agent registers with home agent
  - home agent updates care-of-address for mobile
  - packets continue to be forwarded to mobile (but with new care-of-address)

- Mobility, changing foreign networks transparent: on going connections can be maintained!

Mobility via Direct Routing

- correspondent requests, receives foreign address of mobile
- foreign agent receives packets, forwards to mobile

- overcomes triangle routing problem
- non-transparent to correspondent: correspondent must get care-of-address from home agent
  - What happens if mobile changes networks?

- RFC 3220
  - has many features we’ve seen:
    - home agents, foreign agents, foreign agent registration, care-of-addresses, encapsulation (packet within a packet)
  - three components to standard:
    - agent discovery
    - registration with home agent
    - indirect routing of datagrams
Mobile IP: agent discovery

- **agent advertisement**: foreign/home agents advertise service by broadcasting ICMP messages (type 9).

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>type</td>
<td>9 (agent advertisement)</td>
</tr>
<tr>
<td>code</td>
<td>0 (default)</td>
</tr>
<tr>
<td>checksum</td>
<td>0</td>
</tr>
<tr>
<td>router address</td>
<td>0</td>
</tr>
<tr>
<td>H,F bits</td>
<td>0 (0 = home, 1 = foreign)</td>
</tr>
<tr>
<td>R bit</td>
<td>0 (registration required)</td>
</tr>
<tr>
<td>extension length</td>
<td>0</td>
</tr>
<tr>
<td>sequence number</td>
<td>0</td>
</tr>
<tr>
<td>registration lifetime</td>
<td>9999</td>
</tr>
<tr>
<td>0 or more care-of-addresses</td>
<td>COA: 79.129.13.2</td>
</tr>
</tbody>
</table>

Mobile IP: registration example

- **visited network**: 79.129.13/24

<table>
<thead>
<tr>
<th>Event</th>
<th>Details</th>
</tr>
</thead>
</table>