Campus Networking Workshop
Forwarding and Routing
Forwarding and Routing

- **Forwarding** is receiving packets on an interface and re-sending them out on another interface.
- **Routing** is deciding on the best path to reach any given destination.
- These are two different concepts!
  - On a high-end router, Forwarding is done in hardware.
  - Routing is a software function.
Outline forwarding operation

• Receive a datagram
• Is it for us (Destination IP = ours)? Accept
• Decrement the TTL field
  • if TTL reaches zero, discard the datagram
  • recalculate header checksum
• Look up the destination IP address in forwarding table to find the next hop
  • if not found, discard the datagram
• Re-send to next hop
Forwarding

- The best way to reach a given prefix is stored in the **Forwarding Table** or **FIB**
- Each packet's destination address is looked up to decide where to send it next (the *next hop*)

<table>
<thead>
<tr>
<th>Destination Prefix</th>
<th>Next Hop</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.10.0.0/16</td>
<td>1.2.3.3</td>
</tr>
<tr>
<td>10.10.1.0/24</td>
<td>1.2.3.4</td>
</tr>
<tr>
<td>10.10.2.0/24</td>
<td>1.2.3.5</td>
</tr>
</tbody>
</table>
Longest Prefix Rule

- If the destination matches multiple prefixes, the longest prefix wins
- Example: packet destination 10.10.1.1

<table>
<thead>
<tr>
<th>Destination Prefix</th>
<th>Next Hop</th>
<th>Match Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.10.0.0/16</td>
<td>1.2.3.3</td>
<td>MATCH!</td>
</tr>
<tr>
<td>10.10.1.0/24</td>
<td>1.2.3.4</td>
<td>MATCH!</td>
</tr>
<tr>
<td>10.10.2.0/24</td>
<td>1.2.3.5</td>
<td>no match</td>
</tr>
</tbody>
</table>
Default route

- Destination 0.0.0.0/0 or ::/0
- Matches every IP address
- But only when there is no better match (longer prefix) for that destination
Forwarding is hop-by-hop

- Every router has a different forwarding table for its place in the network
- Path chosen from A towards B is not necessarily the same path as B chooses towards A
- And if "ping" doesn't respond, remember it could be either the outbound path or the return path which is broken
Asymmetric paths
Routing

- Deciding the best path to any given destination
- Configured manually: *static routing*
- Learned automatically: *dynamic routing*
Routing and Forwarding

- Routing information populates the FIB

OSPF → Routing Information Base (RIB) → Forwarding Information Base (FIB)

BGP → Routing Information Base (RIB) → Forwarding Information Base (FIB)

Static → Routing Information Base (RIB) → Forwarding Information Base (FIB)

- show ip route
- show ip cef
- show adjacency
Routing protocols

• A collection of routers managed together is called an autonomous system (AS)

• Within an AS you use an Interior Gateway Protocol
  - e.g. OSPF, IS-IS

• Between one AS and another AS you use an Exterior Gateway Protocol
  - e.g. BGP
Routing scalability

- The whole Internet is described by approx. 500,000 IPv4 routes and 17000 IPv6 routes
- In a single-homed network you don't need all these routes
  - Just local routes within your network, and a default route pointing at your ISP
- If you are multi-homed, you need a router which speaks BGP