Configuring IP forwarding

Review of IP forwarding (internetworking)

- B and C are routers: they connect to multiple networks and forward traffic between them
- Why do we need routers? Why not just build one big ethernet LAN?

From the viewpoint of "A"

- "A" can communicate directly with "B"; they are on the same network
- But how can it send data to "D"?

Answer: it must send to "B"

- This gets the packet one hop closer to the destination
- "Hop by hop" forwarding
- Must know which next hop to use
- For each packet, looks up destination in a forwarding table

A's forwarding table

<table>
<thead>
<tr>
<th>Destination</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Next-Hop</td>
<td>direct</td>
<td>B</td>
<td>B</td>
</tr>
</tbody>
</table>

We don't list individual hosts in a forwarding table

- The Internet has hundreds of millions of hosts; the table would be too big
- However, all the hosts on one network share the same prefix
  - Example: network 200.10.194.0/24
  - The first 24 bits of each IP address is the same
- So we can match all the hosts on a remote network with a single forwarding table entry
- A forwarding table for the entire Internet is "only" about 125,000 entries, because each entry represents a whole network
A's forwarding table (new)

<table>
<thead>
<tr>
<th>Destination</th>
<th>Next-Hop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network 1</td>
<td>direct</td>
</tr>
<tr>
<td>Network 2</td>
<td>B</td>
</tr>
<tr>
<td>Network 3</td>
<td>B</td>
</tr>
</tbody>
</table>

What is B's forwarding table?

<table>
<thead>
<tr>
<th>Destination</th>
<th>Next-Hop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network 1</td>
<td></td>
</tr>
<tr>
<td>Network 2</td>
<td>B</td>
</tr>
<tr>
<td>Network 3</td>
<td></td>
</tr>
</tbody>
</table>

In general, all the forwarding tables are *different*

- And they must all be correct, for A to be able to send traffic to D
- Also, forwarding from D to A must be correct so that responses can be received

What happens if a forwarding table entry is wrong?

- "Black holes"
- Forwarding loops
  - Why are they not forwarded forever?

Static routing

- Means that the forwarding table entries are built by hand
- Perfectly OK for small networks
- Error-prone for large networks
- If network topology changes, tables must be rebuilt

Dynamic routing

- Routers communicate with each other to discover the network topology
  - Examples: OSPF, IS-IS, RIP (bad)
- Forwarding tables built automatically
- Automatically responds to changes in topology, e.g. link failures
- Traffic can take alternate paths for resilience
**IP forwarding in Linux**

- Linux machines can make adequate routers
- Why do we prefer to buy expensive hardware routers (e.g. Cisco?)

**Configuring interfaces**

- `ifconfig eth0 x.x.x.x netmask y.y.y.y`
  - `x.x.x.x` is YOUR IP address
  - `y.y.y.y` is the netmask for the network
  - You will immediately be able to ping other machines which are directly connected to `eth0`
    - On the same network as you
    - Have the same IP prefix as you

**Adding static routes to reach remote networks**

- `route add -net x.x.x.x netmask y.y.y.y gw z.z.z.z`
  - `x.x.x.x/y.y.y.y` are the network address and netmask of a remote network
  - `z.z.z.z` is the IP address of the next hop router
  - `z.z.z.z` must be on the same network as you
  - You can now ping any machine on that network (but you won’t get a response until *all* intermediate hops are configured)

**Reviewing your configuration**

- `ifconfig`
  - Shows the interface configuration
- `route -n`
  - Shows the contents of the forwarding table

**Testing the network**

- `ping x.x.x.x`
  - Check you can get packets to and from that remote machine
- `traceroute -n x.x.x.x`
  - Shows the route traffic takes towards `x.x.x.x`
  - If it stops at a certain point, that may indicate where the error is
  - `-n` prevents DNS lookups
    - This is VERY important; if your network is broken then probably your DNS servers are not reachable, and attempting to do so will introduce long delays

**Classroom exercise**

- Break the class into a "backbone" network with separate edge networks

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**Hints**

- Test your network one step at a time
  - Make sure you can ping your next hop before you try to route traffic through it
- Remember that ping will not work unless you have routes to their network AND they have routes to your network
- Pick another desk and work with them until you are able to ping both their machines and they can ping both of yours
- Review your configuration frequently. Make sure netmasks are correct!

**How to get full connectivity to the Internet?**

- We prefer not to add 125,000 routes!