Campus Networking Workshop

Introduction to Routing and Forwarding

UNIVERSITY OF OREGON

NSRC
Network Startup Resource Center

Routing and Forwarding

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

Routing

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

How Does Routing Work?

- Internet is made up of the ISPs who connect to each other's networks
- How does an ISP in Kenya tell an ISP in Japan what customers they have?
- And how does that ISP send data packets to the customers of the ISP in Japan, and get responses back
  - After all, as on a local ethernet, two way packet flow is needed for communication between two devices

How Does Routing Work?

- ISP in Kenya could buy a direct connection to the ISP in Japan
  - But this doesn't scale – thousands of ISPs, would need thousands of connections, and cost would be astronomical
- Instead, ISP in Kenya tells his neighbouring ISPs what customers he has
  - And the neighbouring ISPs pass this information on to their neighbours, and so on
  - This process repeats until the information reaches the ISP in Japan

How Does Routing Work?

- This process is called “Routing”
- The mechanisms used are called “Routing Protocols”
- Routing and Routing Protocols ensures that
  - The Internet can scale
  - Thousands of ISPs can provide connectivity to each other
  - We have the Internet we see today

Static Routing

- Static Routes are manually configured routing entries used by routers for forwarding traffic
- Static routes are fixed and do not change when the network is changed
- Can you used to provide a gateway of last resort

Dynamic 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. 520,000 IPv4 routes and 19,000 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

Forwarding

- **Forwarding** is receiving packets on an interface and re-sending them out on another interface

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 Table

- 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)

Destination Prefix	Next Hop
10.10.0.0/16	1.2.3.3
10.10.1.0/24	1.2.3.4
10.10.2.0/24	1.2.3.5

Longest Prefix Rule

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

Destination Prefix	Next Hop	
10.10.0.0/16	1.2.3.3	MATCH!
10.10.1.0/24	1.2.3.4	MATCH! Longest Prefix
10.10.2.0/24	1.2.3.5	no match

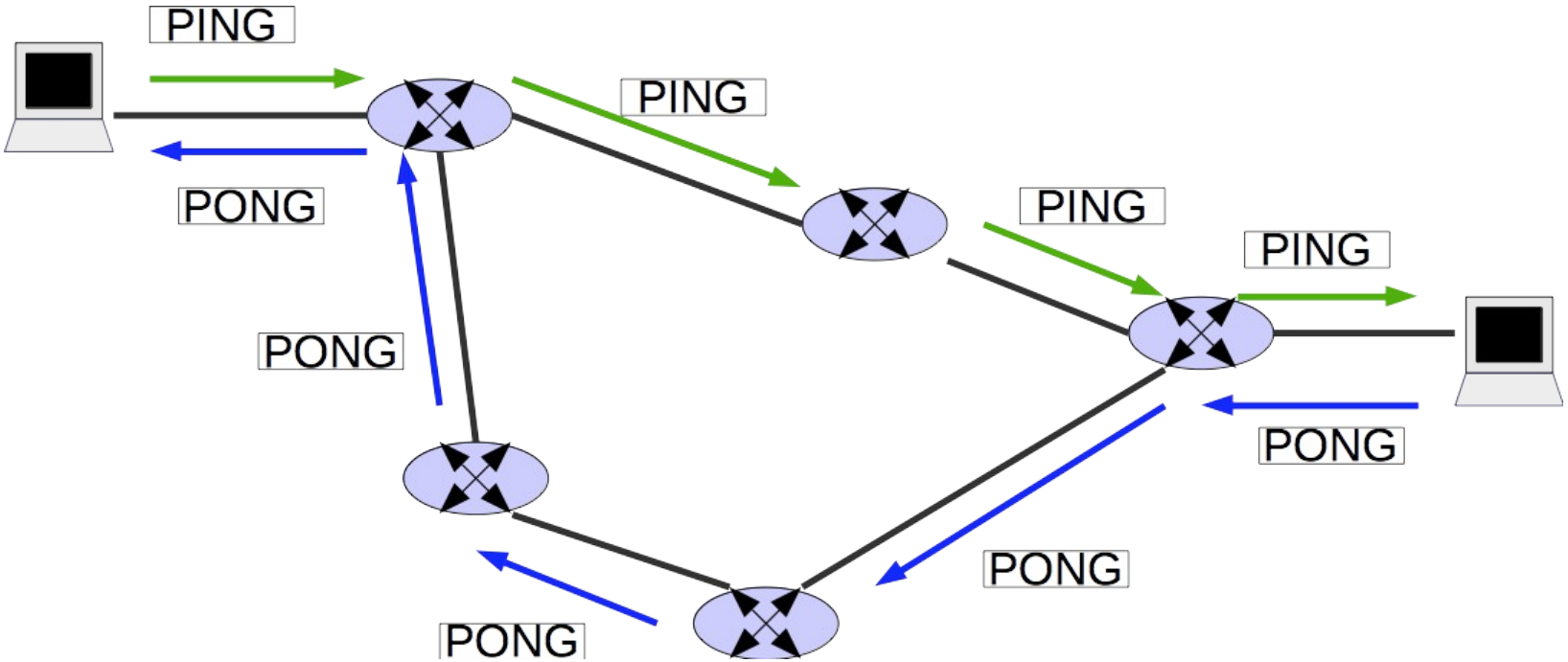
Default route

- 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 and Forwarding

- Routing information populates the FIB