

Lecture 12:

IPv6 and ICMP

CSE 123: Computer Networks

Aaron Schulman



Today's Lecture

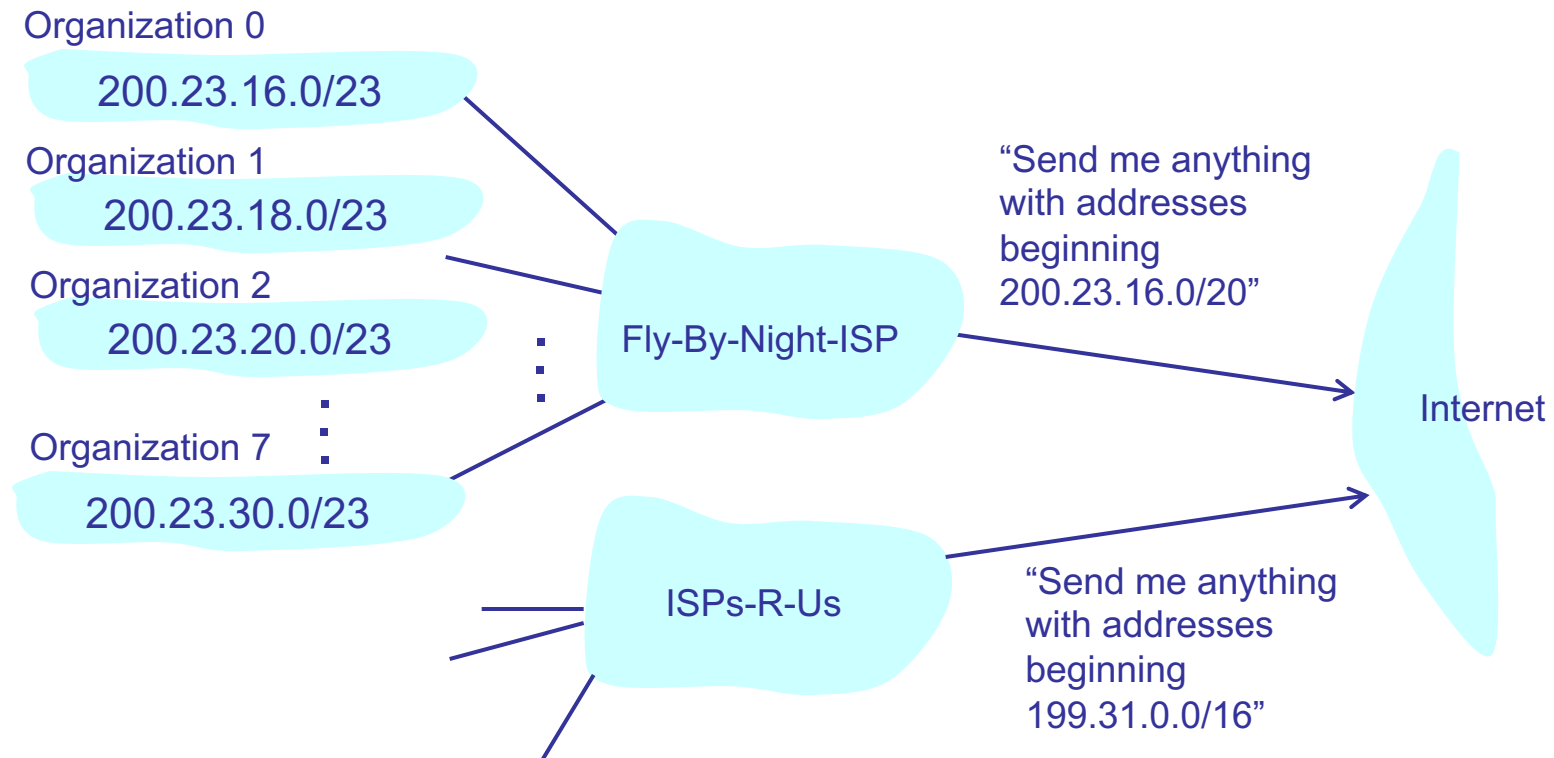


- Finish up describing how address are used for **routing**
 - ◆ How Longest prefix match example in practice
- Dealing with the space crunch! (**IPv6**)
- Notifying about errors in the internetwork (**ICMP**)



Route Aggregation

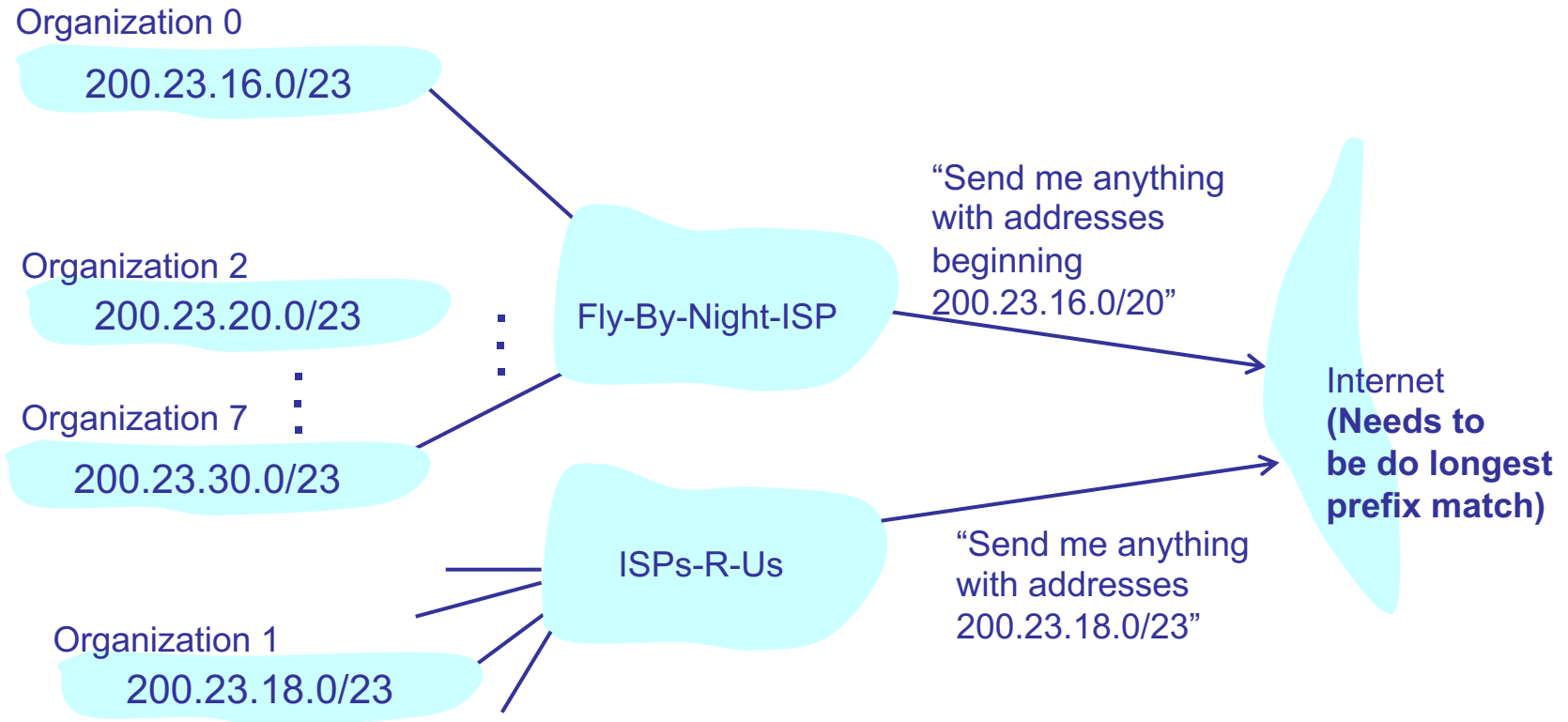
- Combine adjacent networks in forwarding tables
 - ◆ Helps keep forwarding table size down





Most Specific Route

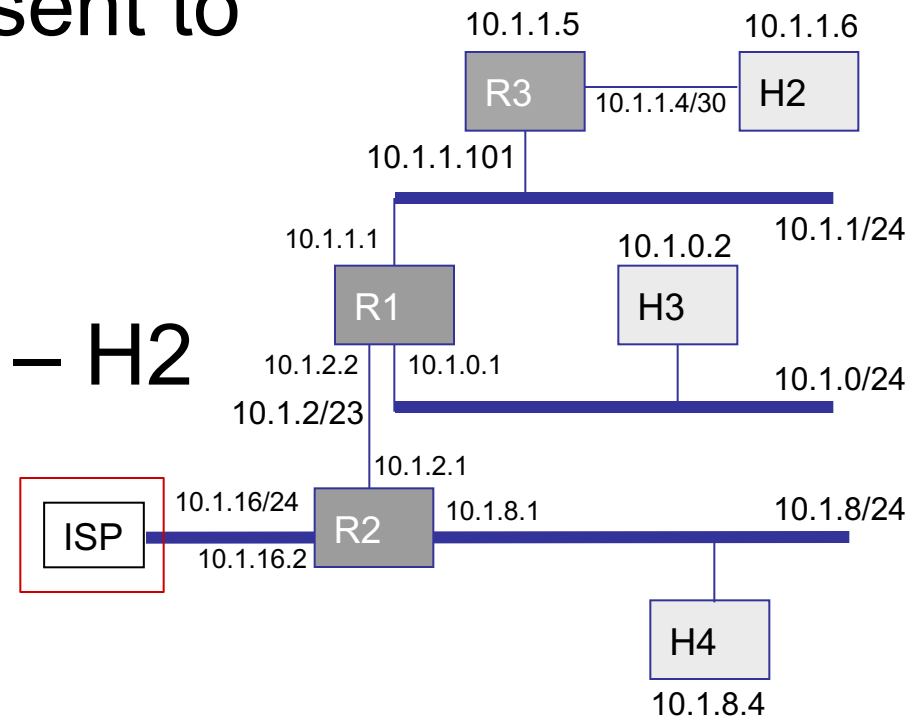
- But what if address range is not contiguous?





Forwarding example

- Packet to 10.1.1.6 is sent to to your ISP
- Path is R2 – R1 – H1 – H2



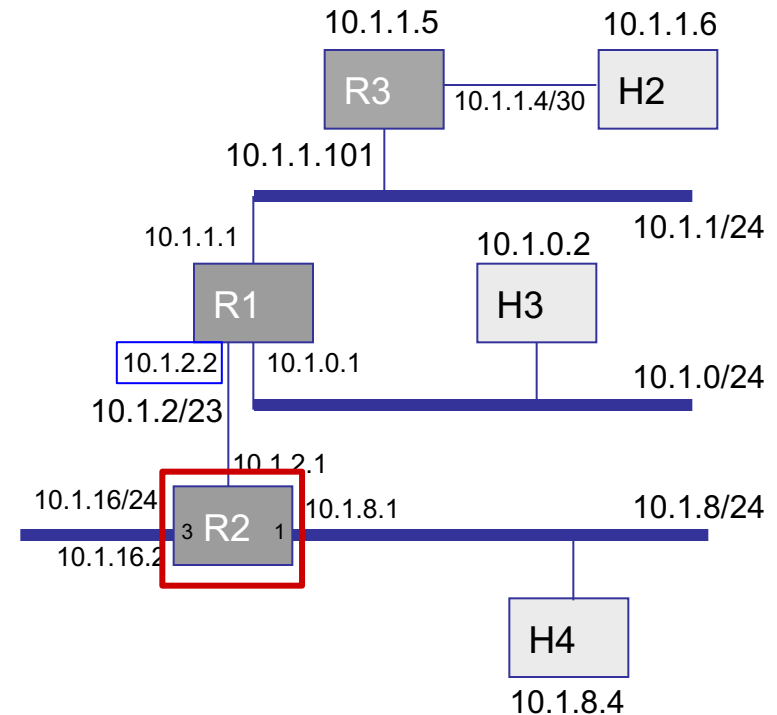


Forwarding example (2)

- Packet to 10.1.1.6
- Matches 10.1.0.0/23

Forwarding table at R2

Destination	Next Hop
127.0.0.1	loopback
Default or 0/0	10.1.16.1
10.1.8.0/24	interface1
10.1.2.0/23	interface2
10.1.0.0/23	10.1.2.2
10.1.16.0/24	interface3



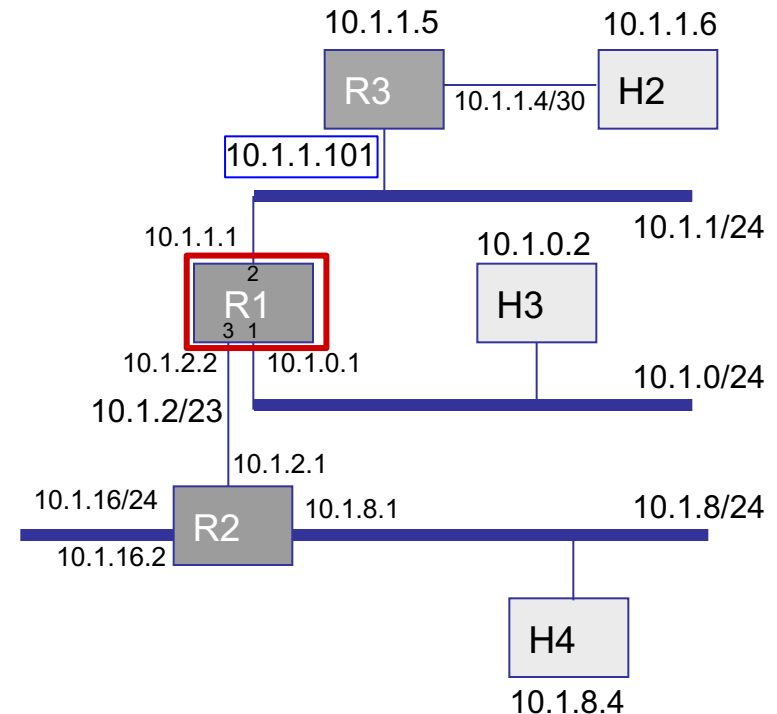


Forwarding example (3)

- Packet to 10.1.1.6
- Matches 10.1.1.4/30
 - Longest prefix match

Routing table at R1

Destination	Next Hop
127.0.0.1	loopback
Default or 0/0	10.1.2.1
10.1.0.0/24	interface1
10.1.1.0/24	interface2
10.1.2.0/23	interface3
10.1.1.4/30	10.1.1.101



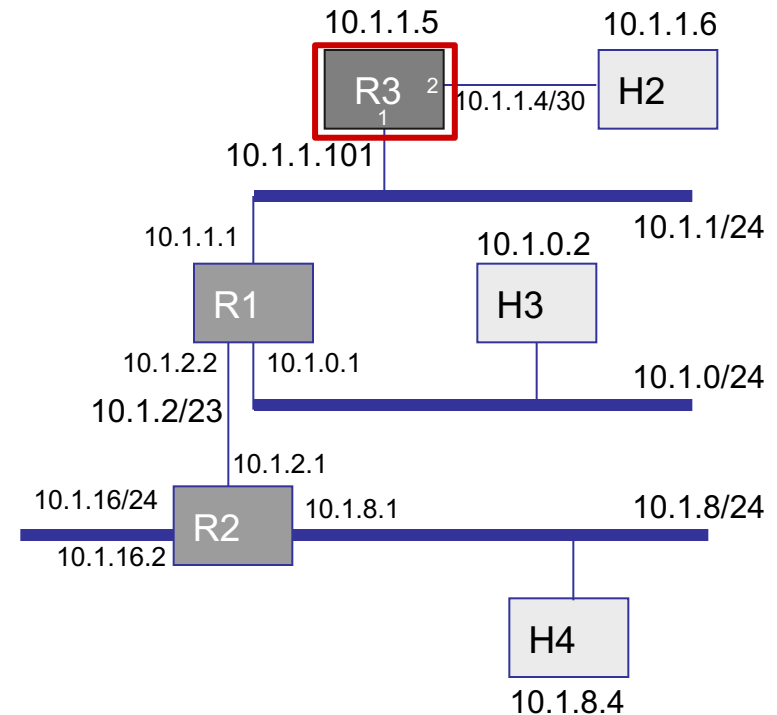


Forwarding example (4)

- Packet to 10.1.1.6
- Direct route
 - Longest prefix match

Routing table at R3

Destination	Next Hop
127.0.0.1	loopback
Default or 0/0	10.1.1.1
10.1.1.0/24	interface1
10.1.1.4/30	interface2





The space crunch...

- Still running out of IP addresses... what to do?
- Two solutions
 - ◆ Network Address Translation – multiple multiple hosts on a single IP address (future class)
 - ◆ Get bigger addresses -> IPv6
- IPv6: 128bit addresses... we won't run out
 - ◆ Often 64bit routing prefix, 64bit host id!

An IPv6 address (in hexadecimal)

2001:0DB8:AC10:FE01:0000:0000:0000:0000



2001:0DB8:AC10:FE01::

Zeros can be omitted

0010000000000001:0000110110111000:1010110000010000:1111111000000001:

0000000000000000:0000000000000000:0000000000000000:0000000000000000



Orgs have fun with v6

- What provider is using this address?
 - ◆ 2a03:2880:f003:0c07:**face:b00c**:0000:0002
- Fun opportunities to include vanity HEX in hosts



IPv6 Addresses

- Colon-Hex notation
 - ◆ 8 groups of four HEX digits separated by colons, e.g.
 - » FEDC:0000:0000:0065:4321:0000:DEAD:BEEF
 - ◆ Can drop leading zeros:
 - » FEDC:0000:0000:65:4321:0000:DEAD:BEEF
 - ◆ Can even skip **first** sequence of all zeros w/ ::
 - » FEDC::65:4321:0000:DEAD:BEEF
 - ◆ Every IPv4 address is a IPv6 address:
 - » E.g., ::222.173.190.239 (prepended w/zeros)
- Network names expressed as prefix/length:
 - ◆ Still can do internal subnetting
 - » FEDC::65:43/50

Address Types



- Each interface has multiple different addresses
 - ◆ Link local, prefixed with FE80::/10 (1111 1110 10)
 - » Used only for communication between adjacent IPv6 devices
 - » Packets are NOT forwarded by routers
 - » Automatically assigned upon boot
 - ◆ Unique local, prefixed with FC00::/7 (1111 110)
 - » Used only internal to one network
 - » Not routable on the global Internet
 - ◆ Global
 - » Like an IPv4 address



IPv6 vs IPv4 header

Ver.	Traffic Class	Flow Label		
Payload Length		Next Header	Hop Limit	
Source Address				
Destination Address				

Ver.	Hdr Len	Type of Service	Total Length	
Identification			Flg	Fragment Offset
Time to Live		Protocol	Header Checksum	
Source Address				
Destination Address				
Options...				

- Gray bits are unique to each header
- Changes
 - Eliminate fragmentation-related fields
 - Eliminate header checksum
 - Added flow label
 - Quadruple size of addresses
 - IPv6 header (40 bytes) vs IPv4 (20 bytes)
 - Hop limit == TTL



Extension Headers

- Effectively a linked list of headers
 - ◆ The “next header” field is the pointer
- Two different types
 - ◆ **Destination**, intended for the IP end point. E.g.,
 - » 44: Fragmentation Header (it's baaack!)
 - » 43: Routing header (dictates how to route the packet)
 - ◆ **Hop-by-hop**, processed by each node on the path
 - » Each node takes a look at it and can modify it



IPv6 Transition is slow

- Need to support both protocols at the same time
 - ◆ Complicated... if a destination has both a IPv4 and IPv6 address which to use?
- Less need in developed world -> slower adoption
- That said
 - ◆ All major operating systems now support IPv6
 - ◆ All major router vendors
 - ◆ US Mobile carriers (e.g., Tmobile, Verizon, etc)
 - ◆ Offered as option by many US wired ISPs
- As of this year IPv6 is dominating mobile carrier traffic

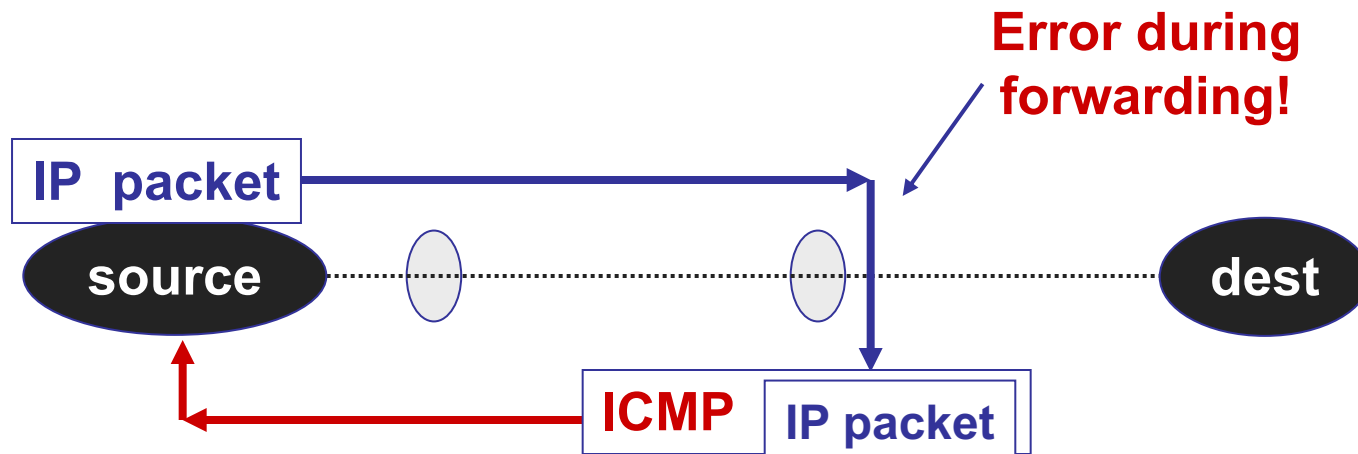


Dealing with errors: ICMP

- What happens when things go wrong?
 - ◆ Need a way to test/debug a large, widely distributed system
- ICMP = Internet Control Message Protocol (RFC792)
 - ◆ Companion to IP – required functionality
- Used for error and information reporting:
 - ◆ Errors that occur during IP forwarding
 - ◆ Queries about the status of the network



ICMP Error Message Generation





Common ICMP Messages

- Destination unreachable
 - ◆ “Destination” can be host, network, port, or protocol
- Redirect
 - ◆ To shortcut circuitous routing
- TTL Expired
 - ◆ Used by the “traceroute” program
 - » traceroute traces packet routes through Internet
- Echo request/reply
 - ◆ Used by the “ping” program
 - » ping just tests for host liveness
- ICMP messages include portion of IP packet that triggered the error (if applicable) in their payload



ICMP Restrictions

- The generation of error messages is limited to avoid cascades ... error causes error that causes error...
- Don't generate ICMP error in response to:
 - ◆ An ICMP error
 - ◆ Broadcast/multicast messages (link or IP level)
 - ◆ IP header that is corrupt or has bogus source address
 - ◆ Fragments, except the first
- ICMP messages are often rate-limited too
 - ◆ Don't waste valuable bandwidth sending tons of ICMP messages



For Next Time

- Homework 2 due Tuesday
- Midterm not next Monday but the following MONDAY
 - Online on GradeScope:
- Read 9.3, 3.3 (DHCP,ARP)