COMP202-08B
Computer Communications

Lecture 9

IP Routing

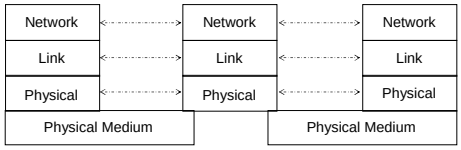
THE UNIVERSITY OF WAIKATO

So far

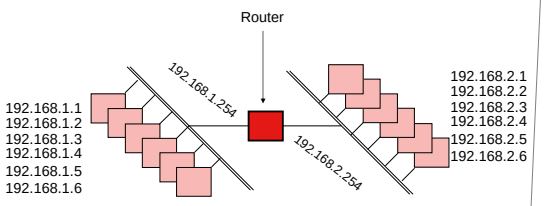
- Internet Protocol v4 (IPv4)
  - 32 bit IP addresses
  - Structured addressing scheme
  - Internet-wide addressing
- This lecture
  - A structured addressing scheme lends itself to reasonably efficient routing
  - Flat addressing schemes are not scalable

OSI

- Physical, Link: Ethernet
- Network: IPv4



Networks



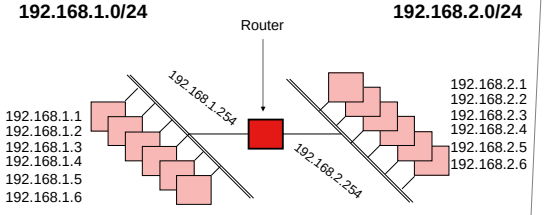
MAC addresses are wired in (flat)
IP addresses are chosen (structured)

IP addresses

- An IP address consists of
  - A network id (prefix)
  - A machine id (suffix)
- The network address usually occupies anywhere between 8 and 24 bits of the IP address
  - Though it can go all the way to 31.

Networks

192.168.1.0/24 **192.168.2.0/24**

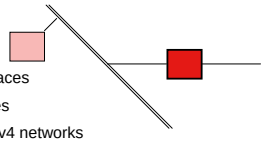


192.168.1.6/24

The first 24 bits of the IP address correspond to the network address

IP Routing

- IP End-systems, typically:
  - Have one network interface card (Ethernet)
  - Have one IPv4 address
  - Are directly connected to a single IPv4 network
  - Have a 'default router'
- IP Routers, typically:
  - Have multiple network interfaces
  - Have multiple IPv4 addresses
  - Are connected to multiple IPv4 networks
  - Usually, but not always, have a 'default router'
  - Configured to forward packets
- All IP systems have routing tables



Routers

- A router is where a message is forwarded to when the destination is not on the local network
- Sending a message to a router should move the message closer to its intended destination
- Default router:
  - A catch-all when there is not a more specific route
  - 0.0.0.0/0

Routing Tables

- End nodes and routers have routing tables
- A routing table contains
  - A list of network ids
  - Which gateway to relay frames through
  - Which network interface to use
- My machine, an end system: 130.217.250.39/16

Destination	Gateway	Netif
0.0.0.0/0	130.217.64.2	rl0
127.0.0.1/32	127.0.0.1	lo0
130.217.0.0/16	link#2	rl0

Binary – base two

- The only valid way to check if two IPv4 addresses are in the same network is to convert them to binary
- Converting 155_{10} to base two

• 155	>=	128:	1	(remainder 27)
• 27	<	64	0	(remainder 27)
• 27	<	32	0	(remainder 27)
• 27	>=	16	1	(remainder 11)
• 11	>=	8	1	(remainder 3)
• 3	<	4	0	(remainder 3)
• 3	>=	2	1	(remainder 1)
• 1	>=	1	1	(remainder 0)

Binary – base two

- The only valid way to check if two IPv4 addresses are in the same network is to convert them to binary
  - 1
  - 2
  - 4
  - 8
  - 16
  - 32
  - 64
  - 128

10011011

1 + 2 + 8 + 16 + 128 = 155

192.168.1.6/24

192	.	168	.	1	.	6
1100 0000		1010 1000		0000 0001		0000 0110

192.168.2.3/24

192	.	168	.	2	.	3
1100 0000		1010 1000		0000 0010		0000 0011

These two IP addresses are on different networks because their network addresses are not identical.

192.168.238.45/20

```
   192    .    168    .    238    .    45
1100 0000   1010 1000   1110 1110   0010 1101
```

192.168.241.55/20

```
   192    .    168    .    241    .    55
1100 0000   1010 1000   1111 0001   0011 0111
```

These two IP addresses are on different networks because their network addresses are not identical.

What about these two?

- 10.55.1.30/12
- 10.56.44.99/12

Subnet masks

- Sometimes you will see a subnet mask written in dotted-quad (like an IP address) when looking at routing tables
- A subnet mask is a value that is used with the logical and operation to extract the network id
- A subnet mask when written in binary contains all-ones, then all-zeros
- 255.255.0.0 => masks out first 16 bits
  - 1111 1111 1111 1111 0000 0000 0000 0000
- 255.255.240.0 => masks out first 20 bits
  - 1111 1111 1111 1111 1111 0000 0000 0000

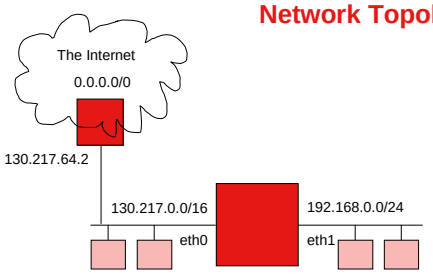
netstat –rn (Linux)

Destination	Gateway	Genmask	Iface
192.168.0.0	0.0.0.0	255.255.255.0	eth1
130.217.0.0	0.0.0.0	255.255.0.0	eth0
0.0.0.0	130.217.64.2	0.0.0.0	eth0

no gateway
systems are directly connected
do not need a router

Default route
Catch-all

Network Topology



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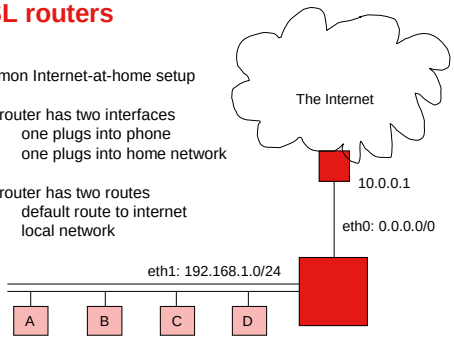
130.217.0.0	0.0.0.0	255.255.0.0	eth0
0.0.0.0	130.217.64.2	0.0.0.0	eth0

DSL routers

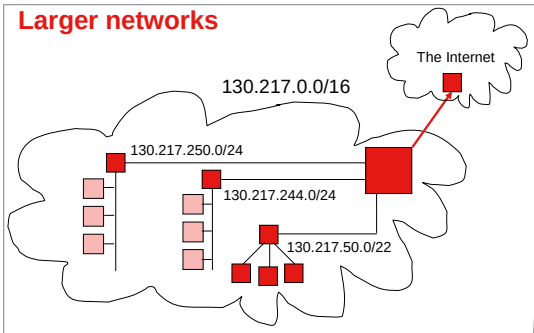
Common Internet-at-home setup

DSL router has two interfaces
- one plugs into phone
- one plugs into home network

DSL router has two routes
- default route to internet
- local network



Larger networks



Smaller networks can be aggregated to a single larger network. Useful scaling property, as the upstream router doesn't need to know the complex details of the downstream network.

Summary

- IP addresses contain a built-in network id
  - Useful scaling property: can often aggregate smaller network IDs into a single larger network ID.
- Extract network ID by masking it out
- Systems determine how to reach a destination by consulting their IP routing table