

Today's Topics

- Small Scale Routing
- Small Scale Routing (more realistic)
- Large Scale Routing

Routing In An Internet

- We've already discussed the general routing mechanism
 - Host delivers datagrams to directly connected machines
 - Host sends non-local datagrams to next-hop gateway
 - Gateways forward datagrams to other gateways
 - Final gateway delivers datagram directly to destination host

Routing Tables

- Routing decisions are based on table lookup
- Routing tables keep only network portion of addresses
 - Requires a network mask
- Algorithm is efficient and understandable
- Possible to automate routing table updates
 - Use the network to collect the information
 - We'll discuss this in detail later when we discuss routing protocols

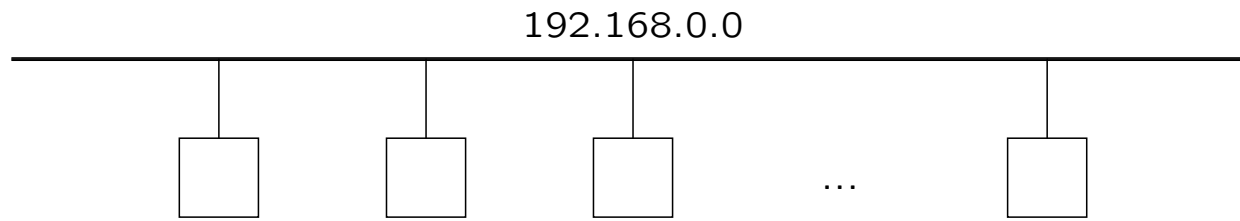
Quick Aside

Private IP Address Ranges

- The IETF has allocated 3 address ranges for “private use”
- Intended for isolated networks
 - Won’t traverse the Internet (very far, anyway)
 - Often used in conjunction with NAT boxes
- The addresses
 - 10.0.0.0/8
 - 10.0.0.0 - 10.255.255.255
 - 172.16.0.0/12
 - 172.16.0.0 - 172.31.255.255
 - 192.168.0.0/16
 - 192.168.0.0 - 192.168.255.255

Small Scale Routing

Disconnected Hosts

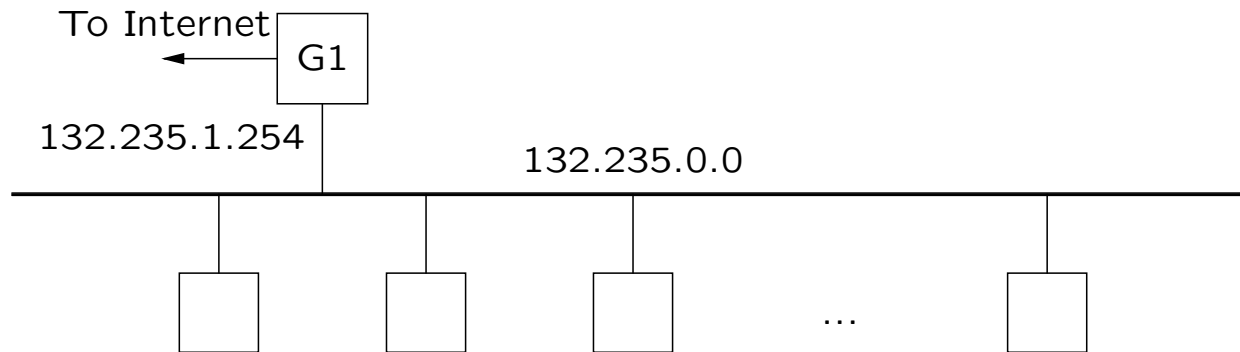


- Architecture: hosts on an isolated Ethernet

Destination	Mask	Route
192.168.0.0	ffff0000	direct

Small Scale Routing

Simple Network Hosts



- Architecture: hosts on an Ethernet with one gateway
- Host routing table

Destination	Mask	Route
132.235.0.0	ffff0000	direct
default	00000000	132.235.1.254

Small Scale Routing Simple Example

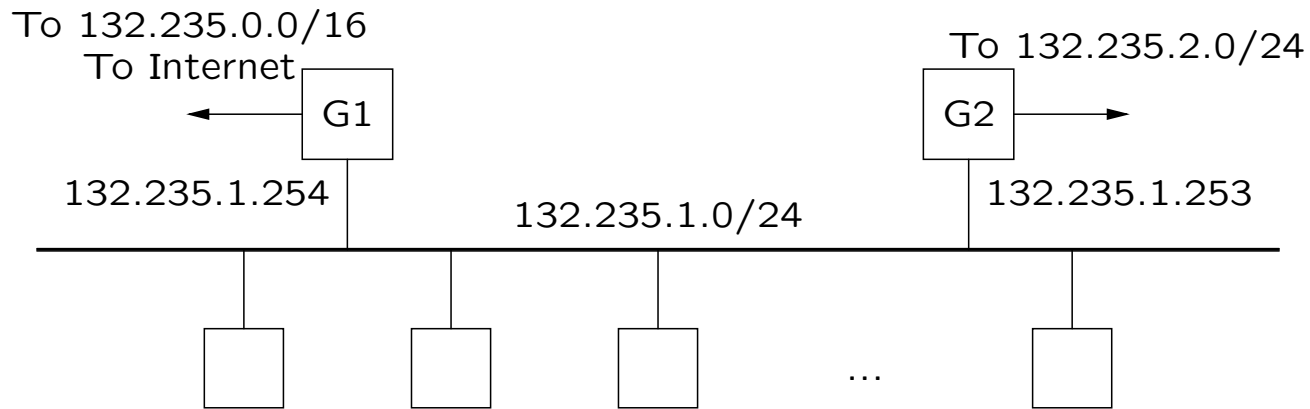
```
KSH:vger> ifconfig -a  
hme0: flags=1000843<UP,BROADCAST,RUNNING,MULTICAST,IPv4> mtu 1500 index 2  
      inet 132.235.3.132 netmask ffffffff broadcast 132.235.3.255
```

```
KSH:vger> netstat -rnv
```

Destination	Mask	Gateway	Device	Mxfrg	Flg
132.235.3.0	255.255.255.0	132.235.3.132	hme0	1500*	U
224.0.0.0	240.0.0.0	132.235.3.132	hme0	1500*	U
default	0.0.0.0	132.235.3.159		1500*	UG
127.0.0.1	255.255.255.255	127.0.0.1	lo0	8232*	UH

Small Scale Routing More Interesting Networks

- Architecture: hosts on an Ethernet with two gateways



Destination	Mask	Route
132.235.1.0	ffffff00	direct
132.235.2.0	ffffff00	132.235.1.253
132.235.0.0	ffff0000	132.235.1.254
default	00000000	132.235.1.254

Small Scale Routing Less Simple Example

```
KSH:sp-black-red> ifconfig -a
lo0: flags=1000849<UP,LOOPBACK,RUNNING,MULTICAST,IPv4> mtu 8232 index 1
    inet 127.0.0.1 netmask ff000000
hme0: flags=1000843<UP,BROADCAST,RUNNING,MULTICAST,IPv4> mtu 1500 index 2
    inet 132.235.2.102 netmask fffffff0 broadcast 132.235.2.255
KSH:sp-black-red> netstat -nrv
```

Destination	Mask	Gateway	Device	Mxfrg	Flg
132.235.1.1	255.255.255.255	132.235.2.1		1500*	UGH
132.235.1.7	255.255.255.255	132.235.2.7		1500*	UGH
132.235.1.11	255.255.255.255	132.235.2.11		1500*	UGH
132.235.1.12	255.255.255.255	132.235.2.12		1500*	UGH
132.235.2.0	255.255.255.0	132.235.2.102	hme0	1500*	U
132.235.15.0	255.255.255.0	132.235.2.102	hme0	1500*	U
132.235.16.0	255.255.255.0	132.235.2.102	hme0	1500*	U
132.235.17.0	255.255.255.0	132.235.2.102	hme0	1500*	U
224.0.0.0	240.0.0.0	132.235.2.102	hme0	1500*	U
default	0.0.0.0	132.235.2.254		1500*	UG
127.0.0.1	255.255.255.255	127.0.0.1	lo0	8232*	UH

Small Scale Routing

Multi-Homed Host Example 1

```
KSH:masaka> ifconfig -a
lo0: flags=1000849<UP,LOOPBACK,RUNNING,MULTICAST,IPv4> mtu 8232 index 1
    inet 127.0.0.1 netmask ff000000
hme0: flags=1000843<UP,BROADCAST,RUNNING,MULTICAST,IPv4> mtu 1500 index 2
    inet 132.235.3.154 netmask fffffff0 broadcast 132.235.3.255
hme0:1: flags=1000843<UP,BROADCAST,RUNNING,MULTICAST,IPv4> mtu 1500 index 2
    inet 132.235.3.136 netmask fffffff0 broadcast 132.235.3.255
hme1: flags=1000843<UP,BROADCAST,RUNNING,MULTICAST,IPv4> mtu 1500 index 3
    inet 132.235.201.2 netmask fffffff80 broadcast 132.235.201.127
```

```
KSH:masaka> netstat -nrv
```

Destination	Mask	Gateway	Device	Mxfrg	Flg
132.235.201.0	255.255.255.128	132.235.201.2	hme1	1500*	U
132.235.3.0	255.255.255.0	132.235.3.154	hme0	1500*	U
default	0.0.0.0	132.235.3.159		1500*	UG
127.0.0.1	255.255.255.255	127.0.0.1	lo0	8232*	UH

Small Scale Routing Multi-Homed Host Example 2

```
KSH:p2> ifconfig -a
lo0: flags=1000849<UP,LOOPBACK,RUNNING,MULTICAST,IPv4> mtu 8232 index 1
    inet 127.0.0.1 netmask ff000000
hme0: flags=1000843<UP,BROADCAST,RUNNING,MULTICAST,IPv4> mtu 1500 index 2
    inet 132.235.1.12 netmask fffffff0 broadcast 132.235.1.255
qfe0: flags=1000843<UP,BROADCAST,RUNNING,MULTICAST,IPv4> mtu 1500 index 3
    inet 132.235.2.12 netmask fffffff0 broadcast 132.235.2.255
```

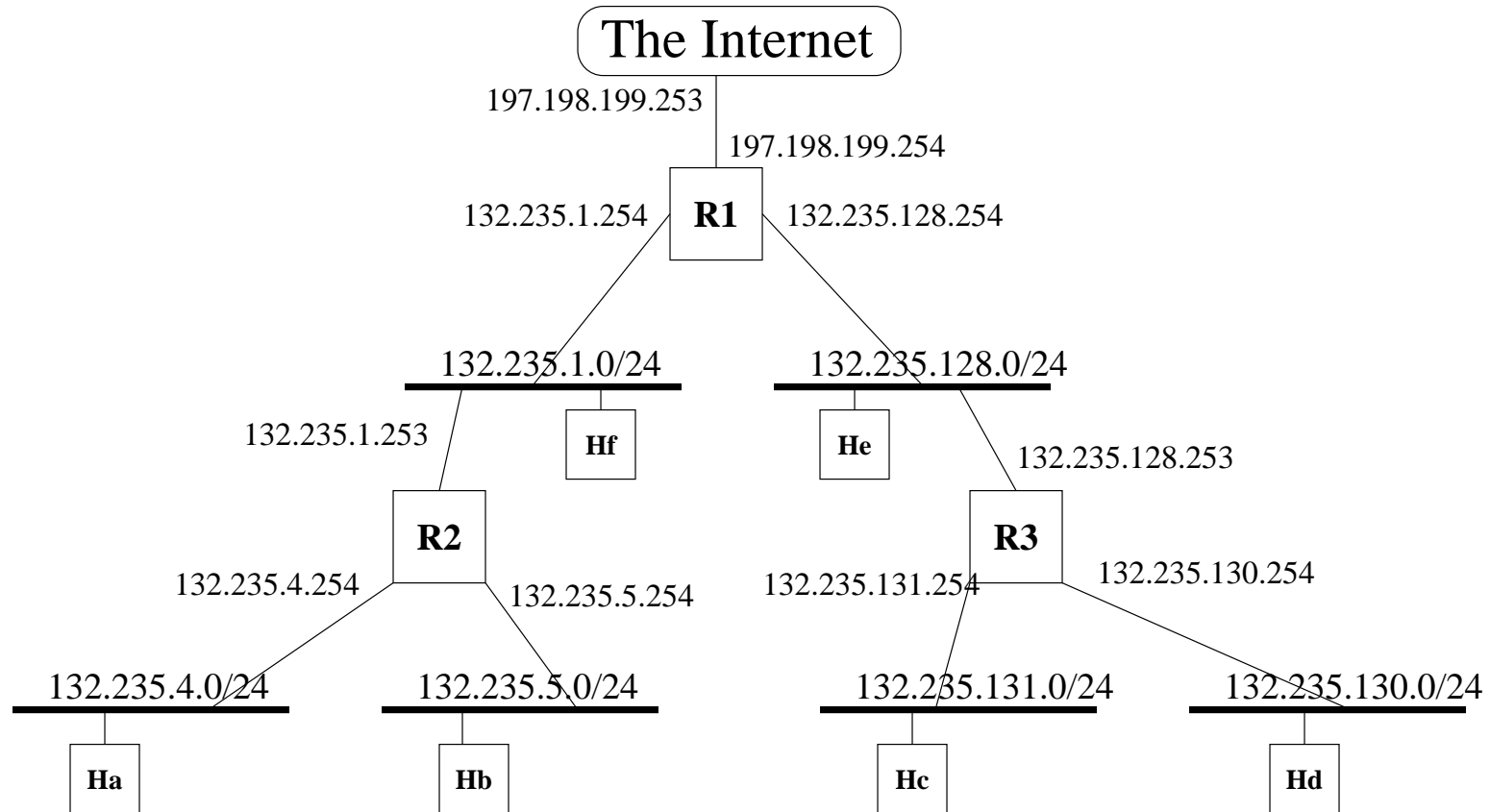
```
KSH:p2> netstat -nrv
```

Destination	Mask	Gateway	Device	Mxfrg	Flg
132.235.1.0	255.255.255.0	132.235.1.12	hme0	1500*	U
132.235.2.0	255.255.255.0	132.235.2.12	qfe0	1500*	U
132.235.15.0	255.255.255.0	132.235.2.12	qfe0	1500*	U
132.235.16.0	255.255.255.0	132.235.2.12	qfe0	1500*	U
132.235.17.0	255.255.255.0	132.235.2.12	qfe0	1500*	U
132.235.18.0	255.255.255.0	132.235.2.12	qfe0	1500*	U
132.235.3.0	255.255.255.0	132.235.15.250		1500*	UG
224.0.0.0	240.0.0.0	132.235.1.12	hme0	1500*	U
default	0.0.0.0	132.235.1.254		1500*	UG
127.0.0.1	255.255.255.255	127.0.0.1	lo0	8232*	UH

Large Scale Routing

- Host routing table can often be trivial
 - Normally, there's not much to know
 - In the worst case, the routing is slightly inefficient
- With the last few examples, we've almost reached the complexity of routers
 - Routers can't afford to be inefficient

Sample Router Network



OK, When Does It Get Hard??

- Point-to-point networks
- Multiple subnet masks
- Multiple routes

Summary

- In simple cases, it's easy to set the routing up
- In slightly harder cases, it takes more concentration
- In the Internet in general, there must be a better way
 - ... and there is, Routing Protocols
 - we'll discuss those later