

Today's Topics

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

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Routing 1

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

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Routing 2

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

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Routing 3

Quick Aside Private IP Address Ranges

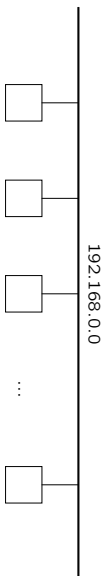
- The IETF has allocated 3 address ranges for "private use"
- Intended for isolated networks
 - Won't traverse the Internet (very far, anyway)
 - Often used in conjunction with NAT boxes
- The addresses
 - 10.0.0.0/8
 - 10.0.0.0 - 10.255.255.255
 - 172.16.0.0/12
 - 172.16.0.0 - 172.31.255.255
 - 192.168.0.0/16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

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Routing 4

Small Scale Routing Disconnected Hosts



- Architecture: hosts on an isolated Ethernet

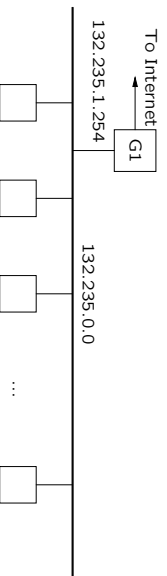
Destination	Mask	Route
192.168.0.0	fffff000	direct

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 ffffff00 broadcast 132.235.3.255
KSH:~vger> netstat -rnv
Destination      Mask              Gateway           Device Mxfrg  Flag
-----
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        100      8232*    UH
  
```

Small Scale Routing Simple Network Hosts

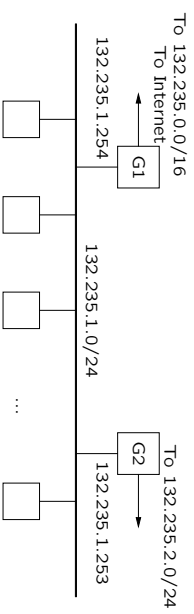


- Architecture: hosts on an Ethernet with one gateway

- Host routing table

Destination	Mask	Route
132.235.0.0	fffff000	direct
default	00000000	132.235.1.254

Small Scale Routing More Interesting Networks



- Architecture: hosts on an Ethernet with two gateways

Destination	Mask	Route
132.235.1.0	fffff00	direct
132.235.2.0	fffff00	132.235.1.253
132.235.0.0	fffff000	132.235.1.254
default	00000000	132.235.1.254

Small Scale Routing Less Simple Example

```
KSH:sp-black-red> ifconfig -a
100: flags=1000849<UP,LOOPBACK,RUNNING,MULTICAST,IPv4> mtu 8232 index 1
    inet 127.0.0.1 netmask ffffffff
hme0: flags=1000843<UP,BROADCAST,RUNNING,MULTICAST,IPv4> mtu 1500 index 2
    inet 132.235.2.102 netmask ffffffff broadcast 132.235.2.255
KSH:sp-black-red> netstat -nrv
Destination      Mask              Gateway           Device MxIrg  Flg
-----
132.235.1.1      255.255.255.255  132.235.2.1      hme0    1500*  UH
132.235.1.7      255.255.255.255  132.235.2.7      hme0    1500*  UGH
132.235.1.11     255.255.255.255  132.235.2.11     hme0    1500*  UGH
132.235.1.12     255.255.255.255  132.235.2.12     hme0    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    hme0    1500*  UG
127.0.0.1        255.255.255.255  127.0.0.1        100     8232*  UH
```

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Small Scale Routing Multi-Homed Host Example 1

```
KSH:masaka> ifconfig -a
100: flags=1000849<UP,LOOPBACK,RUNNING,MULTICAST,IPv4> mtu 8232 index 1
    inet 127.0.0.1 netmask ffffffff
hme0: flags=1000843<UP,BROADCAST,RUNNING,MULTICAST,IPv4> mtu 1500 index 2
    inet 132.235.3.154 netmask ffffffff broadcast 132.235.3.255
hme0:1: flags=1000843<UP,BROADCAST,RUNNING,MULTICAST,IPv4> mtu 1500 index 2
    inet 132.235.3.136 netmask ffffffff broadcast 132.235.3.255
hme1: flags=1000843<UP,BROADCAST,RUNNING,MULTICAST,IPv4> mtu 1500 index 3
    inet 132.235.201.2 netmask ffffffff broadcast 132.235.201.127
KSH:masaka> netstat -nrv
Destination      Mask              Gateway           Device MxIrg  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    hme0    1500*  UG
127.0.0.1        255.255.255.255  127.0.0.1        100     8232*  UH
```

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Small Scale Routing Multi-Homed Host Example 2

```
KSH:p2> ifconfig -a
100: flags=1000849<UP,LOOPBACK,RUNNING,MULTICAST,IPv4> mtu 8232 index 1
    inet 127.0.0.1 netmask ffffffff
hme0: flags=1000843<UP,BROADCAST,RUNNING,MULTICAST,IPv4> mtu 1500 index 2
    inet 132.235.1.12 netmask ffffffff broadcast 132.235.1.255
qfe0: flags=1000843<UP,BROADCAST,RUNNING,MULTICAST,IPv4> mtu 1500 index 3
    inet 132.235.2.12 netmask ffffffff broadcast 132.235.2.255
KSH:p2> netstat -nrv
Destination      Mask              Gateway           Device MxIrg  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   hme0    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    hme0    1500*  UG
127.0.0.1        255.255.255.255  127.0.0.1        100     8232*  UH
```

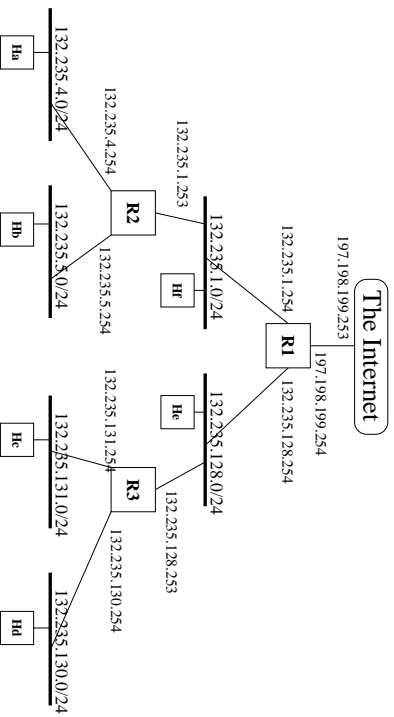
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Large Scale Routing

- 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

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Sample Router Network



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OK, When Does It Get Hard??

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

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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

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