Static Routing Exercise

Scalable Infrastructure Workshop
AfNOG 2011
What will the exercise involve?

- Unix network interface configuration
- Cisco network interface configuration
- Static routes
- Default route
- Testing
Routing

- Routing is done based on destination IP address.

- Without routing, an interface can only reach destinations that are on their local network segment.

- A device with at least 2 interfaces can route.
Routing

- **Static route**
  - specifically instructs router on which route to take to a particular destination network. This will almost always override anything else that the router knows.

- **Dynamic route**
  - learnt via routing protocols implemented on routers

- **Default route**
  - route that instructs a machine where to send packets for destinations that are not in the routing table. This is usually the 'last resort' that a router will take.
Static Routing

- Advantages
  - Simple to configure and maintain
  - Secure as only defined routes can be accessed
  - Bandwidth is not used for sending routing updates

- Disadvantages
  - Manual update of routes after changes
  - Explicit addition of routes for all networks
  - Potential for configuration mistakes
IP Routing Configuration
Static/default route example

To Internet

172.16.3.2
172.16.2.2
172.16.2.1

172.16.3.1
172.16.2.2
172.16.1.0
255.255.255.0

ip route 172.16.1.0 255.255.255.0 172.16.2.1 # STATIC
ip route 0.0.0.0 0.0.0.0 172.16.3.1 # DEFAULT
Classroom Network Layout
Exercise One
## IPv4 Address Assignments

<table>
<thead>
<tr>
<th>Switch</th>
<th>Address Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>196.200.220.240/28</td>
</tr>
<tr>
<td>M</td>
<td>196.200.220.224/28</td>
</tr>
<tr>
<td>L</td>
<td>196.200.220.208/28</td>
</tr>
<tr>
<td>K</td>
<td>196.200.220.192/28</td>
</tr>
<tr>
<td>J</td>
<td>196.200.220.176/28</td>
</tr>
<tr>
<td>I</td>
<td>196.200.220.160/28</td>
</tr>
<tr>
<td>H</td>
<td>196.200.220.144/28</td>
</tr>
<tr>
<td>A</td>
<td>196.200.220.32/28</td>
</tr>
<tr>
<td>B</td>
<td>196.200.220.48/28</td>
</tr>
<tr>
<td>C</td>
<td>196.200.220.64/28</td>
</tr>
<tr>
<td>D</td>
<td>196.200.220.80/28</td>
</tr>
<tr>
<td>E</td>
<td>196.200.220.96/28</td>
</tr>
<tr>
<td>F</td>
<td>196.200.220.112/28</td>
</tr>
<tr>
<td>G</td>
<td>196.200.220.128/28</td>
</tr>
</tbody>
</table>

### Diagram

![IPv4 Address Diagram](#)
IPv4 Address Assignment

- You already have an IP address for your router’s backbone link (A=.1, B=.2, ...)

- You have a /28 for your local network (PC and router connected back to back)

- Assign your own host addresses from your /28 to your local network.
FreeBSD Network Interface Configuration

- configure interface on Unix host
  - `ifconfig em0 inet n.n.n.n netmask m.m.m.m`
  
(you need to be root to change the IP address)

- `em0` is the interface name
- `n.n.n.n` is IP address
- `m.m.m.m` is netmask
Connect PC to router console port

- Connect cable to console port on router, serial port on FreeBSD box
- Use the tip command to connect your keyboard and screen to the serial port
  - e.g. `bash$ tip com1`
- You may have to edit `/etc/remote`
- See man pages for tip(1) and remote(5)
  - HINT: to exit tip, type ~.
Cisco Router Network Interface Configuration

- configure backbone interface on cisco router
  ```
  conf t
  interface fastethernet0/0
  ip address n.n.n.n m.m.m.m
  ```
  fastethernet0/0 is interface name
  n.n.n.n is IP address
  m.m.m.m is netmask

- Now configure the local interface on your router that connects to your PC (ie. Fa0/1). Use the IP address assignments that you made 3 slides ago.
Cisco Router Network Interface Configuration

- Cisco global config should always include:
  - ip classless
  - ip subnet-zero
  - ip cef

- Cisco interface config should usually include:
  - no shutdown
  - no ip proxy-arp
  - no ip redirects
  - no ip directed-broadcast
Forwarding Tables at this point in the exercise

**You**
- PC
- **Destination:** Next Hop
  - **Your subnet:** Connected
  - **Backbone subnet:** Connected
    - (no default or anything else)

**Your Router**
- fa0/1
- fa0/0
- fa0/0

**Their Router**
- fa0/1

**Their PC**
- **Destination:** Next Hop
  - **Their subnet:** Connected
    - (no default)

**Destination:** Next Hop
- **Backbone subnet:** Connected
  - (fa0/0)
- (no default or anything else)
Test Connectivity

- PC can ping local interface of router
- Router can ping PC
- Router can ping other routers

- PC cannot ping backbone interface of router
- PC cannot ping other routers or other PCs
- Router cannot ping other PCs.
Configure a default route

- Add route on PC
  ```
  route add default g.g.g.g
  g.g.g.g is the IP address of your gateway, which will be the IP address of your router's interface to your subnet. (Don't use your router's backbone IP address.)
  ```

- Display forwarding table
  ```
  netstat -rn
  ```
Forwarding Tables at this point in the exercise

Your PC → Your Router

Your subnet: Connected
Backbone subnet: Connected (fa0/0)
(no default or anything else)

Destination: Next Hop
Default: Your router

Their Router → Their PC

Their subnet: Connected (fa0/1)
Backbone subnet: Connected (fa0/0)
(no default or anything else)

Destination: Next Hop
Default: Their router
Test connectivity

- All PCs should now be able to reach the backbone IP address of their own routers.

- But, you still can’t reach other PCs, or other routers.
  - why?
When you ping their router...

PING
src = Your PC
dst = Their Router (backbone address)

destination: Next Hop
Your subnet: Connected
Default: Your router

1

their router

2

Backbone subnet: Connected (fa0/0)
(no default or anything else)

Your router

3

destination: Next Hop
Their subnet: Connected
Default: Their router

Their router

3 ???
Configure static routes for the remaining classroom desks

- On your router, add static routes to the other PCs, using their router's backbone IP addresses as the next-hop.

  \[ \text{ip route } n.n.n.n \text{ m.m.m.m g.g.g.g} \]

  \( n.n.n.n \text{ m.m.m.m} \) is their subnet and netmask
  \( g.g.g.g \) is their router's address on the backbone
- Do this for every PC/router cluster in the class
  - There are A LOT of them. Cut and paste?
- Consult the map earlier to obtain the PC/router local subnet, and the corresponding router backbone IP address.
Forwarding Tables at this point in the exercise

Your PC  
Your Router  
Their Router  
Their PC

Destination: Next Hop
Your subnet: Connected
Default: Your router

Destination: Next Hop
Your subnet: Connected (fa0/1)
Backbone subnet: Connected (fa0/0)
Their subnet: Their router
Another subnet: Another router
(no default)

Destination: Next Hop
Their subnet: Connected (fa0/1)
Backbone subnet: Connected (fa0/0)
Your subnet: Your router
Another subnet: Another router
(no default)
Test Connectivity

- All routers can reach all PCs
- All PCs can reach all backbone IP addresses
- All PCs can reach PCs in other rows
- Test with traceroute
When your PC pings their PC...

PING
src = Your PC
dst = Their PC

1. Your PC
   Destination: Next Hop
   Your subnet: Connected
   Default: Your router

2. Your Router
   Destination: Next Hop
   Their subnet: Their router
   Backbone subnet: Connected (fa0/0)
   Another subnet: Another router (no default)

3. Their Router
   Destination: Next Hop
   Their subnet: Connected (fa0/1)
   Backbone subnet: Connected (fa0/0)
   Your subnet: Your router
   Another subnet: Another router (no default)

4. Their PC
... and the reply from their PC

PING
src = Your PC
dst = Their PC

Your
Router

Your subnet: Connected
Default: Your router

Destination: Next Hop

Their
Router

Their subnet: Connected
Default: Their router

REPLY
src = Their PC
dst = Your PC

Their
PC

Destination: Next Hop
Their subnet: Connected
Default: Their router

Your subnet: Connected (fa0/1)
Backbone subnet: Connected (fa0/0)
Their subnet: Their router
Another subnet: Another router
(no default)

Destination: Next Hop
Your subnet: Connected (fa0/1)
Backbone subnet: Connected (fa0/0)
Their subnet: Their router
Another subnet: Another router
(no default)
Static Exercise using IPv6

- Now let's repeat this exercise using IPv6 addressing
- Consult addressing plan for IPv6 addresses
  - Link between router and PC gets a /60
    - Group A use 2001:43f8:220:10::/60
    - Group B use 2001:43f8:220:20::/60
    - etc
  - Backbone is numbered from 2001:43f8:220:0::/64
    - Group A use 2001:43f8:220:0::1/64
    - Group A use 2001:43f8:220:0::2/64
Big Hint!

- If you are not using COPY/PASTE or the TFTP method to upload your config, you are wasting a lot of your time!
IPV6 Address Assignments

G 2001:4348:220:ff7::/60
F 2001:4348:220:ff60::/60
E 2001:4348:220:ff50::/60
D 2001:4348:220:ff40::/60
C 2001:4348:220:ff30::/60
B 2001:4348:220:ff20::/60
A 2001:4348:220:ff10::/60

H 2001:4348:220:ff80::/60
I 2001:4348:220:ff90::/60
J 2001:4348:220:ff9a0::/64
K 2001:4348:220:ffb0::/60
L 2001:4348:220:ffc0::/60
M 2001:4348:220:ffd0::/60
N 2001:4348:220:ffe0::/60
FreeBSD Network Interface Configuration

- configure interface on Unix host
  `ifconfig em0 inet6 n:n:n:n/m`

  *em0 is interface name*
  *n:n:n:n is IPv6 address*
  *m is netmask*
Configure the backbone interface on your router:

```shell
config t
ipv6 unicast-routing
interface fastethernet0/0
    ipv6 address n:n:n:n/m
```

- `fastethernet0/0` is the interface name.
- `n:n:n:n` is the IPv6 address.
- `m` is the netmask.

Now configure the local (LAN-facing) interface on your router too.
Cisco Router Network Interface Configuration

- Cisco ipv6 global config should always include:
  - `no ipv6 source-route`
  - `ipv6 cef`
- Cisco interface config should additionally include:
  - `no ipv6 redirects`
Configure a default route

- Add route on PC

```bash
route add -inet6 default g:g:g:g
```
- `g:g:g:g` is IPv6 address of gateway (which is on Cisco router)
- `-inet6` tells FreeBSD that this is an IPv6 route

- Display forwarding table

```bash
netstat -rn
```
Configure static routes for the remaining classroom desks

- On your router, add static routes to the other clusters, similar to how you did for ipv4.
  - next hop is backbone interface of other row’s router

 ipv6 route n:n:n:n/m g:g:g:g

- Repeat several times until complete
Test Connectivity

- All routers can reach all PCs
- All PCs can reach all backbone IP addresses
- All PCs can reach PCs in other rows
- Test with traceroute
Exercise Two
IPv4 Address Assignments

196.200.220.30/27 (E2 Router)

Switch

A 196.200.220.32/28
B 196.200.220.48/28
C 196.200.220.64/28
D 196.200.220.80/28
E 196.200.220.96/28
F 196.200.220.112/28
G 196.200.220.128/28

196.200.220.0/27

.1
.2
.3
.4
.5
.6
.7
.8
.9
.10
.11
.12
.13
.14

H 196.200.220.144/28
I 196.200.220.160/28
J 196.200.220.176/28
K 196.200.220.192/28
L 196.200.220.208/28
M 196.200.220.224/28
N 196.200.220.240/28

\text{SWITCH}
IPv6 Address Assignments

E2 Router
2001:4348:220::F/64

SWITCH
2001:4348:220::F/64

A
2001:4348:220:ff10::/60

B
2001:4348:220:ff20::/60

C
2001:4348:220:ff30::/60

D
2001:4348:220:ff40::/60

E
2001:4348:220:ff50::/60

F
2001:4348:220:ff60::/60

G
2001:4348:220:ff70::/60

H
2001:4348:220:ff80::/60

I
2001:4348:220:ff90::/60

J
2001:4348:220:ffa0::/64

K
2001:4348:220:ffb0::/60

L
2001:4348:220:ffc0::/60

M
2001:4348:220:ffd0::/60

N
2001:4348:220:ffe0::/60
Configure static routes to classroom router

- On your router, remove all static routes
  `no ip route n.n.n.n m.m.m.m g.g.g.g`
- Repeat until complete

- Add a default route point to the SIE classroom router
  - (next hop is backbone IP address of the SIE router)
  `ip route 0.0.0.0 0.0.0.0 g.g.g.g`
- Do the same for IPv6:
  `no ipv6 route n:n:n:n/m g:g:g:g`
  `ipv6 route ::/0 g:g:g:g`
Test Connectivity

- All routers can reach all PCs
- All PCs can reach all backbone IP addresses
- All PCs can reach PCs in other rows
- Test with traceroute
  - Test both IPv4 & Ipv6

- How is this working?
  - All static routes have been added to the classroom router.
Edit FreeBSD's ‘/etc/rc.conf’ file

- On production machines, add lines to /etc/rc.conf to preserve network settings on reboot

  hostname="porcupine.tomato.example"
  ifconfig_em0="inet X.X.X.X netmask Y.Y.Y.Y"
  ipv6_ifconfig_em0="X:X:X:X prefixlen 64"
  defaultrouter="G.G.G.G"
  ipv6_defaultrouter="G:G:G:G"

- See /etc/default/rc.conf for more information
Static Routing
Exercise

The End