Cisco Router Configuration Basics

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Router Components

- Bootstrap – stored in ROM microcode – brings router up during initialisation, boots router and loads the IOS.
- POST – Power On Self Test - stored in ROM microcode – checks for basic functionality of router hardware and determines which interfaces are present
- ROM Monitor – stored in ROM microcode – used for manufacturing, testing and troubleshooting
- Mini-IOS – a.k.a RXBOOT/boot loader by Cisco – small IOS ROM used to bring up an interface and load a Cisco IOS into flash memory from a TFTP server; can also perform a few other maintenance operations

Router Components

- RAM – holds packet buffers, ARP cache, routing table, software and data structure that allows the router to function; running-config is stored in RAM, as well as the decompressed IOS in later router models
- ROM – starts and maintains the router
- Flash memory – holds the IOS; is not erased when the router is reloaded; is an EEPROM [Electrically Erasable Programmable Read-Only Memory] created by Intel, that can be erased and reprogrammed repeatedly through an application of higher than normal electric voltage
- NVRAM – Non-Volatile RAM - holds router configuration; is not erased when router is reloaded

Router Components

- Config-Register
  - controls how router boots;
  - value can be seen with “`show version`” command;
  - is typically 0x2102, which tells the router to load the IOS from flash memory and the `startup-config` file from NVRAM

Purpose of the Config Register

- Reasons why you would want to modify the config-register:
  - Force the router into ROM Monitor Mode
  - Select a boot source and default boot filename
  - Enable/Disable the Break function
  - Control broadcast addresses
  - Set console terminal baud rate
  - Load operating software from ROM
  - Enable booting from a TFTP server

System Startup

- POST – loaded from ROM and runs diagnostics on all router hardware
- Bootstrap – locates and loads the IOS image; default setting is to load the IOS from flash memory
- IOS – locates and loads a valid configuration from NVRAM; file is called `startup-config`; only exists if you copy the `running-config` to NVRAM
- startup-config – if found, router loads it and runs embedded configuration; if not found, router enters setup mode

Overview

- Router configuration controls the operation of the router’s:
  - Interface IP address and netmask
  - Routing information (static, dynamic or default)
  - Boot and startup information
  - Security (passwords and authentication)

Where is the Configuration?

- Router always has two configurations:
- Running configuration
  - In RAM, determines how the router is currently operating
  - Is modified using the `configure` command
  - To see it: `show running-config`
- Startup confguration
  - In NVRAM, determines how the router will operate after next reload
  - Is modified using the `copy` command
  - To see it: `show startup-config`

Where is the Configuration?

- Can also be stored in more permanent places:
  - External hosts, using TFTP (Trivial File Transfer Protocol)
  - In flash memory in the router
- Copy command is used to move it around
  - copy run start   copy run tftp
  - copy start tftp   copy tftp start
  - copy flash start   copy start flash

Router Access Modes

- User EXEC mode – limited examination of router
  - Router>
- Privileged EXEC mode – detailed examination of router, debugging, testing, file manipulation (router prompt changes to an octothorp)
  - Router#
- ROM Monitor – useful for password recovery & new IOS upload session
- Setup Mode – available when router has no `startup-config` file

External Configuration Sources

- Console
  - Direct PC serial access
- Auxiliary port
  - Modem access
- Virtual terminals
  - Telnet/SSH access
- TFTP Server
  - Copy configuration file into router RAM
- Network Management Software
  - e.g., CiscoWorks

Changing the Configuration

- Configuration statements can be entered interactively
  - changes are made (almost) immediately, to the running configuration
- Can use direct serial connection to console port, or
- Telnet/SSH to vty's ("virtual terminals"), or
- Modem connection to aux port, or
- Edited in a text file and uploaded to the router at a later time via tftp; `copy tftp start` or `config net`

Logging into the Router

- Connect router to console port or telnet to router

```
router>
router>enable
password
router#
router#?
```

- Configuring the router
  - Terminal (entering the commands directly)

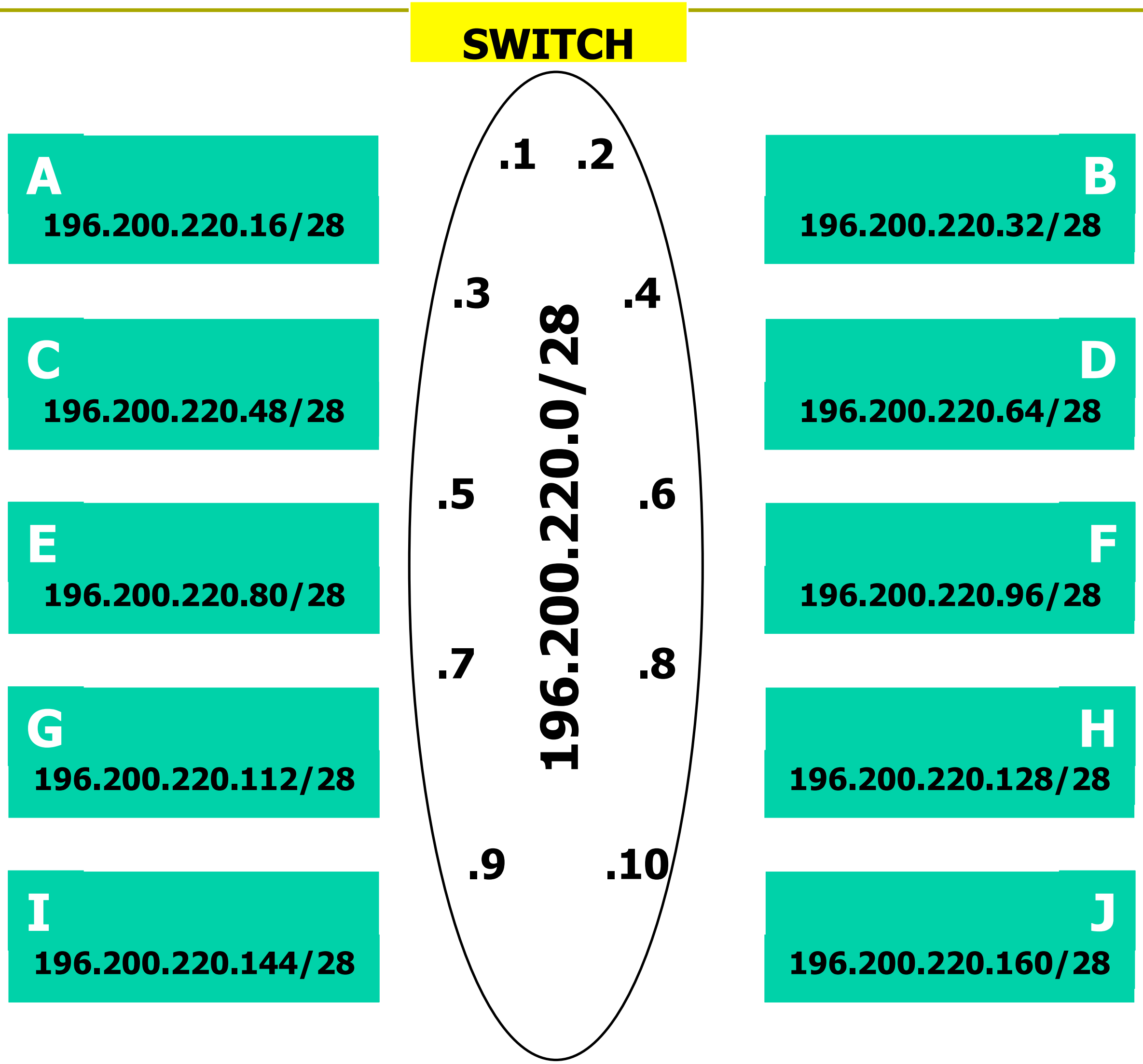
```
router# configure terminal
router(config)#
```

Connecting your FreeBSD Machine to the Router's Console Port

- Connect your machine to the console port using the rollover serial cable provide
- Go to /etc/remote to see the device configured to be used with "tip”. you will see at the end, a line begin with com1

```
bash$ tip com1 <enter>
router>
router>enable
router#
```

Address Assignments



SWITCH

196.200.220.0/28

.1 .2 .3 .4 .5 .6 .7 .8 .9 .10

A 196.200.220.16/28

B 196.200.220.32/28

C 196.200.220.48/28

D 196.200.220.64/28

E 196.200.220.80/28

F 196.200.220.96/28

G 196.200.220.112/28

H 196.200.220.128/28

I 196.200.220.144/28

J 196.200.220.160/28

New Router Configuration Process

- Load configuration parameters into RAM
  - `Router#configure terminal`
- Personalize router identification
  - `Router#(config)hostname RouterA`
- Assign access passwords
  - `RouterA#(config)line console 0`
  - `RouterA#(config-line)password cisco`
  - `RouterA#(config-line)login`

New Router Configuration Process

- Configure interfaces
  - **`RouterA#(config)interface ethernet 0/0`**
  - **`RouterA#(config-if)ip address n.n.n.n m.m.m.m`**
  - **`RouterA#(config-if)no shutdown`**
- Configure routing/routed protocols
- Save configuration parameters to NVRAM
  - **`RouterA#copy running-config startup-config`**
  - (or **`write memory`**)

Router Prompts – How to tell where you are on the router

- You can tell in which area of the router's configuration you are by looking at the router prompts:
  - `Router>` => USER prompt mode
  - `Router#` => PRIVILEGED EXEC prompt mode
  - `Router(config)` => terminal configuration prompt
  - `Router(config-if)` => interface configuration prompt
  - `Router(config-subif)` => sub-interface configuration prompt

Router Prompts – How to tell where you are on the router

- You can tell in which area of the router's configuration you are by looking at the router prompts:
  - **`Router(config-route-map)#`** => route-map configuration prompt
  - **`Router(config-router)#`** => router configuration prompt
  - **`Router(config-line)#`** => line configuration prompt
  - `rommon 1>` => ROM Monitor mode

Configuring your Router

- Set the enable (secret) password:
  - **`router(config)# enable secret`** “your pswd”
    - This MD5 encrypts the password
  - The old method was to use the **`enable password`** command. But this is not secure (weak encryption) and is ABSOLUTELY NOT RECOMMENDED. DO NOT USE!
- Ensure that all passwords stored on router are (weakly) encrypted rather than clear text:
  - **`router(config)# service password-encryption`**

Configuring Your Router

- To configure interface you should go to interface configuration prompt

  `router(config)# interface ethernet0` (or 0/x)

  `router(config-if)#`

- Save your configuration

  - **`router#copy running-config startup-config`**

Configuring Your Router

- Global:

```
enable secret e2@fnog
```

- Interface:

```
interface ethernet 0/0
 ip address n.n.n.n m.m.m.m
```

- Router:

```
router ospf 1
 network n.n.n.n w.w.w.w area 0
```

- Line:

```
line vty 0 4
```

Global Configuration

- Global configuration statements are independent of any particular interface or routing protocol, *e.g.*:
  - **`hostname`** ***`e2-@fnog`***
  - **`enable secret`** ***`tracke2`***
  - **`service password-encryption`**
  - **`logging facility`** ***`local0`***
  - **`logging`** ***`n.n.n.n`***

Global Configuration

- IP specific global configuration statements:

```
ip classless
ip name-server n.n.n.n
```

- Static Route Creation

```
ip route n.n.n.n m.m.m.m g.g.g.g
```

_n.n.n.n_ = network block

_m.m.m.m_ = network mask denoting block size

_g.g.g.g_ = next hop gateway destination packets are sent to

The NO Command

- Used to reverse or disable commands e.g

```
ip domain-lookup
no ip domain-lookup

router ospf 1
no router ospf 1

ip address 1.1.1.1 255.255.255.0
no ip address
```

Interface Configuration

- Interfaces are named by slot/type; *e.g.*:
  - ethernet0, ethernet1,... Ethernet5/1
  - Serial0/0, serial1 ... serial3
- And can be abbreviated:
  - ethernet0 or eth0 or e0
  - Serial0/0 or ser0/0 or s0/0

Interface Configuration

- Administratively enable/disable the interface

```
router(config-if)#no shutdown
router(config-if)#shutdown
```

- Description

```
router(config-if)#description ethernet
  link to admin building router
```

Global Configuration Commands

- Cisco **global** config should always include:

```
ip classless
ip subnet-zero
no ip domain-lookup
```

- Cisco **interface** config should usually include:

```
no shutdown
no ip proxy-arp
no ip redirects
no ip directed-broadcast
```

- Industry recommendations are at http://www.cymru.com/Documents

Looking at the Configuration

- Use “**`show running-configuration`**” to see the current configuration

- Use “**`show startup-configuration`**” to see the configuration in NVRAM, that will be loaded the next time the router is rebooted or reloaded

Interactive Configuration

- Enter configuration mode, using "**`configure terminal`**"
  - Often abbreviated to "**`conf t`**"
- Prompt gives a hint about where you are:

```
router#configure terminal
router(config)#ip classless
router(config)#ip subnet-zero
router(config)#int e0/1
router(config-if)#ip addr n.n.n.n m.m.m.m
router(config-if)#no shut
router(config-if)#^Z
```

Storing the Configuration on a Remote System

- Requires: '**tftpd**' on a unix host; destination file must exist before the file is written and must be world writable...

```
router#copy run tftp
Remote host []? n.n.n.n
Name of configuration file to write [hoste2-rtr-
  confg]? hoste2-rtr-confg
Write file hoste2-rtr-confg on Host n.n.n.n?
  [confirm]
Building configuration...

Writing hoste2-rtr-confg !![OK]
router#
```

Restoring the Configuration from a Remote System

- Use ‘tftp’ to pull file from UNIX host, copying to running-config or startup-config

```
router#copy tftp start
Address of remote host [255.255.255.255]? n.n.n.n
Name of configuration file [hoste2-rtr-confg]?
Configure using hostel-rtr-confg from n.n.n.n?
  [confirm]
Loading hoste2-rtr-confg from n.n.n.n (via
  Ethernet0/0): !
[OK - 1005/128975 bytes]
[OK]
hoste2-rtr# reload
```

Getting Online Help

- IOS has a built-in help facility;
  - use “?” to get a list of possible configuration statements
- “?” after the prompt lists all possible commands:
  - `router#?`
- “<partial command> ?” lists all possible subcommands, e.g.:
  - `router#show ?`
  - `router#show ip ?`

Getting Online Help

- “<partial command>?” shows all possible command completions

```
router#con?

  configure  connect
```

- This is different:

```
hostel-rtr#conf ?
  memory             Configure from NVRAM
  network            Configure from a TFTP network host
  overwrite-network  Overwrite NV memory from TFTP...
                                           network
  host
  terminal           Configure from the terminal
  <cr>
```

Getting Online Help

- This also works in configuration mode:

```
router(config)#ip a?
  accounting-list  accounting-threshold
  accounting-transits  address-pool
  alias as-path

router(config)#int e0/0
router(config-if)#ip a?
  access-group  accounting  address
```

Getting Online Help

- Can “explore” a command to figure out the syntax:

```
router(config-if)#ip addr ?
  A.B.C.D  IP address

router(config-if)#ip addr n.n.n.n ?
  A.B.C.D  IP subnet mask

router(config-if)#ip addr n.n.n.n m.m.m.m ?
  secondary  Make this IP address a secondary address
  <cr>

router(config-if)#ip addr n.n.n.n m.m.m.m
router(config-if)#
```

Getting Lazy Online Help

- TAB character will complete a partial word

```
hostel-rtr(config)#int<TAB>
hostel-rtr(config)#interface et<TAB>
hostel-rtr(config)#interface ethernet 0
hostel-rtr(config-if)#ip add<TAB>
hostel-rtr(config-if)#ip address n.n.n.n m.m.m.m
```

- Not really necessary; partial commands can be used:

```
router#conf t
router(config)#int e0/0
router(config-if)#ip addr n.n.n.n
```

Getting Lazy Online Help

- Command history
  - IOS maintains short list of previously typed commands
  - up-arrow or '^p' recalls previous command
  - down-arrow or '^n' recalls next command
- Line editing
  - left-arrow, right-arrow moves cursor inside command
  - '^d' or backspace will delete character in front of cursor
  - Ctrl-a takes you to start of line
  - Ctrl-e takes you to end of line

Connecting your FreeBSD machine to the Router's Console port

- Look at your running configuration
- Configure an IP address for e0/0 depending on your table
  - use n.n.n.n for table A etc
- Look at your running configuration and your startup configuration
- Check what difference there is, if any

Deleting your Router’s Configuration

- To delete your router’s configuration

```
Router#erase startup-config
```

OR

```
Router#write erase
Router#reload
```

  - Router will start up again, but in setup mode, since startup-config file does not exists

Using Access Control Lists (ACLs)

- Access Control Lists used to implement security in routers
  - powerful tool for network control
  - filter packets flow *in* or *out* of router interfaces
  - restrict network use by certain users or devices
  - deny or permit traffic

Rules followed when comparing traffic with an ACL

- Is done in sequential order; line 1, line 2, line 3 etc
- Is done in the direction indicated by the keyword *in* or *out*
- Is compared with the access list until a match is made; then NO further comparisons are made
- There is an implicit "deny" at the end of each access list; if a packet does not match in the access list, it will be discarded

Using ACLs

- Standard IP Access Lists
  - ranges (1 - 99) & (1300-1999)
  - simpler address specifications
  - generally permits or denies entire protocol suite
- Extended IP Access Lists
  - ranges (100 - 199) & (2000-2699)
  - more complex address specification
  - generally permits or denies specific protocols
- There are also named access-lists
  - Standard
  - Extended
  - Named access-lists easier to manage as lines may be deleted or added by sequence number. NO need to delete and reinstall the entire ACL. Not supported with all features.

ACL Syntax

- Standard IP Access List Configuration Syntax
  - **access-list access-list-number {permit | deny} source {source-mask}**
  - **ip access-group access-list-number {in | out}**
- Extended IP Access List Configuration Syntax
  - **access-list access-list-number {permit | deny} protocol source {source-mask} destination {destination-mask}**
  - **ip access-group access-list-number {in | out}**
- Named IP Access List Configuration Syntax
  - **ip access-list {standard | extended} {name | number}**

Where to place ACLs

- Place **Standard IP** access list close to **destination**
- Place **Extended IP** access lists close to the **source** of the traffic you want to manage

What are Wild Card Masks?

- Are used with access lists to specify a host, network or part of a network
- To specify an address range, choose the next largest block size e.g.
  - to specify 34 hosts, you need a 64 block size
  - to specify 18 hosts, you need a 32 block size
  - to specify 2 hosts, you need a 4 block size

What are Wild Card Masks?

- Are used with the host/network address to tell the router a range of addresses to filter
- Examples:
  - To specify a host:
    - 196.200.220.1 0.0.0.0
  - To specify a small subnet:
    - 196.200.220.8 – 196.200.220.15 (would be a /29)
    - Block size is 8, and wildcard is always one number less than the block size
    - Cisco access list then becomes 196.200.220.8 0.0.0.7
  - To specify all hosts on a /24 network:
    - 196.200.220.0 0.0.0.255

What are Wild Card Masks?

- Short cut method to a quick calculation of a network subnet to wildcard:
  - 255 – {netmask bits on subnet mask}
- Examples:
  - to create wild card mask for 196.200.220.160 255.255.255.240
    - 196.200.220.160 0.0.0.15 {255 – 240}
  - to create wild card mask for 196.200.220.0 255.255.252.0
    - 196.200.220.0 0.0.3.255

ACL Example

- **`Router(config)#access-list <access-list-number> {permit|deny} {test conditions}`**
- **`Router(config)#int eth0/0`**
- **`Router(config-if)#{protocol} access-group <access-list-number>`**
- e.g., check for IP subnets 196.200.220.80 to 196.200.220.95
  - 196.200.220.80 0.0.0.15

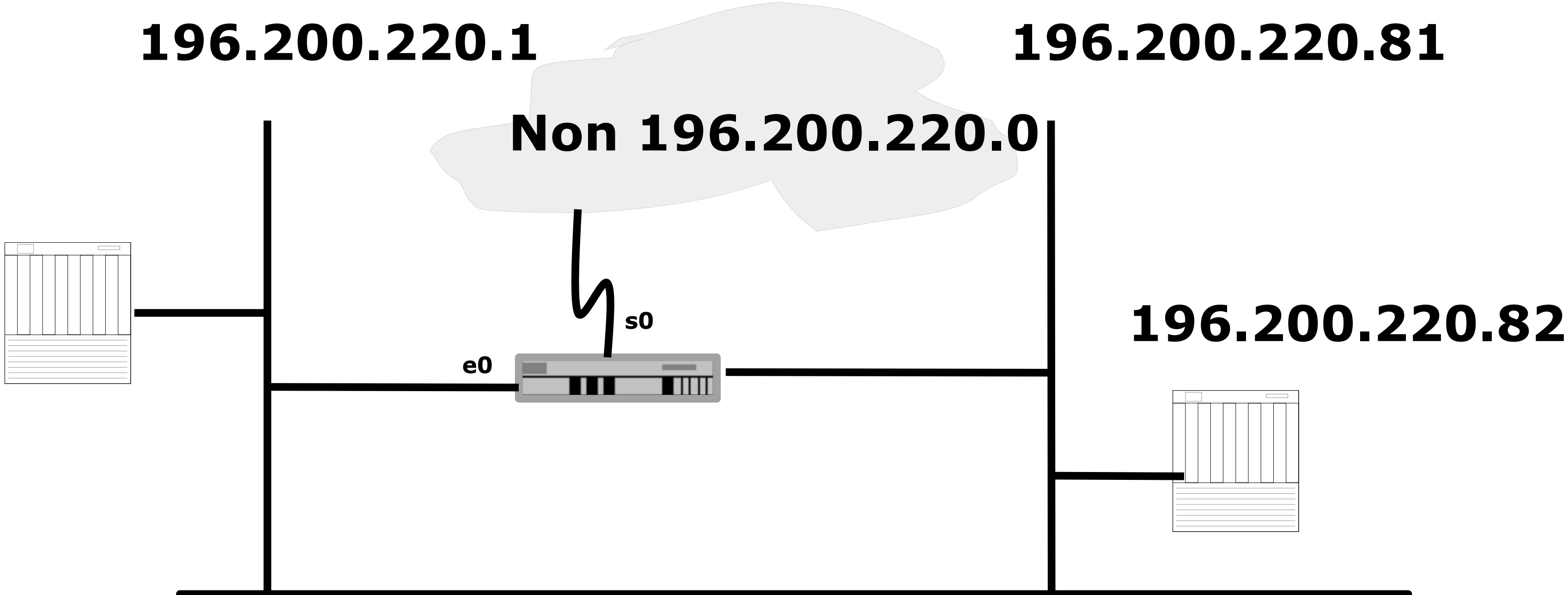
ACL Example

- Wildcard bits indicate how to check corresponding address bit
  - 0=check or match
  - 1=ignore
- Matching Any IP Address
  - 0.0.0.0 255.255.255.255
  - or abbreviate the expression using the keyword '**`any`**'
- Matching a specific host
  - 196.200.220.8 0.0.0.0
  - or abbreviate the wildcard using the IP address preceded by the keyword '**`host`**'

Permit telnet access only for my network

```
access-list 1 permit 196.200.220.192 0.0.0.15
access-list 1 deny any
line vty 0 4
  access-class 1 in
```

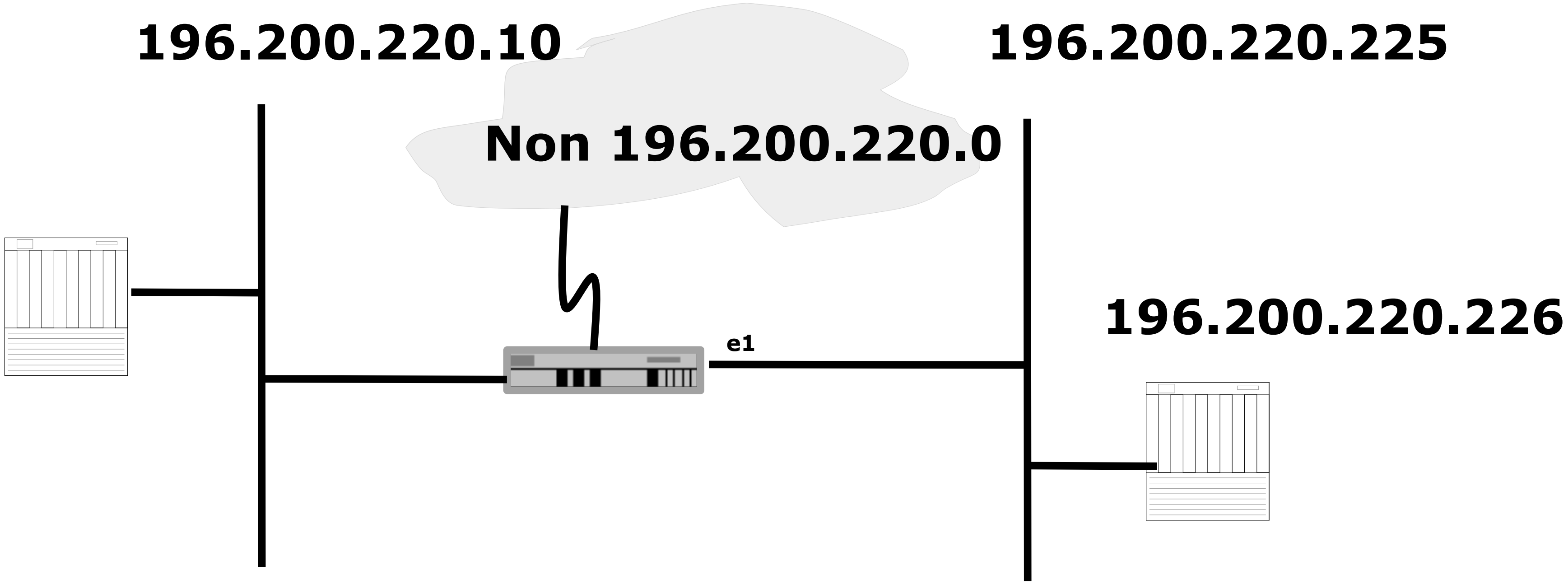
Standard IP ACLs
Permit only my network



```
access-list 1 permit 196.200.220.80 0.0.0.15

interface ethernet 0
 ip access-group 1 out
interface serial 0
 ip access-group 1 out
```

Extended IP ACLs:
Deny FTP access through Interface E1



```
access-list 101 deny tcp 196.200.220.0 0.0.0.15 196.200.220.224 0.0.0.15 eq 21
access-list 101 deny tcp 196.200.220.0 0.0.0.15 196.200.220.224 0.0.0.15 eq 20
access-list 101 permit ip 196.200.220.0 0.0.0.15 0.0.0.0 255.255.255.255
interface ethernet 1
ip access-group 101 out
```

Prefix Lists

- Cisco first introduced prefix lists in IOS 12.0
- Used to filter routes, and can be combined with route maps for route filtering and manipulation
- Provide much higher performance than access control lists and distribute lists
- Are much easier to configure and manage
  - Using CIDR address/mask notation
  - Sequence numbers (as in named access-lists)

Prefix Lists

- Prefix lists have an implicit “deny” at the end of them, like access control lists
- Are quicker to process than regular access control lists
- If you do have IOS 12.0 or later, it is STRONGLY RECOMMENDED to use prefix lists rather than access lists for route filtering and manipulation

Prefix List Configuration Syntax

- Prefix list configuration syntax

```
config t
  ip prefix-list list-name {seq seq-
 value} {permit|deny} network/len {ge
 ge-value} {le le-value}
```

  - **list-name** – name to use for the prefix list
  - **seq-value** – numeric value of the sequence; optional
  - **network/len** – CIDR network address notation

Prefix List Configuration Syntax

- Prefix list configuration Syntax
  - **`ge-value`** – “from” value of range; matches equal or longer prefixes (more bits in the prefix, smaller blocks of address space)
  - **`le-value`** – “to” value of range; matches equal or shorter prefixes (less bits in the prefix, bigger blocks of address space)

Prefix List Configuration Example

- To deny a single /28 prefix:

```
ip prefix-list t2afnog seq 5 deny 196.200.220.192/28
```

- To accept prefixes with a prefix length of /8 up to /24:

```
ip prefix-list test1 seq 5 permit 196.0.0.0/8 le 24
```

- To deny prefixes with a mask greater than 25 in 196.200.220.0/24:

```
ip prefix-list test2 seq 10 deny 196.200.220.0/24 ge 25
```

- To allow all routes:

```
ip prefix-list test3 seq 15 permit 0.0.0.0/0 le 32
```

Disaster Recovery – ROM Monitor

- ROM Monitor is very helpful in recovering from emergency failures such as:
  - Password recovery
  - Upload new IOS into router with NO IOS installed
  - Selecting a boot source and default boot filename
  - Set console terminal baud rate to upload new IOS quicker
  - Load operating software from ROM
  - Enable booting from a TFTP server

Getting to the ROM Monitor

- Windows using HyperTerminal for the console session
  - Ctrl-Break
- FreeBSD/UNIX using Tip for the console session
  - <Enter>, then ~# OR
  - Ctrl-], then Break or Ctrl-C
- Linux using Minicom for the console session
  - Ctrl-A F

Disaster Recovery: How to Recover a Lost Password

- Connect your PC’s serial port to the router’s console port
- Configure your PC’s serial port:
  - 9600 baud rate
  - No parity
  - 8 data bits
  - 1 stop bit
  - No flow control

Disaster Recovery: How to Recover a Lost Password

- Your configuration register should be 0x2102; use "**`show version`**" command to check
- Reboot the router and apply the Break-sequence within 60 seconds of powering the router, to put it into ROMMON mode

```
Rommon 1>confreg 0x2142
Rommon 2>reset
```

  - Router reboots, bypassing startup-config file

Disaster Recovery: How to Recover a Lost Password

```
Type Ctrl-C to exit Setup mode

Router>enable
Router#copy start run (only!!!)
Router#show running

Router#conf t
Router(config)enable secret forgotten
Router(config)int e0/0…
Router(config-if)no shut
Router(config)config-register 0x2102
Router(config)Ctrl-Z or end
Router#copy run start
Router#reload
```

Cisco Router Configuration Basics

Questions?