Troubleshooting, Editing, Port #’s

- **show ip interface brief** (display interface designations, IP address and status)
- **show ip route** (display routing table)
- **show vlan brief** (on switch - show what VLANs exist, names, ports assigned)
- **show controllers serial x/x/x** (see if DCE or DTE connected and if clockrate is present)
- **show interface trunk** (what ports are trunking, native vlan, allowed vlans)
- **show running-config** (display the running configuration - active)
- **show startup-config** (display the startup configuration)
- **show ip protocol** (what routing protocol, which networks, passive interfaces, neighbors)
- **show cdp neighbors** (see directly connected Cisco devices)
- **show cdp neighbors detail** (includes IP address at other end)
- **show cdp interface** (which interfaces are running CDP)
- **show interface serial x/x/x** (what encapsulation, IP address, counters)
- **show interface fastethernet x/x switchport** (configured mode and operating mode)
- **show version** (which IOS, capability, memory, configuration-register)
- **show run | begin interface** (will start listing at the first instance of ‘interface’)
- **show ip route connected** (show routing table entries for directly connected networks)
- **show ip route static**
- **show ip route ospf** (show routing table entries learned through OSPF)
- **show ip route eigrp** (show routing table entries learned through EIGRP)
- **show mac-address-table** or **show mac address-table** (varies with different IOS)
- **show flash** (display filenames and directories in Flash memory)
- **show clock** (current date/time in this device)
- **show ipv6 ??** (does the IPv6 version of many IPv4 commands)
- **show processes** (shows active processes running on router)
- **show process cpu** (shows cpu statistics)
- **show memory** (shows memory allocation)
- **show users** (show who is telnetted into this device)
- **show standby** (see if HSRP is active)
- **ping X.X.X.X** (try to reach the destination host at X.X.X.X)
- **trace X.X.X.X** (show the path taken to reach the destination host at X.X.X.X)
- R1(config)# **do show ???** (execute show commands from configuration mode)
- **debug ???** (real-time reporting about processes related to almost any function)
- **debug all** (very dangerous as the router can become consumed by reporting everything)
- **undebug all** (turn off all debugging commands – handy if this is a busy router)
CCNA Commands Summary

Line editing commands

ctrl-a (go to the beginning of the current line)
ctrl-e (go to the end of the current line)
ctrl-p or up-arrow (repeat up to 10 previous commands in the current mode)
ctrl-n or dn-arrow (if you have gone back in command history, this moves forward)
backspace-key (erase the character to the left of the current cursor position)
ctrl-z or end (go out to privilege mode)
ext (move back one level in the hierarchical command structure)
ctrl-c (cancel current command or leave Setup mode if you accidentally get into it)
ctrl-shift-6 (stop ping or trace)
terminal length 0 [zero] (turn off paging – makes output without breaks)
terminal length 24 (normal page breaks in output)
wr (shortcut for 'copy running-config startup-config)

Common Port Numbers and Protocols

File Transfer Protocol (FTP)
  FTP Control=TCP port 21
  FTP Data = TCP Port 20
Secure Shell (SSH) - TCP Port 22
Telnet - TCP Port 23
Simple Mail Transfer Protocol (SMTP) - TCP Port 25
Domain Name System (DNS) - TCP/UDP Port 53
Dynamic Host Configuration Protocol (DHCP)
  BOOTPS=UDP Port 67 (DHCP request from client to server)
  BOOTPC=UDP Port 68 (DHCP reply from server to client)
Hypertext Transfer Protocol (HTTP) - TCP Port 80
Post Office Protocol – incoming mail (POP) - TCP Port 110
Network Time Protocol (NTP) - UDP Port 123
Simple Network Management Protocol (SNMP) - UDP Port 161
Secure Hypertext Transfer Protocol (HTTPS) - TCP Port 443
Basic Router / Switch Configuration

To Restore a Switch or Router to Default Configuration
S1# delete vlan.dat (hit ‘enter’ to accept defaults) [Note: Only do this on a switch]
S1# erase startup-config (hit ‘enter’ to accept defaults [Router or Switch])
S1# reload (answer ‘no’ if asked to save current config [Router or Switch])

Router / Switch Basic Configuration
R1# configure terminal (enter global configuration mode)
R1(config)# hostname NAME (configure the NAME of the Router or Switch)
R1(config)# security passwords min-length 5 (set minimum password length)
R1(config)# service password-encryption (encrypt all passwords – except secret)
R1(config)# login block-for 60 attempts 3 within 30 (wait 1 min if 3 bad attempts in 30 sec)
R1(config)# enable secret PASSWORD (make the privilege level password ‘PASSWORD’)
R1(config)# no ip domain-lookup (suppress DNS attempt when a command is mistyped)
R1(config)# banner motd MESSAGE (create a MESSAGE that will display when logging in)
R1(config)# line console 0 [zero] (enter the console connection configuration mode)
R1(config-line)# password PASSWORD (make the user level password ‘PASSWORD’)
R1(config-line)# login (instruct the router that you want it to check for a password)
R1(config-line)# logging synchronous (assists by keeping command entry more orderly)
R1(config-line)# exec-timeout 0 0 [zeroes] (no timeout while configuring the router)
R1(config)# line vty 0 4 [zero 4] (configure the same options as line console above)
S1(config)# line vty 0 15 [zero 15] (configure the same options in a switch)
R1# copy running-configuration startup-configuration (save config in NVRAM)
R1# wr (legacy command - Same as copy running-configuration startup-configuration)
R1(config)# ! (remark – makes no configuration changes)

For Switch Management Interface Configuration
S1(config)# interface vlan 1 (create a virtual host on the switch)
S1(config-if)# description Management interface for this switch (optional description)
S1(config-if)# ip address 192.168.100.50 255.255.255.0 (assign an IP address)
S1(config-if)# no shut (must turn it on)
S1(config-if)# exit (leave interface config and return to global config)
S1(config)# ip default-gateway 192.168.100.1 (must be on same subnet as Mgt interface)
S1(config)# enable secret class (must have an enable password for remote config)
S1(config)# line vty 0 15 (switches may have 16 VTY connections at once)
S1(config-line)# password cisco (must set a login password for telnet to be possible)
S1(config-line)# login (tell the VTY ports to ask for password from remote user)
S1(config-line)# transport input telnet (allows only telnet for remote config – default)
Configuring IPv4 Router Interface
R1(config)# interface INTERFACE-TYPE (enter configuration mode for an interface)
R1(config-if)# ip address ADDRESS SNM (assign the IP Address and subnet mask)
R1(config-if)# description WORDS (document what this interface is used for)
R1(config-if)# clock rate CLOCK (on serial DCE interfaces, set the speed of the link)
R1(config-if)# bandwidth VALUE (used by the routing protocol for the speed of the link)
R1(config-if)# no shutdown (turn the interface on)
R1(config-if)# shutdown (turn the interface off)

Configuring IPv6 Router Interface
R1(config)# ipv6 unicast-routing (activate IPv6 routing – off by default)
R1(config)# interface Gi1/1
R1(config-if)# ipv6 enable (turn on ipv6 in this interface)
R1(config-if)# ipv6 address 3ffe:b00:c18:1::3 /64 (manually enter complete address)
-or-
R1(config-if)# ipv6 address 3ffe:b00:c18:1:: /64 eui-64 (auto configure host portion)
R1(config-if)# ipv6 address fe80::4 link-local (configure link-local address)

Layer-3 Switch Commands
S1(config)# ip routing (activate IPv4 routing within the switch)
S1(config)# ipv6 routing (activate IPv6 routing within the switch)
S1(config-if)# no switchport (used to designate that this is a router port, not a switchport)
S1(config-if)# switchport trunk encapsulation dot1q (to configure trunking for dot1Q)
VLANS, Trunks, Router-on-a-Stick, VTP

VLAN Creation and Port Assignment

S1(config)# vlan 10 (create VLAN 10 in the VLAN.DAT database)
S1(config-vlan)# name Management (optionally name the VLAN)
S1(config)# interface fa0/12 (select a port on the switch) --or--
S1(config)# interface range fa0/12 – 20 (select a range of ports to be configured the same)
S1(config-if)# switchport mode access (set the port to Access mode)
S1(config-if)# switchport access vlan 10 (assign this port(s) to VLAN 10)

Trunk Creation

S1(config)# interface gi1/1 (select port for trunking)
S1(config-if)# switchport trunk encapsulation dot1q (NOTE: on Layer 3 switch only)
S1(config-if)# switchport mode trunk (set the port to be in trunk mode)
S1(config-if)# switchport trunk native vlan 99 (set VLAN 99 to carry native traffic)
S1(config-if)# switchport trunk allowed vlan 1,10,20,99 (optional – which VLANs are permitted to go across this trunk. Don’t forget to include VLAN 1 and the native VLAN)

Router-on-a-Stick Configuration

R1(config)# interface Fa0/0 (select the main interface)
R1(config-if)# no ip address (there should not be any IP Address on the main interface)
R1(config-if)# interface Fa0/0.10 (create a sub-interface – the number can be anything)
R1(config-if)# encapsulation dot1q 10 (use 802.1Q trunking; assign to this VLAN #)
R1(config-if)# ip address 172.16.10.1 255.255.255.255 (define the default-gateway IP)
R1(config-if)# interface Fa0/0.99 (create another sub-interface - this one for native traffic)
R1(config-if)# encapsulation dot1q 99 native (802.1Q trunking; VLAN #; and native)
(NOTE: No IP address unless workstations or management interfaces are on this VLAN)

R1(config)# ip classless (classless routing behavior – default in IOS 11.3+)
R1(config)# no ip classless (classful routing behavior)

VLAN Trunking Protocol (VTP) Configuration

S1(config)# vtp mode server (configure this switch to be in server mode) --or--
S1(config)# vtp mode client (configure this switch to be in client mode) ---or--
S1(config)# vtp mode transparent (configure this switch in transparent mode - Suggested)
S1(config)# vtp domain NAME (change the VTP domain name of this switch to NAME)
S1(config)# vtp password PASSWORD (change the VTP password for this switch)
S1(config)# vtp pruning (activate VTP pruning – Not supported in Packet Tracer)
S1(config)# vtp version 2 (change the VTP version to 2)

S1# show vtp status (see VTP mode, revision, version, domain name, pruning mode, etc)
S1# show vtp password (only way to see the VTP password – does not show in status)
Etherchannel (PortChannel)

To configure a Layer 2 (trunking) Etherchannel:

S1(config)# interface range fa0/1 – 4 (group of physical interfaces)
S1(config-if)# switchport trunk encapsulation dot1q (NOTE: on Layer 3 switch only)
S1(config-if)# switchport mode trunk (set to trunk mode)
S1(config-if)# switchport trunk native vlan 777 (Set native VLAN)
S1(config-if)# channel-protocol lacp (set this interface to LACP portchannel) -or--
S1(config-if)# channel-protocol pagp (set this interface to PAgP portchannel)
S1(config-if)# channel-group 3 mode [see choices below]
  passive (enable LACP only if a LACP device is detected)
  active (enable LACP unconditionally)
  auto (enable PAgP only if a PAgP device is detected)
  desirable (enable PAgP unconditionally)
  on (enable Etherchannel)
S1(config)# interface port-channel 3 (configure the virtual interface from 1 to 6)
S1(config-if)# switchport mode trunk (set to trunk mode)
S1(config-if)# switchport trunk native vlan 777 (set native VLAN the same as the physical)
S1(config-if)# no shutdown (turn on the virtual interface)

To configure a Layer 3 Etherchannel:

SW1(config)# interface range fa0/1 – 2
SW1(config-if)# no switchport
SW1(config-if)# channel-group 1 mode {active, passive, on}
SW1(config)# interface port-channel 1
SW1(config-if)# no switchport
SW1(config-if)# ip address x.x.x.x m.m.m.m
(The other end is configured the same)

EtherChannel uses a load-balancing algorithm based on selected type or criteria:

- Source IP Address (src-ip)
- Destination IP Address (dst-ip)
- Both Source and Destination IP (src-dst-ip) – default L3 type
- Source MAC address (src-mac) – default L2 type
- Destination MAC address (dst-mac)
- Both Source and Destination MAC (src-dst-mac)
- Source TCP/UDP port number (src-port)
- Destination TCP/UDP port number (dst-port)
- Both Source and Destination port number (src-dst-port)

SW1(config)# port-channel load-balance TYPE
Spanning Tree Protocol (STP), HSRP

**Spanning Tree**

S1(config)# spanning-tree mode pvst (configure for PVST – Default)
S1(config)# spanning-tree mode rapid-pvst (configure this switch for rapid PVST)
S1(config)# spanning-tree vlan 10,20 root primary (make root bridge for these VLANs)
S1(config)# spanning-tree vlan 10 root secondary (make secondary root bridge for VLAN)
S1(config)# spanning-tree vlan 10 priority 8192 (set the BID priority to 8192 in this VLAN)
S1(config)# spanning-tree portfast default (default Portfast on all interfaces in this switch)
S1(config)# interface range fa0/10 – 20 (must be configured as Access ports for Portfast)
S1(config-if)# spanning-tree portfast (set interfaces for Portfast)
S1(config-if)# spanning-tree bpduguard enable (disables interface if it receives a BPDU)
S1(config)# interface fa0/1 (select a port to set STP port priority)
S1(config-if)# spanning-tree vlan 10 port-priority 16 (set port priority to 16; default is 128)

S1# show spanning-tree (see spanning-tree status on a VLAN-by-VLAN basis)
S1# show spanning-tree vlan 10 (see detail spanning-tree information for VLAN 10)
S1# show spanning-tree summary (among other things, see if this is the root bridge)
S1# show spanning-tree blockedports (see which ports are in STP blocking status)
S1# show spanning-tree root (see which BID is root on a VLAN-by-VLAN basis)

**Hot Standby Routing Protocol (HSRP) for IPv4**

R1(config)# interface fastethernet 0/1
R1(config)# standby version 2 (use the same version at each end)
R1(config-if)# standby [optional group#] ip [optional IP-ADDRESS] [optional secondary]
(Them other end is configured the same)
R1(config-if)# standby [optional group#] priority NUMBER [optional preempt]
Set a higher priority (default 100) to make this router the primary in HSRP
Preempt will make this router the active one if it had been down and comes back up

**Hot Standby Routing Protocol (HSRP) for IPv6**

R1(config)# interface fastethernet 0/1
R1(config-if)# standby version 2 (use the same version at each end)
R1(config-if)# standby GROUP# ipv6 autoconfig (create virtual IPv6 Link-Local address)
R1(config-if)# standby GROUP# ipv6 2001:CAFE:ACAD:4::1/64 (set virtual shared IP)
(The other end is configured the same)
R1(config-if)# standby GROUP# priority NUMBER [optional preempt]
Set a higher priority (default 100) to make this router the primary in HSRP
Preempt will make this router the active one if it had been down and comes back up

R1# show standby (verify the configuration)
Security Practices

R1(config)# service password-encryption (encrypt all passwords (except ‘secret’))
R1(config)# security password min-length 8 (set minimum 8 character passwords)
R1(config)# login block-for 120 attempts 3 within 60 (block for 2 minutes if more than 3 failed logins within 60 seconds)

SSH Configuration

Router(config)# hostname R1 (must change the name of the device from the default)
R1(config)# username Bob password Let-me-in! (configure a local user and password)
R1(config)# ip domain-name ANYTHING.COM (must set for crypto-key generation)
R1(config)# crypto key generate rsa (make an encryption key - select 1024 bits)
R1(config)# ip ssh version 2 (configure for SSH version 2)
R1(config)# line vty 0 15 (change parameters for remote access)
R1(config-line)# login local (select to authenticate against usernames in this device)
R1(config-line)# transport input ssh (only allow SSH for remote management)

Port Security Configuration on a Switch

S1(config)# interface fa0/1 or interface range fa0/1 – 15, gi1/1
S1(config-if)# switchport mode access (must change from dynamic to access mode)
S1(config-if)# switchport port-security (must do to activate port-security)
S1(config-if)# switchport port-security maximum 25 (allow 25 MAC addresses)
S1(config-if)# switchport port-security mac-address sticky (memorize MAC addresses)
S1(config-if)# switchport port-security violation restrict (send SNMP message) --or--
S1(config-if)# switchport port-security violation protect (only stop excess MACs) --or--
S1(config-if)# switchport port-security violation shutdown (shutdown interface - default)
S1(config-if)# switchport protected (does not allow traffic to/from other protected ports)
S1(config-if)# spanning-tree bpduguard enable (disables interface if it receives a BPDU)
S1(config-if)# shutdown then no shutdown (restore individual interface if it has shutdown)
S1# errdisable recovery cause psecure_violation (restore shutdown interfaces in 5 min)

S1# show port-security interface fa0/12 (show security configuration for an interface)

Enable/Disable Cisco Discovery Protocol (CDP)

R1(config)# cdp run (activate CDP globally in the router – on by default)
R1(config)# no cdp run (disable CDP within the entire router)
R1(config-if)# no cdp enable (stop CDP updates leaving through this specific interface)

IP DHCP Snooping

R1(config)# ip dhcp snooping (globally enable DHCP snooping)
R1(config-if)# ip dhcp snooping trust (interface with DHCP server)
Routing (Static, RIP, EIGRP, OSPF)

Configuring Static Routes
R1(config)# ip route 0.0.0.0 0.0.0.0 serial0/0 (default-route goes out serial 0/0)
R1(config)# ip route 0.0.0.0 0.0.0.0 50.77.4.13 (default-route goes to next-hop 50.77.4.13)
R1(config)# ip route 0.0.0.0 0.0.0.0 serial0/0 150 (default-route goes out serial 0/0. An optional parameter is added to set the administrative distance to 150)
R1(config)# ip route 47.151.2.0 255.255.255.0 172.24.2.11 (to get to network 47.151.2.0/24, go to next-hop address of 172.24.2.11)
R1(config)# ip route 47.151.2.0 255.255.255.0 serial0/1 (to get to network 47.151.2.0/24, go out serial 0/1)
R1(config)# ip route 47.151.2.0 255.255.255.0 192.168.12.2 fastethernet0/0 (to get to network 47.151.2.0/24, go to the next-hop 192.168.12.2 out Fastethernet0/0; on Ethernet both are needed)

Configuring RIP (IPv4)
R1(config)# no router rip (remove all RIP configurations and routing table entries)
R1(config)# router rip (enter rip configuration commands)
R1(config-router)# network 192.168.10.0 (define which directly connected network(s) to include in RIP update processes. No subnet mask – always classful)
R1(config-router)# passive-interface fastethernet0/0 (prevent RIP updates from broadcasting out this interface)
R1(config-router)# default-information originate (configure RIP to include default-routes in updates to other routers. This is disabled by default. Only on router with default-route)
R1(config-router)# redistribute static (configure RIP to include classful static routes in updates to other routers. This is disabled by default. Only needed if there are static routes)
R1# debug ip rip (examine RIP updates in real-time)

Additional Commands to configure RIP Version 2
R1(config-router)# version 2 (configure RIP for RIPv2)
R1(config-router)# no auto-summary (turn off automatic classful summarization- suggested)

Configuring RIPng (for IPv6)
R1(config)# ipv6 route ::/0 S0/0/1 (default route goes out S0/0/1)
R1(config)# ipv6 router rip NAME (start the RIPng instance)
R1(config)# interface fa0/1
R1(config-if)# ipv6 rip NAME enable (include this interface and subnet in routing)
R1(config-if)# ipv6 rip NAME default-information originate (send default route)
Configuring IPv4 EIGRP

R1(config)# no router eigrp 100 (completely remove this instance of EIGRP in this router)
R1(config)# router eigrp 100 (100=Process ID within this network – Cisco calls this Autonomous System)
R1(config)# eigrp router-id 5.5.5.5 (use this ID when identifying EIGRP neighbors)
R1(config-router)# no auto-summary (the default is to summarize to classful boundaries)
R1(config-router)# network 172.16.0.0 (no subnet or wildcard mask is needed if classful)
R1(config-router)# network 172.16.25.0 0.0.0.255 (wildcard mask – this is inverse of /24)
R1(config-router)# passive-interface default (no routing updates out any interface)
R1(config-router)# no passive-interface fastethernet 0/1 (allow certain interfaces)
R1(config-router)# passive-interface fastethernet 0/0 (no routing updates out Fa0/0)
R1(config-router)# redistribute static (one statement redistributes static routes - including the default-route)
R1(config-if)# maximum paths 2 (load balancing paths: default=4, no load balancing=1)
R1(config-router)# metric weights 0 k1 k2 k3 k4 k5 (used to modify the metric multipliers)
R1(config-if)# bandwidth 768 (indicate the serial line speed for the routing protocol – this example is 768-K)
R1(config-if)# ip summary-address eigrp 100 172.16.24.0 255.255.252.0 (manually summarized network statement configured on outbound interface)
R1(config-if)# ip bandwidth-percent eigrp 100 40 (in this example limit EIGRP AS=100 updates to a maximum of 40% of the link bandwidth)
R1(config-if)# ip hello-interval eigrp 100 30 (in this example, set hello intervals on this interface to 30 seconds for EIGRP AS=100)
R1(config-if)# ip hold-time eigrp 100 90 (in this example, set the hold-time on this interface to 90 seconds for EIGRP AS=100)
R1(config)# key chain MYCHAIN (name the key chain – done in global config)
R1(config-keychain)# key 1 (must assign a number – same at both ends of link)
R1(config-keychain-key)# key-string securetraffic (‘securetraffic’ is the passphrase)
R1(config)# interface serial 0/1 (interface to the other EIGRP router)
R1(config-subif)# ip authentication mode eigrp 10 md5 (turn on authentication)
R1(config-subif)# ip authentication key-chain eigrp 10 MYCHAIN (use this key)

R1# show ip eigrp neighbors (see neighbor adjacencies)
R1# show ip eigrp topology (see the EIGRP topology table)
R1# debug eigrp fsm (see what DUAL does when a route is removed from the routing table)
Configuring IPv4 OSPF(v2)
R1(config)# interface loopback 10 (optionally create a virtual interface for OSPF router ID)
R1(config)# router ospf 1 (configure an OSPF routing process)
R1(config-router)# router-id 2.2.2.2 (optionally configure the OSPF Router ID - Suggested)
R1(config-router)# network 172.16.45.0 0.0.0.255 area 0 (include directly connected networks that match this parameter)
R1(config-router)# default-information originate (propagate the quad-0 default route)
R1(config-router)# redistribute static (propagate classful static routes configured on this router to other OSPF routers)
R1(config-router)# redistribute static subnets (propagate classless static routes configured on this router to other OSPF routers)
R1(config-router)# passive-interface default (no routing updates out any interface)
R1(config-router)# no passive-interface fastethernet 0/1 (allow certain interfaces)
R1(config-router)# passive-interface fastethernet 0/1 (do not send OSPF routing updates out this interface)
R1(config-router)# area 7 range 172.16.8.0 255.255.248.0 (on ABR summarize addresses)
R1(config-router)# summary address 172.16.8.0 255.255.248.0 (On ASBR – to summarize non-OSPF routes imported into OSPF)
R1(config-router)# auto-cost reference-bandwidth ??? (optionally change the reference bandwidth in terms of Mbits per second 1-4294967; must be the same on all routers)
R1(config-router)# area AREA-ID authentication message-digest (globally activate MD-5 authentication within an OSPF area)
R1(config-router)# ip ospf message-digest-key 1 md5 PASSWORD (authentication key)
R1(config-if)# ip ospf message-digest-key 1 md5 PASSWORD (on this interface, configure the OSPF authentication key – will not activate authentication)
R1(config-if)# ip ospf authentication message-digest (activate OSPF authentication)
R1(config-if)# ip ospf cost 1562 (optionally configure an absolute OSPF cost for a link – this example same as bandwidth 64)
R1(config-if)# ip ospf hello-interval seconds (change hello timer from default 10 seconds)
R1(config-if)# ip ospf dead-interval seconds (change dead timer from default 40 seconds)
R1(config-if)# ip ospf priority {0 - 255} (for OSPF DR/BDR election, default=1, ineligible=0)

R1# show ip ospf neighbor (display OSPF neighbor adjacencies – State should be ‘FULL’ or ‘2WAY’)
R1# show ip protocols (includes the OSPF Router ID of this router)
R1# clear ip ospf process (re-calculate OSPF Router ID based on current parameters)
R1# show ip ospf (display OSPF process and router IDs, as well as area information)
R1# show ip ospf interface serial 0/0/0 (see DR/BDR information, hello and dead intervals)
Configure IPv6 OSPF(v3)

R1(config)# ipv6 unicast-routing (turn on ipv6 routing)
R1(config)# no ipv6 router ospf 55 (remove this instance of OSPF in this router)
R1(config)# ipv6 router ospf 100 (create the OSPF process in this router)
R1(config-rtr)# router-id 5.5.5.5 (must have router id)
R1(config-rtr)# default-information originate (redistribute default route to other routers)
R1(config-rtr)# redistribute static (redistribute classful static routes, including default)
R1(config-rtr)# redistribute static subnets (redistribute classless static routes)
R1(config-rtr)# no passive-interface default (no routing updates out any interface)
R1(config-rtr)# passive-interface gi 1/0 (no routing updates out gi 1/1)
R1(config-rtr)# no shutdown (turn it on)
R1(config)# interface gi 1/1 (networks are assigned through the interface)
R1(config-if)# ipv6 enable (allow IPv6 on this interface)
R1(config-if)# ipv6 ospf 100 area 0 (associate this interface with IPv6 OSPF 55, area 0)

Configure IPv6 EIGRP

R1(config)# ipv6 unicast-routing (turn on ipv6 routing)
R1(config)# no ipv6 router eigrp 100 (remove this instance of EIGRP in this router)
R1(config)# ipv6 router eigrp 100 (create the EIGRP process)
R1(config-rtr)# eigrp router-id 5.5.5.5 (must have a router id)
R1(config-rtr)# redistribute static (redistribute static and default routes to other routers)
R1(config-rtr)# passive-interface default (no routing updates out any interface)
R1(config-rtr)# no passive-interface gi 1/0 (allow updates out this interface)
R1(config-rtr)# passive-interface gi 1/1 (no routing updates out gi 1/1)
R1(config-rtr)# no shutdown (must turn on EIGRP in this router)
R1(config)# interface gi 1/1 (networks are assigned through the interface)
R1(config-if)# ipv6 enable (allow IPv6 on this interface)
R1(config-if)# ipv6 eigrp 100 (associate this interface with IPv6 EIGRP process 100)
R1(config-if)# ipv6 summary-address eigrp 100 2001:123A::AAA0::/60 (EIGRP summary address)
R1(config-if)# ipv6 bandwidth-percent eigrp 100 40 (in this example limit EIGRP AS=100 updates to a maximum of 40% of the link bandwidth)
R1(config)# key chain MYCHAIN (name the key chain – done in global config)
R1(config-keychain)# key 1 (must assign a number – same at both ends of link)
R1(config-keychain-key)# key-string securetraffic (‘securetraffic’ is the passphrase)
R1(config)# interface serial 0/1 (interface to the other EIGRP router)
R1(config-subif)# ipv6 authentication mode eigrp 10 md5 (turn on authentication)
R1(config-subif)# ipv6 authentication key-chain eigrp 10 MYCHAIN (use this key)
PPP and Frame-Relay

Configuring PPP with Authentication

R1(config)# **username R-2 password PASSWORD** (configure for PAP / CHAP)
- If PAP, the username and password must match the sent-username and password from other router.
- If CHAP, the username must be the hostname of the other router and the passwords must be the same in each routers username configuration.

R1(config)# interface serial 0/0/0 (select the interface for ppp configuration)
R1(config-if)# encapsulation ppp (set interface to PPP)
R1(config-if)# compress [predictor / stac] (optional-configure data compression)
R1(config-if)# ppp quality [percentage] (optional-set a threshold of throughput before the ppp link will reset)
R1(config-if)# ppp authentication pap (optional-configure for PAP authentication)
R1(config-if)# ppp pap sent-username R-1 password PASSWORD (if PAP is used, this must be configured)
R1(config-if)# ppp authentication chap (optional-configure for CHAP authentication)
R1(config-if)# ppp multilink (optional-combine multiple PPP links for more bandwidth)
R1(config-if)# encapsulation hdlc (reset the interface to the default value of HDLC)

Frame-Relay Commands
- There are two basic types of Frame-Relay configuration: Point-to-Point and Multi-Point.
- A Point-to-Point link involves a single IP subnet and one DLCI. It may be configured directly on the physical interface or may be done as a sub-interface.

**FR Point-to-Point no sub-interface; Sample Configuration 1:**

R1(config)# interface serial 0/0/0
R1(config-if)# ip address 192.168.5.1 255.255.255.252 (typically /30)
R1(config-if)# encapsulation frame-relay [ietf, cisco] PVC=IEFT is optional, cisco=default)
R1(config-if)# frame-relay lmi-type [ansi, q933a, cisco] (optional, cisco=default)
R1(config-if)# frame-relay map ip 192.168.5.1 752 (to allow local ping- 192.168.5.1 is the local interface IP, DLCI=752 is a valid DLCI for this interface)
R1(config-if)# frame-relay map ip 192.168.5.2 752 broadcast [ietf, cisco] (192.168.5.2 is next hop, DLCI=752, broadcast is optional, PVC=IEFT is optional – cisco is default)

**FR Point-to-Point with sub-interface; Sample Configuration 2:**

R1(config-if)# interface serial 0/0/0
R1(config-if)# no ip address (no IP address on the main interface)
R1(config-if)# encapsulation frame-relay [ietf, cisco] PVC=IEFT is optional, cisco=default)
R1(config-if)# frame-relay lmi-type [ansi, q933a, cisco] (optional, cisco=default)
R1(config-if)# interface serial 0/0/0.752 point-to-point (sub-int # is customarily DLCI #)
R1(config-subif)# ip address 192.168.5.1 255.255.255.252 (typically /30)
R1(config-subif)# frame-relay interface-dlci 752 (DLCI=752, next hop and broadcast are dynamically assigned)

robert.samson@mesacc.edu
Multi-point configurations are when there is one IP subnet with multiple connections (DLCIs). It may be configured directly on the physical interface or may be done as a sub-interface.

**Multi-Point no sub-interface; Sample Configuration 3:**

```
R1(config)# interface serial 0/0/0
R1(config-if)# ip address 192.168.5.1 255.255.255.248 (not /30)
R1(config-if)# encapsulation frame-relay
R1(config-if)# frame-relay lmi-type [ansi, q933a, cisco] (optional, cisco=default)
R1(config-if)# frame-relay map ip 192.168.5.1 752 (to allow local ping - 192.168.5.1 is the local interface IP, DLCI=752 is a valid DLCI for this interface)
R1(config-if)# frame-relay map ip 192.168.5.2 752 broadcast [ietf, cisco] (192.168.5.2 is next hop, DLCI=752, broadcast is optional, PVC=IEFT is optional – cisco is default)
R1(config-if)# frame-relay map ip 192.168.5.3 339 broadcast [ietf, cisco] (192.168.5.3 is next hop, DLCI=339, broadcast is optional, PVC=IEFT is optional – cisco is default)
```

**Multi-Point with sub-interface; Sample Configuration 4:**

```
R1(config)# interface serial 0/0/0
R1(config-if)# no ip address (no IP address on the main interface)
R1(config-if)# encapsulation frame-relay (not configured on sub-interface)
R1(config-if)# frame-relay lmi-type [ansi, q933a, cisco] (optional, cisco=default)
R1(config-if)# interface serial 0/0/0.752 multipoint (sub-interface # is customarily DLCI #)
R1(config-subif)# ip address 192.168.5.1 255.255.255.248 (not /30)
R1(config-subif)# frame-relay map ip 192.168.5.1 752 (to allow local ping - 192.168.5.1 is the local interface IP, DLCI=752 is a valid DLCI for this interface)
R1(config-subif)# frame-relay map ip 192.168.5.2 752 broadcast [ietf, cisco] (192.168.5.2 is next hop, DLCI=752, broadcast is optional, PVC=IEFT is optional – cisco is default)
R1(config-subif)# frame-relay map ip 192.168.5.3 339 broadcast [ietf, cisco] (192.168.5.3 is next hop, DLCI=339, broadcast is optional, PVC=IEFT is optional – cisco is default)
```

R1# show frame-relay map (display mapping of IPs and DLCIs)
   Static: Map entry was from a ‘frame-relay map’ statement.
   Dynamic: Map entry was created through inverse-ARP.
R1# show frame-relay lmi (see status of local link to Frame-Relay cloud)
R1# show frame-relay pvc (see which links are actually up end-to-end)
   Active: PVC is fully connected and functional.
   Inactive: Connected to FR switch, but other side isn’t seen.
   Delete: Not talking to the FR switch.
Access Control Lists

Standard Access Lists

- Standard access lists only evaluate the source IP field. They can use the 'host' and 'any' keywords, or apply wildcard masks. They do not use port numbers.

**Named Standard Access List:**

```
R-1(config)# ip access-list standard NAME (name the list)
R-1(config-std-nacl)# deny host 192.168.20.5 log (deny a specific host / log matches)
R-1(config-std-nacl)# permit 192.168.20.0 0.0.0.255 (permit subnet 192.168.20.0)
R-1(config-std-nacl)# deny any (deny all other IP addresses)
```

**Numbered IP Standard Access List:**

```
R-1(config)# access-list 25 deny host 192.168.20.5 (deny specific host)
R-1(config)# access-list 25 permit 192.168.20.0 0.0.0.255 (permit entire subnet)
R-1(config)# access-list 25 deny any (deny all other IP addresses)
```

Extended Access Lists

```
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>permit</td>
<td>IP</td>
<td>IP address &amp; Wildcard mask</td>
<td>eq</td>
<td>23 - telnet</td>
<td>IP address &amp; Wildcard mask</td>
<td>eq</td>
<td>23 - telnet</td>
</tr>
<tr>
<td>deny</td>
<td>TCP</td>
<td>Wildcard mask</td>
<td></td>
<td>80 - http</td>
<td>Wildcard mask</td>
<td>80 - http</td>
<td></td>
</tr>
<tr>
<td>remark</td>
<td>UDP</td>
<td>any</td>
<td>lt</td>
<td>443 - https</td>
<td>any</td>
<td>lt</td>
<td>443 - https</td>
</tr>
<tr>
<td></td>
<td>ICMP</td>
<td>host X.X.X.X</td>
<td>neq</td>
<td>echo (ping)</td>
<td>host X.X.X.X</td>
<td>neq</td>
<td>echo (ping)</td>
</tr>
<tr>
<td></td>
<td>OSPF</td>
<td>range</td>
<td>echo-replay</td>
<td></td>
<td>range</td>
<td>echo-replay</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EIGRP</td>
<td>Etc...</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```

There can be additional optional commands (log, time-of-day, established, etc) on the end of most statements. The protocol field must match the destination port / protocol - if they are used (example: TCP=Telnet, ICMP=Ping, UDP=DNS).

**Named Extended Access List:**

```
R-1(config)# ip access-list extended NAME (name the list)
```

Example: Deny an individual host to an entire subnet for Telnet and also log matches:
```
R-1(config-ext-nacl)# deny tcp host 192.168.20.10 172.16.0.0 0.0.255.255 eq 23 log
```

Example: Permit an entire subnet to go anywhere:
```
R-1(config-ext-nacl)# permit ip 192.168.20.0 0.0.0.255 any
```

Example: Deny everything:
```
R-1(config-ext-nacl)# deny ip any any (this is applied by default if not configured)
```

Applying Access Lists

```
R-1(config)# interface fastethernet 0/0
R-1(config-if)# ip access-group NAME in (evaluate packets coming in to the router)
R-1(config-if)# ip access-group NAME out (evaluate packets leaving the router)
R-1(config)# line vty 0 4
R-1(config-line)# access-class NAME in (evaluate packets for telnet or SSH)
```
Dynamic Access List (Stateful-Firewall)

R1(config)# ip access-list extended OUTBOUND-TRAFFIC
R1(config-ext-nacl)# permit tcp any any reflect TCP-TRAFFIC
R1(config-ext-nacl)# permit udp any any reflect UDP-TRAFFIC
R1(config-ext-nacl)# permit icmp any any reflect ICMP-TRAFFIC
R1(config-ext-nacl)# deny ip any any

R1(config)# ip access-list extended EVALUATE-INBOUND
R1(config-ext-nacl)# evaluate TCP-TRAFFIC
R1(config-ext-nacl)# evaluate UDP-TRAFFIC
R1(config-ext-nacl)# evaluate ICMP-TRAFFIC

R1(config)# interface serial 0/0/0
R1(config-if)# ip access-group OUTBOUND-TRAFFIC out
R1(config-if)# ip access-group EVALUATE-INBOUND in

Time-Based ACL

R-1(config)# time-range MON-WED-FRI
R-1(config-time-range)# periodic Monday Wednesday Friday 8:00 to 17:00
R-1(config)# access-list 133 permit tcp 192.168.20.0 0.0.0.255 any
                     eq telnet time-range MON-WED-FRI

R-1# show access-list (see access lists on this router and # of ‘matches’ per line)
R-1# show access-list NAME (see a specific access list and # of ‘matches’ per line)
DHCP and NAT

Configuring DHCP for IPv4

R-1(config)# ip dhcp excluded 172.16.2.1 172.16.2.7 (excluded IP range)
R-1(config)# ip dhcp pool LAN-2 (name this DHCP pool)
R-1(config-dhcp)# network 172.16.2.0 255.255.255.128 (entire network range)
R-1(config-dhcp)# default-router 172.16.2.1 (address on router port)
R-1(config-dhcp)# dns-server 140.198.8.14 (DNS server – can have up to 4)
R-1(config-dhcp)# domain-name MCC.COM (optional domain name)
R-1(config-dhcp)# lease-time 5 (optional - change to 5 day lease, 1 day is default)

R-3(config)# interface fastethernet 0/1 (interface for network with DHCP clients)
R-3(config-if)# ip helper-address 192.168.15.2 (address where DHCP server is)

show ip dhcp binding (see what IP addresses are assigned & MAC addresses)
DOS-PROMPT>ipconfig /release (remove dynamically assigned IP information on PC)
DOS-PROMPT>ipconfig /renew (get new IP address from DHCP server)

Configuring DHCP for IPv6 Stateless Address Auto-Configuration (SLAAC)

R1(config)# ipv6 unicast routing (make sure IPv6 is activated)
R1(config)# ipv6 dhcp pool LAN-10-STATELESS (create pool for addresses and DNS)
R1(config-dhcpv6)# dns-server 2001:345:ACAD:F::5 (IPv6 DNS server address)
R1(config-dhcpv6)# domain-name cisco.com (optional domain name)
R1(config)# interface g/1
R1(config-if)# ipv6 address 2001:A1B5:C13:10::1/64 (configure IPv6 address)
R1(config-if)# ipv6 dhcp server LAN-10-STATELESS (look to this DHCP pool)
R1(config-if)# ipv6 nd other-config-flag (enable IPv6 Neighbor Discovery)

Configuring DHCP for IPv6 Stateful Address Auto-configuration

R1(config)# ipv6 unicast routing (make sure IPv6 is activated)
R1(config)# ipv6 dhcp pool LAN-10-STATEFUL (create pool for addresses and DNS)
R1(config-dhcpv6)# address prefix 2001:D7B:CAFÉ:10::/64 lifetime infinite infinite lifetime
R1(config-dhcpv6)# dns-server 2001:345:ACAD:F::5 (IPv6 DNS server address)
R1(config-dhcpv6)# domain-name cisco.com (optional domain name)
R1(config)# interface g/1
R1(config-if)# ipv6 address 2001:D7B:CAFÉ:10::1/64 (configure IPv6 address)
R1(config-if)# ipv6 dhcp server LAN-10-STATEFUL (look to this DHCP pool)
R1(config-if)# ipv6 nd managed-config-flag (enable IPv6 Neighbor Discovery)
R-3(config)# interface fastethernet 0/1 (interface for network with DHCP clients)
R-3(config-if)# ip dhcp relay destination 2001:A123:7CA1::15 (IPv6 DHCP server address)
R1# show ipv6 dhcp relay
R1# show ipv6 dhcp pool
R1# show ipv6 dhcp binding
Configure NAT for IPv4

- For both static and dynamic NAT, designate interfaces as inside or outside:
  R-1(config)# interface fa0/0 (typically designate all interfaces except the outside one)
  R-1(config-if)# ip nat inside (designate this as an inside interface)
  R-1(config)# interface serial 0/0/0 (typically there is only one outside interface)
  R-1(config-if)# ip nat outside (designate this as an outside interface)

- Static NAT requires only one statement. The IP addresses are inside / outside:
  R-1(config)# ip nat inside source static 192.168.10.22  73.2.34.137

- Dynamic NAT may use a pool of ‘outside addresses’. If you do not use a pool, you will have
  to use the address on the outside interface. You can use ‘netmask’:
  R-1(config)# ip nat pool POOL-NAME 73.2.34.138  73.2.34.143 netmask 255.255.255.248
  - or - You may choose to use ‘prefix-length’:
  R-1(config)# ip nat pool POOL-NAME 73.2.34.138  73.2.34.143 prefix-length 29

- Dynamic NAT requires an ACL to define which internal addresses can be NATted:
  R-1(config)# ip access-list standard NAT-ELIGIBLE
  R-1(config-std-nacl)# permit 192.168.10.0  0.0.0.255 (include all subnets)
  R-1(config-std-nacl)# deny any

- Dynamic NAT can use the pool for outside addresses:
  R-1(config)# ip nat inside source list NAT-ELIGIBLE pool POOL-NAME
    - or - Dynamic NAT can use the pool with overload to share outside addresses:
  R-1(config)# ip nat inside source list NAT-ELIGIBLE pool POOL-NAME overload
    - or - Dynamic NAT can use the exit interface – almost always will use overload:
  R-1(config)# ip nat inside source list NAT-ELIGIBLE interface serial 0/0/0 overload

R-1# show ip nat translations (current translations- dynamic and static)
R-1# show ip nat statistics (see # of active translations, role of interfaces, etc)
PPP Protocol – PAP & CHAP Authentication:

For PPP-PAP to work, the sent-username and password from one router must exist in the username table of the other router.

For PPP-CHAP to work, the name of the peer router must be in each routers username table and the passwords must be the same in each table.

Frame-Relay Configurations: Multipoint and Point-to-Point

<table>
<thead>
<tr>
<th>Frame-Relay Multipoint (all three router interfaces are on the same subnet)</th>
<th>Frame-Relay Point-to-Point (all three router interfaces are on different IP subnets)</th>
</tr>
</thead>
</table>
| !
| !PHX Router
| !
| interface Serial0/0
| ip address 192.168.10.1  255.255.255.0
| encapsulation frame-relay
| frame-relay map ip 192.168.10.2  157 broadcast
| frame-relay map ip 192.168.10.3  333 broadcast
| frame-relay map ip 192.168.10.1  157
| frame-relay lmi-type ansi
| !
| !CHG and DAL are similar except for different IP
| ! Addresses on S0/0, different IPs and DLCIs in the
| ! Frame-Relay map statements, and PHX is LMI=Ansi. |
| !
| !PHX Router
| !
| interface Serial0/0
| no ip address
| encapsulation frame-relay
| !
| interface Serial0/0.157 point-to-point
| ip address 192.168.20.1  255.255.255.0
| frame-relay interface-dlci 157
| !
| interface Serial0/0.333 point-to-point
| ip address 192.168.10.1  255.255.255.0
| frame-relay interface-dlci 333
Frame-Relay Logical Diagram – LMI, SVC and PVC:

LMI = Cisco, ANSI, Q933a

SVC

PVC (Frame-Relay Encapsulation = Cisco, IETF)

ACLs – (Access Control Lists):

R1

! interface FastEthernet 0/0
ip access-group NO-PING-PC2-TO-PC3-LAN in
!
ip access-list extended NO-PING-PC2-TO-PC3-LAN
remark Deny Ping from PC-2 to PC-3's LAN
deny icmp host 192.168.10.20 192.168.11.0 0.0.0.255 echo
remark Permit all other traffic
permit ip any
!
interface FastEthernet 0/1
ip access-group RESTRICT-WEB1-TRAFFIC out
!
ip access-list standard RESTRICT-WEB1-TRAFFIC
remark Permit PC-1
permit host 192.168.10.10
remark Deny all PC-1 and PC-3 LAN traffic
deny 192.168.10.0 0.0.1.255
remark Allow all other traffic
permit any
!

R2

! access-list 10 remark Only allow PC-1
access-list 10 permit host 192.168.10.10
access-list 10 remark Deny all others
access-list 10 deny any
!
line vty 0-4
access-class 10 in
!
DHCP & NAT Configuration:

R-1

!  
ip dhcp excluded-address 192.168.50.1 192.168.50.7  
ip dhcp excluded-address 192.168.50.129 192.168.50.131  
!  
ip dhcp pool LAN-1  
  network 192.168.50.0 255.255.255.128  
  default-router 192.168.50.1  
  dns-server 140.198.8.14  
!  
ip dhcp pool LAN-2  
  network 192.168.50.128 255.255.255.224  
  default-router 192.168.50.129  
  dns-server 140.198.8.14

R-2

!  
interface FastEthernet0/0  
  ip address 192.168.50.129 255.255.255.224  
  ip helper-address 192.168.50.253  
  ip nat inside  
!  
interface Serial0/0  
  ip address 209.165.200.170 255.255.255.252  
  ip nat outside  
!  
interface Serial0/0/1  
  ip address 192.168.50.254 255.255.255.252  
  ip nat inside  

!  
  ip nat inside source list INSIDE-ADDRESSES interface Serial0/0/0 overload  
  ip route 0.0.0.0 0.0.0.0 Serial0/0/0  
!  
ip access-list standard INSIDE-ADDRESSES  
  permit 192.168.50.0 0.0.0.127  
  permit 192.168.50.128 0.0.0.31  
  permit 192.168.50.252 0.0.0.3  
  deny any
IPv6 Configuration with EIGRP, AS=200:

<table>
<thead>
<tr>
<th>R-1</th>
<th>R-2</th>
<th>ISP</th>
</tr>
</thead>
<tbody>
<tr>
<td>! ipv6 unicast-routing ! ipv6 unicast-routing !</td>
<td></td>
<td></td>
</tr>
<tr>
<td>! interface FastEthernet0/0 ! interface FastEthernet0/0 ! interface FastEthernet0/0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>no ip address no ip address no ip address</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ipv6 address FE80::1 link-local ipv6 address FE80::2 link-local ipv6 address FE80::3 link-local</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ipv6 address 2001:DB8:1:22::1/64 ipv6 address 2001:DB8:1:33::1/64 ipv6 address 2222:1111:5:1::1/64</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ipv6 eigrp 200 ipv6 eigrp 200 ipv6 eigrp 200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>! interface Serial0/0/0 ! interface Serial0/0/0 ! interface Serial0/0/0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>no ip address no ip address no ip address</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ipv6 address FE80::1 link-local ipv6 address FE80::2 link-local ipv6 address FE80::3 link-local</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ipv6 address 2001:DB8:1:11::1/64 ipv6 address 2001:DB8:1:11::2/64 ipv6 address ABCD:1234:2:1::1/64</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ipv6 eigrp 200 ipv6 eigrp 200 ipv6 eigrp 200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>! interface Serial0/0/1 ! interface Serial0/0/1 ! interface Serial0/0/0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>no ip address no ip address no ip address</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ipv6 address FE80::2 link-local ipv6 address FE80::2 link-local ipv6 address FE80::3 link-local</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ipv6 address 2001:DB8:1:11::1/64 ipv6 address 2001:DB8:1:1::5/64 ipv6 address 2001:DB8:1:1::1/64</td>
<td></td>
<td></td>
</tr>
<tr>
<td>! ipv6 eigrp 200 ipv6 eigrp 200 ipv6 eigrp 200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>router id 1.1.1.1 router id 2.2.2.2 router id 3.3.3.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>no shutdown no shutdown no shutdown</td>
<td></td>
<td></td>
</tr>
<tr>
<td>! ipv6 router eigrp 200 ! ipv6 router eigrp 200 ! ipv6 route Fe80::/0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>! ! route Fe80::/0 Serial0/0/0 !</td>
<td></td>
<td></td>
</tr>
<tr>
<td>! ! redistribute static !</td>
<td></td>
<td></td>
</tr>
<tr>
<td>! ! !</td>
<td></td>
<td></td>
</tr>
<tr>
<td>! ! !</td>
<td></td>
<td></td>
</tr>
<tr>
<td>! ! !</td>
<td></td>
<td></td>
</tr>
<tr>
<td>! ! !</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
VPN GRE Tunnel:

```
R-1
!
interface Tunnel10
  ip address 10.10.10.1 255.255.255.252
  tunnel source Serial0/0/0
  tunnel destination 80.80.80.2
!
interface FastEthernet0/0
  ip address 192.168.10.1 255.255.255.0
  ip nat inside
!
interface Serial0/0/0
  ip address 50.50.50.1 255.255.255.0
  ip nat outside
!
routerr ip
  version 2
  passive-interface Serial0/0/0
  network 10.0.0.0
  network 192.168.10.0
  no auto-summary
!
ip nat inside source list 1 interface Serial0/0/0 overload
!
ip route 0.0.0.0 0.0.0.0 Serial0/0/0
!
access-list 1 permit 192.168.10.0 0.0.0.255
access-list 1 deny any
R-1#sh ip route  *some output omitted*
Gateway of last resort is 0.0.0.0 to network 0.0.0.0

C  10.10.10.0 is directly connected, Tunnel10
C  50.50.50.0 is directly connected, Serial0/0/0
R  192.168.10.0/24 is directly connected, Fa0/0
R  192.168.20.0/24 [120/1] via 10.10.10.2, Tunnel10
S*  0.0.0.0/0 is directly connected, S0/0/0
```

```
R-5
!
interface Tunnel55
  ip address 10.10.10.2 255.255.255.252
  tunnel source Serial0/0/1
  tunnel destination 50.50.50.1
!
interface FastEthernet0/0
  ip address 192.168.20.1 255.255.255.0
  ip nat inside
!
interface Serial0/0/1
  ip address 80.80.80.2 255.255.255.0
  ip nat outside
!
routerr ip
  version 2
  passive-interface Serial0/0/1
  network 10.0.0.0
  network 192.168.20.0
  no auto-summary
!
ip nat inside source list NAT interface Serial0/0/1 overload
!
ip route 0.0.0.0 0.0.0.0 Serial0/0/1
!
ip access-list standard NAT
  permit 192.168.20.0 0.0.0.255
  deny any

Gateway of last resort is 0.0.0.0 to network 0.0.0.0

C  10.10.10.0 is directly connected, Tunnel55
C  80.80.80.0 is directly connected, Serial0/0/1
R  192.168.10.0/24 [120/1] via 10.10.10.1, Tunnel55
C  192.168.20.0/24 is directly connected, Fa0/0
S*  0.0.0.0/0 is directly connected, Serial0/0/1
```