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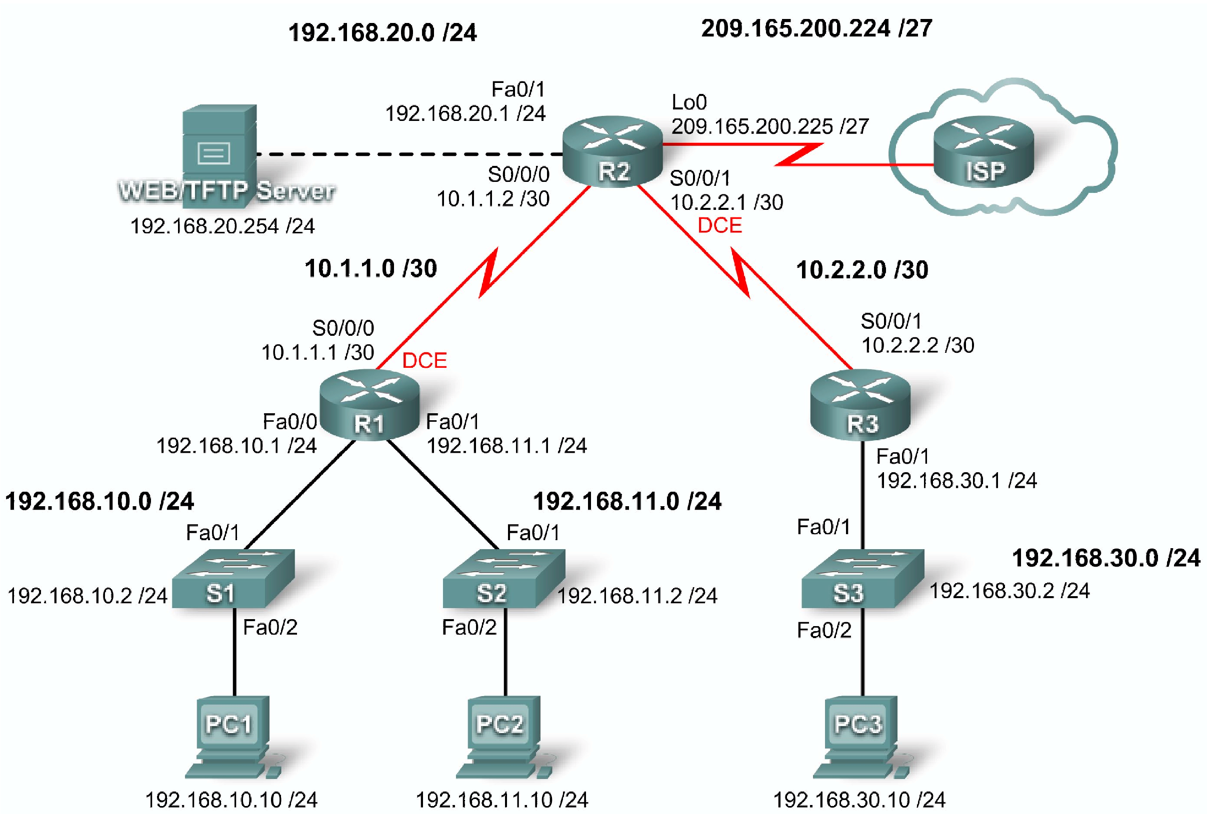
Lab 5.5.1: Basic Access Control Lists

Topology Diagram



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
R1	Fa0/0	192.168.10.1	255.255.255.0	N/A
	Fa0/1	192.168.11.1	255.255.255.0	N/A
	S0/0/0	10.1.1.1	255.255.255.252	N/A
R2	Fa0/1	192.168.20.1	255.255.255.0	N/A
	S0/0/0	10.1.1.2	255.255.255.252	N/A
	S0/0/1	10.2.2.1	255.255.255.252	N/A
	Lo0	209.165.200.225	255.255.255.224	N/A
R3	Fa0/1	192.168.30.1	255.255.255.0	N/A
	S0/0/1	10.2.2.2	255.255.255.252	N/A
S1	Vlan1	192.168.10.2	255.255.255.0	192.168.10.1

S2	**Vlan1**	192.168.11.2	255.255.255.0	192.168.11.1
S3	**Vlan1**	192.168.30.2	255.255.255.0	192.168.30.1
PC1	**NIC**	192.168.10.10	255.255.255.0	192.168.10.1
PC2	**NIC**	192.168.11.10	255.255.255.0	192.168.11.1
PC3	**NIC**	192.168.30.10	255.255.255.0	192.168.30.1
Web Server	**NIC**	192.168.20.254	255.255.255.0	192.168.20.1

Learning Objectives

Upon completion of this lab, you will be able to:

- Design named standard and named extended ACLs.
- Apply named standard and named extended ACLs.
- Test named standard and named extended ACLs.
- Troubleshoot named standard and named extended ACLs.

Scenario

In this lab, you will learn how to configure basic network security using Access Control Lists. You will apply both standard and extended ACLs.

Task 1: Prepare the Network

Step 1: Cable a network that is similar to the one in the topology diagram.

You can use any current router in your lab as long as it has the required interfaces shown in the topology diagram.

Note: This lab was developed and tested using 1841 routers. If you use 1700, 2500, or 2600 series routers, the router outputs and interface descriptions might be different. On older routers, or versions of the IOS before 12.4, some commands may be different or non-existent.

Step 2: Clear any existing configurations on the routers.

Task 2: Perform Basic Router Configurations

Configure the R1, R2, R3, S1, S2, and S3 routers and switches according to the following guidelines:

- Configure the router hostname to match the topology diagram.
- Disable DNS lookup.
- Configure an EXEC mode password of **class**.
- Configure a message-of-the-day banner.
- Configure a password of cisco for console connections.
- Configure a password for VTY connections.
- Configure IP addresses and masks on all devices.
- Enable OSPF area 0 with a process ID of 1 on all routers for all networks.
- Configure a loopback interface on R2 to simulate the ISP.

- Configure IP addresses for the VLAN 1 interface on each switch.
- Configure each switch with the appropriate default gateway.
- Verify full IP connectivity using the **ping** command.

Task 3: Configuring a Standard ACL

Standard ACLs can filter traffic based on source IP address only. A typical best practice is to configure a standard ACL as close to the destination as possible. In this task, you are configuring a standard ACL. The ACL is designed to block traffic from the 192.168.11.0/24 network located in a student lab from accessing any local networks on R3.

This ACL will be applied inbound on the R3 serial interface. Remember that every ACL has an implicit "deny all" that causes all traffic that has not matched a statement in the ACL to be blocked. For this reason, add the **permit any** statement to the end of the ACL.

Before configuring and applying this ACL, be sure to test connectivity from PC1 (or the Fa0/1 interface on R1) to PC3 (or the Fa0/1 interface on R3). Connectivity tests should be successful before applying the ACL.

Step 1: Create the ACL on router R3.

In global configuration mode, create a standard named ACL called **STND-1**.

```
R3(config)#ip access-list standard STND-1
```

In standard ACL configuration mode, add a statement that denies any packets with a source address of 192.168.11.0/24 and prints a message to the console for each matched packet.

```
R3(config-std-nacl)#deny 192.168.11.0 0.0.0.255 log
```

Permit all other traffic.

```
R3(config-std-nacl)#permit any
```

Step 2: Apply the ACL.

Apply the ACL **STND-1** as a filter on packets entering R3 through Serial interface 0/0/1.

```
R3(config)#interface serial 0/0/1
R3(config-if)#ip access-group STND-1 in
R3(config-if)#end
R3#copy run start
```

Step 3: Test the ACL.

Before testing the ACL, make sure that the console of R3 is visible. This will allow you to see the access list log messages when the packet is denied.

Test the ACL by pinging from PC2 to PC3. Since the ACL is designed to block traffic with source addresses from the 192.168.11.0/24 network, PC2 (192.168.11.10) should not be able to ping PC3.

You can also use an extended ping from the Fa0/1 interface on R1 to the Fa0/1 interface on R3.

```
R1#ping ip
Target IP address: 192.168.30.1
Repeat count [5]:
Datagram size [100]:
Timeout in seconds [2]:
Extended commands [n]: y
Source address or interface: 192.168.11.1
```



```
Type of service [0]:
Set DF bit in IP header? [no]:
Validate reply data? [no]:
Data pattern [0xABCD]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Sweep range of sizes [n]:
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.30.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.11.1
U.U.U
Success rate is 0 percent (0/5)
```

You should see the following message on the R3 console:

```
*Sep  4 03:22:58.935: %SEC-6-IPACCESSLOGNP: list STND-1 denied 0
0.0.0.0 -> 192.168.11.1, 1 packet
```

In privileged EXEC mode on R3, issue the **show access-lists** command. You see output similar to the following. Each line of an ACL has an associated counter showing how many packets have matched the rule.

```
Standard IP access list STND-1
    10 deny   192.168.11.0, wildcard bits 0.0.0.255 log (5 matches)
    20 permit any (25 matches)
```

The purpose of this ACL was to block hosts from the 192.168.11.0/24 network. Any other hosts, such as those on the 192.168.10.0/24 network should be allowed access to the networks on R3. Conduct another test from PC1 to PC3 to ensure that this traffic is not blocked.

You can also use an extended ping from the Fa0/0 interface on R1 to the Fa0/1 interface on R3.

```
R1#ping ip
Target IP address: 192.168.30.1
Repeat count [5]:
Datagram size [100]:
Timeout in seconds [2]:
Extended commands [n]: y
Source address or interface: 192.168.10.1
Type of service [0]:
Set DF bit in IP header? [no]:
Validate reply data? [no]:
Data pattern [0xABCD]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Sweep range of sizes [n]:
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.30.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.10.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 40/43/44 ms
```

Task 4: Configuring an Extended ACL

When greater granularity is required, you should use an extended ACL. Extended ACLs can filter traffic based on more than just source address. Extended ACLs can filter on protocol, source, and destination IP addresses, and source and destination port numbers.

An additional policy for this network states that devices from the 192.168.10.0/24 LAN are only permitted to reach internal networks. Computers on this LAN are not permitted to access the Internet. Therefore, these users must be blocked from reaching the IP address 209.165.200.225. Because this requirement needs to enforce both source and destination, an extended ACL is needed.

In this task, you are configuring an extended ACL on R1 that blocks traffic originating from any device on the 192.168.10.0/24 network to access the 209.165.200.255 host (the simulated ISP). This ACL will be applied outbound on the R1 Serial 0/0/0 interface. A typical best practice for applying extended ACLs is to place them as close to the source as possible.

Before beginning, verify that you can ping 209.165.200.225 from PC1.

Step 1: Configure a named extended ACL.

In global configuration mode, create a named extended ACL called **EXTEND-1**.

```
R1(config)#ip access-list extended EXTEND-1
```

Notice that the router prompt changes to indicate that you are now in extended ACL configuration mode. From this prompt, add the necessary statements to block traffic from the 192.168.10.0/24 network to the host. Use the **host** keyword when defining the destination.

```
R1(config-ext-nacl)#deny ip 192.168.10.0 0.0.0.255 host 209.165.200.225
```

Recall that the implicit "deny all" blocks all other traffic without the additional **permit** statement. Add the **permit** statement to ensure that other traffic is not blocked.

```
R1(config-ext-nacl)#permit ip any any
```

Step 2: Apply the ACL.

With standard ACLs, the best practice is to place the ACL as close to the destination as possible. Extended ACLs are typically placed close to the source. The **EXTEND-1** ACL will be placed on the Serial interface, and will filter outbound traffic.

```
R1(config)#interface serial 0/0/0
R1(config-if)#ip access-group EXTEND-1 out
R1(config-if)#end
R1#copy run start
```

Step 3: Test the ACL.

From PC1, ping the loopback interface on R2. These pings should fail, because all traffic from the 192.168.10.0/24 network is filtered when the destination is 209.165.200.225. If the destination is any other address, the pings should succeed. Confirm this by pinging R3 from the 192.168.10.0/24 network device.

Note: The extended ping feature on R1 cannot be used to test this ACL, since the traffic will originate within R1 and will never be tested against the ACL applied to the R1 serial interface.

You can further verify this by issuing the **show ip access-list** on R1 after pinging.

```
R1#show ip access-list
Extended IP access list EXTEND-1
    10 deny ip 192.168.10.0 0.0.0.255 host 209.165.200.225 (4 matches)
    20 permit ip any any
```

Task 5: Control Access to the VTY Lines with a Standard ACL

It is good practice to restrict access to the router VTY lines for remote administration. An ACL can be applied to the VTY lines, allowing you to restrict access to specific hosts or networks. In this task, you will configure a standard ACL to permit hosts from two networks to access the VTY lines. All other hosts are denied.

Verify that you can telnet to R2 from both R1 and R3.

Step 1: Configure the ACL.

Configure a named standard ACL on R2 that permits traffic from 10.2.2.0/30 and 192.168.30.0/24. Deny all other traffic. Call the ACL **TASK-5**.

```
R2(config)#ip access-list standard TASK-5
R2(config-std-nacl)#permit 10.2.2.0 0.0.0.3
R2(config-std-nacl)#permit 192.168.30.0 0.0.0.255
```

Step 2: Apply the ACL.

Enter line configuration mode for VTY lines 0–4.

```
R2(config)#line vty 0 4
```

Use the **access-class** command to apply the ACL to the vty lines in the inbound direction. Note that this differs from the command used to apply ACLs to other interfaces.

```
R2(config-line)#access-class TASK-5 in
R2(config-line)#end
R2#copy run start
```

Step 3: Test the ACL

Telnet to R2 from R1. Note that R1 does not have IP addresses in the address range listed in the ACL TASK-5 permit statements. Connection attempts should fail.

```
R1# telnet 10.1.1.2
Trying 10.1.1.2 …
% Connection refused by remote host
```

From R3, telnet to R2. You will be presented with a prompt for the VTY line password.

```
R3# telnet 10.1.1.2
Trying 10.1.1.2 … Open
CUnauthorized access strictly prohibited, violators will be prosecuted
to the full extent of the law.

User Access Verification

Password:
```

Why do connection attempts from other networks fail even though they are not specifically listed in the ACL?

____

____

Task 6: Troubleshooting ACLs

When an ACL is improperly configured or applied to the wrong interface or in the wrong direction, network traffic may be affected in an undesirable manner.

Step 1: Remove ACL STND-1 from S0/0/1 of R3.

In an earlier task, you created and applied a named standard ACL on R3. Use the **show running-config** command to view the ACL and its placement. You should see that an ACL named **STND-1** was configured and applied inbound on Serial 0/0/1. Recall that this ACL was designed to block all network traffic with a source address from the 192.168.11.0/24 network from accessing the LAN on R3.

To remove the ACL, go to interface configuration mode for Serial 0/0/1 on R3. Use the **no ip access-group STND-1 in** command to remove the ACL from the interface.

```
R3(config)#interface serial 0/0/1
R3(config-if)#no ip access-group STND-1 in
```

Use the **show running-config** command to confirm that the ACL has been removed from Serial 0/0/1.

Step 2: Apply ACL STND-1 on S0/0/1 outbound.

To test the importance of ACL filtering direction, reapply the **STND-1** ACL to the Serial 0/0/1 interface. This time the ACL will be filtering outbound traffic, rather than inbound traffic. Remember to use the **out** keyword when applying the ACL.

```
R3(config)#interface serial 0/0/1
R3(config-if)#ip access-group STND-1 out
```

Step 3: Test the ACL.

Test the ACL by pinging from PC2 to PC3. As an alternative, use an extended ping from R1. Notice that this time pings succeed, and the ACL counters are not incremented. Confirm this by issuing the **show ip access-list** command on R3.

Step 4: Restore the ACL to its original configuration.

Remove the ACL from the outbound direction and reapply it to the inbound direction.

```
R3(config)#interface serial 0/0/1
R3(config-if)#no ip access-group STND-1 out
R3(config-if)#ip access-group STND-1 in
```

Step 5: Apply TASK-5 to the R2 serial 0/0/0 interface inbound.

```
R2(config)#interface serial 0/0/0
R2(config-if)#ip access-group TASK-5 in
```

Step 6: Test the ACL.

Attempt to communicate to any device connected to R2 or R3 from R1 or its attached networks. Notice that all communication is blocked; however, ACL counters are not incremented. This is because of the implicit “deny all” at the end of every ACL. This deny statement will prevent all inbound traffic to serial 0/0/0 from any source other than R3. Essentially, this will cause routes from R1 to be removed from the routing table.

You should see messages similar to the following printed on the consoles of R1 and R2 (It will take some time for the OSPF neighbor relationship to go down, so be patient):

```
*Sep  4 09:51:21.757: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.11.1 on
Serial0/0/0 from FULL to DOWN, Neighbor Down: Dead timer expired
```

Once you receive this message, issue the command `show ip route` on both R1 and R2 to see which routes have been removed from the routing table.

Remove ACL TASK-5 from the interface, and save your configurations.

```
R2(config)#interface serial 0/0/0
R2(config-if)#no ip access-group TASK-5 in
R2(config)#exit
R2#copy run start
```


Task 7: Document the Router Configurations

Configurations

Router 1

```
hostname R1
!
enable secret class
!
no ip domain lookup
!
interface FastEthernet0/0
 ip address 192.168.10.1 255.255.255.0
 no shutdown
!
interface FastEthernet0/1
 ip address 192.168.11.1 255.255.255.0
 no shutdown
!
interface Serial0/0/0
 ip address 10.1.1.1 255.255.255.252
 ip access-group EXTEND-1 out
 clockrate 64000
 no shutdown
!
router ospf 1
 network 10.1.1.0 0.0.0.3 area 0
 network 192.168.10.0 0.0.0.255 area 0
 network 192.168.11.0 0.0.0.255 area 0
!
ip access-list extended EXTEND-1
 deny   ip 192.168.10.0 0.0.0.255 host 209.165.200.225
 permit ip any any
!
banner motd ^CUnauthorized access strictly prohibited, violators will be
prosecuted to the full extent of the law.^
!
line con 0
 password cisco
 logging synchronous
 login
!
line vty 0 4
 password cisco
 login
!
```

Router 2

```
hostname R2
!
enable secret class
!
no ip domain lookup
!
```



```
interface Loopback0
 ip address 209.165.200.225 255.255.255.224
!
interface FastEthernet0/1
 ip address 192.168.20.1 255.255.255.0
 no shutdown
!
interface Serial0/0/0
 ip address 10.1.1.2 255.255.255.252
 no shutdown
!
interface Serial0/0/1
 ip address 10.2.2.1 255.255.255.252
 clockrate 125000
 no shutdown
!
router ospf 1
 no auto-cost
 network 10.1.1.0 0.0.0.3 area 0
 network 10.2.2.0 0.0.0.3 area 0
 network 192.168.20.0 0.0.0.255 area 0
 network 209.165.200.224 0.0.0.31 area 0
!
ip access-list standard TASK-5
 permit 10.2.2.0 0.0.0.3
 permit 192.168.30.0 0.0.0.255
!
banner motd ^Unauthorized access strictly prohibited, violators will be
prosecuted to the full extent of the law.^
!
line con 0
 password cisco
 logging synchronous
 login
!
line vty 0 4
 access-class TASK-5 in
 password cisco
 login
!
```

Router 3

```
hostname R3
!
enable secret class
!
no ip domain lookup
!
interface FastEthernet0/1
 ip address 192.168.30.1 255.255.255.0
 no shutdown
!
interface Serial0/0/1
 ip address 10.2.2.2 255.255.255.252
 ip access-group STND-1 in
```



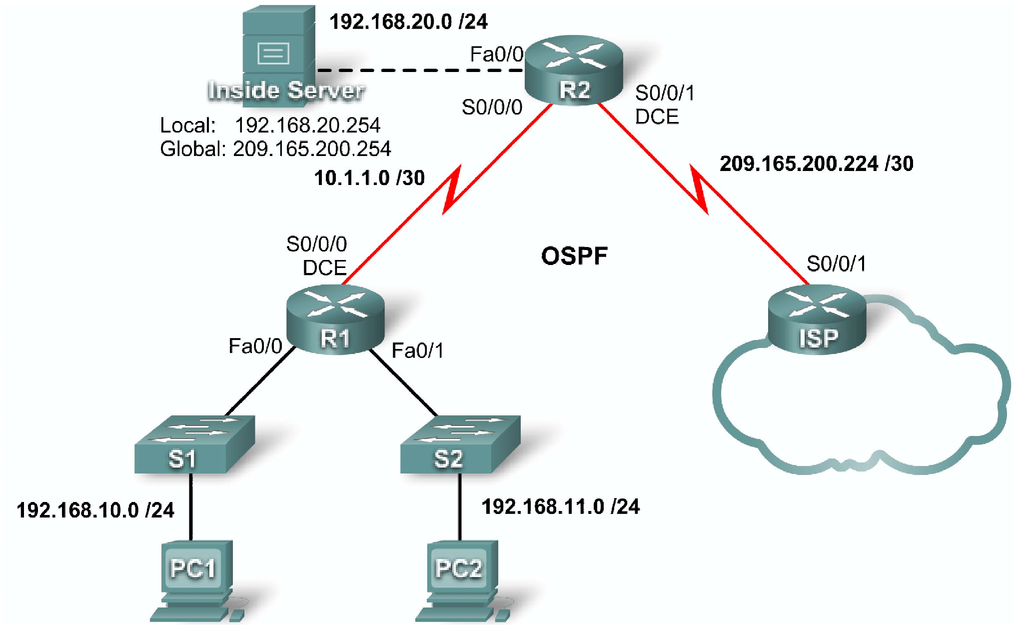
```
 no shutdown
!
router ospf 1
 network 10.2.2.0 0.0.0.3 area 0
 network 192.168.30.0 0.0.0.255 area 0
!
ip access-list standard STND-1
 deny   192.168.11.0 0.0.0.255 log
 permit any
!
banner motd ^Unauthorized access strictly prohibited, violators will be
prosecuted to the full extent of the law.^
!
line con 0
 password cisco
 logging synchronous
 login
!
line vty 0 4
 password cisco
 login
!
end
```

Task 8: Clean Up

Erase the configurations and reload the routers. Disconnect and store the cabling. For PC hosts that are normally connected to other networks, such as the school LAN or the Internet, reconnect the appropriate cabling and restore the TCP/IP settings.

Lab 7.4.1: Basic DHCP and NAT Configuration

Topology Diagram



Addressing Table

Device	Interface	IP Address	Subnet Mask
R1	S0/0/0	10.1.1.1	255.255.255.252
	Fa0/0	192.168.10.1	255.255.255.0
	Fa0/1	192.168.11.1	255.255.255.0
R2	S0/0/0	10.1.1.2	255.255.255.252
	S0/0/1	209.165.200.225	255.255.255.252
	Fa0/0	192.168.20.1	255.255.255.0
ISP	S0/0/1	209.165.200.226	255.255.255.252

Learning Objectives

Upon completion of this lab, you will be able to:

- Prepare the network.
- Perform basic router configurations.
- Configure a Cisco IOS DHCP server.
- Configure static and default routing.
- Configure static NAT.
- Configure dynamic NAT with a pool of addresses.

- Configure NAT overload.

Scenario

In this lab, you will configure the DHCP and NAT IP services. One router is the DHCP server. The other router forwards DHCP requests to the server. You will also configure both static and dynamic NAT configurations, including NAT overload. When you have completed the configurations, verify the connectivity between the inside and outside addresses.

Task 1: Prepare the Network

Step 1: Cable a network that is similar to the one in the topology diagram.

You can use any current router in your lab as long as it has the required interfaces shown in the topology.

Note: If you use a 1700, 2500, or 2600 series router, the router outputs and interface descriptions may look different. On older routers some commands may be different, or not exist.

Step 2: Clear all existing configurations on the routers.

Task 2: Perform Basic Router Configurations

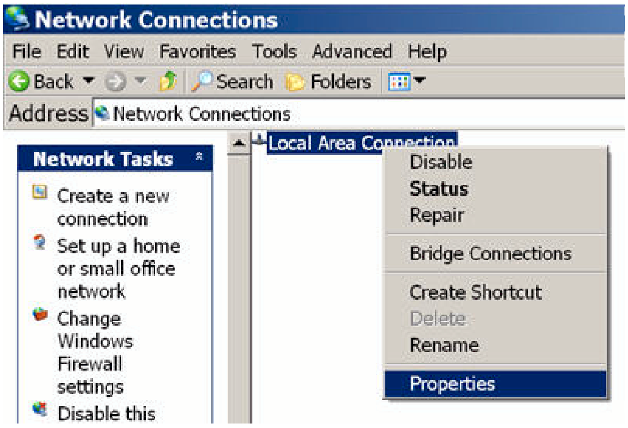
Configure the R1, R2, and ISP routers according to the following guidelines:

- Configure the device hostname.
- Disable DNS lookup.
- Configure a privileged EXEC mode password.
- Configure a message-of-the-day banner.
- Configure a password for the console connections.
- Configure a password for all vty connections.
- Configure IP addresses on all routers. The PCs receive IP addressing from DHCP later in the lab.
- Enable OSPF with process ID 1 on R1 and R2. Do not advertise the 209.165.200.224/27 network.

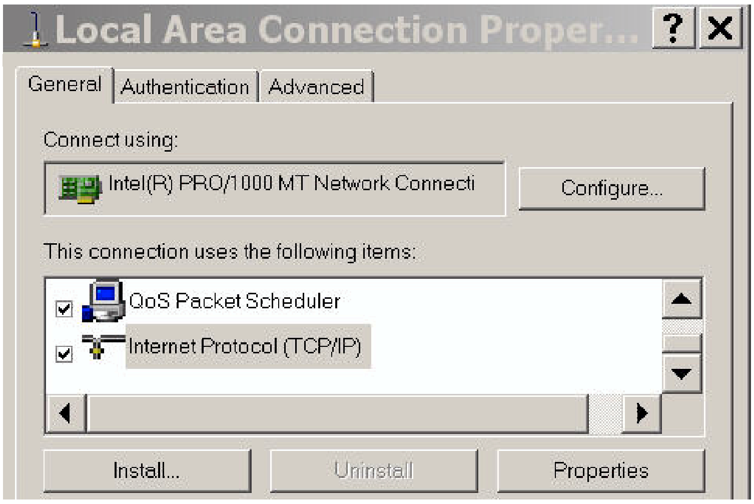
Note: Instead of attaching a server to R2, you can configure a loopback interface on R2 to use the IP address 192.168.20.254/24. If you do this, you do not need to configure the Fast Ethernet interface.

Task 3: Configure PC1 and PC2 to receive an IP address through DHCP

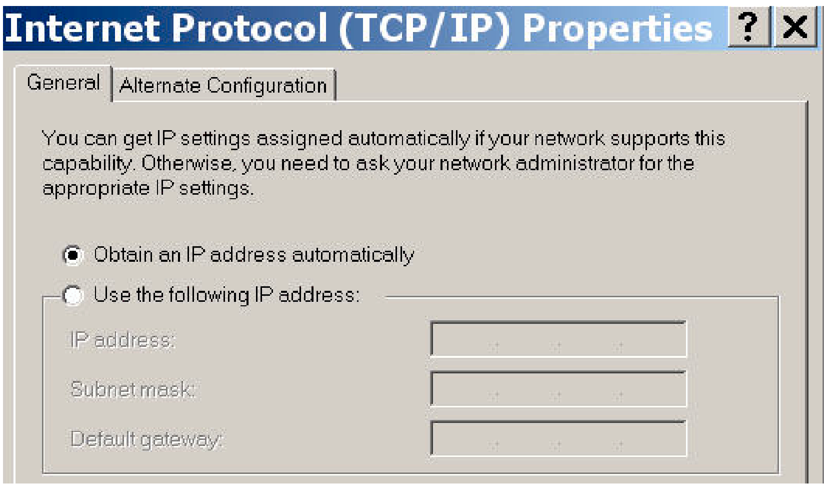
On a Windows PC go to **Start** -> **Control Panel** -> **Network Connections** -> **Local Area Connection**. Right mouse click on the **Local Area Connection** and select **Properties**.



Scroll down and highlight **Internet Protocol (TCP/IP)**. Click on the **Properties** button.



Make sure the button is selected that says **Obtain an IP address automatically**.



Once this has been done on both PC1 and PC2, they are ready to receive an IP address from a DHCP server.

Task 4: Configure a Cisco IOS DHCP Server

Cisco IOS software supports a DHCP server configuration called Easy IP. The goal for this lab is to have devices on the networks 192.168.10.0/24 and 192.168.11.0/24 request IP addresses via DHCP from R2.

Step 1: Exclude statically assigned addresses.

The DHCP server assumes that all IP addresses in a DHCP address pool subnet are available for assigning to DHCP clients. You must specify the IP addresses that the DHCP server should not assign to clients. These IP addresses are usually static addresses reserved for the router interface, switch management IP address, servers, and local network printer. The **ip dhcp excluded-address** command prevents the router from assigning IP addresses within the configured range. The following commands exclude the first 10 IP addresses from each pool for the LANs attached to R1. These addresses will not be assigned to any DHCP clients.

```
R2(config)#ip dhcp excluded-address 192.168.10.1 192.168.10.10
R2(config)#ip dhcp excluded-address 192.168.11.1 192.168.11.10
```

Step 2: Configure the pool.

Create the DHCP pool using the **ip dhcp pool** command and name it **R1Fa0**.

```
R2(config)#ip dhcp pool R1Fa0
```

Specify the subnet to use when assigning IP addresses. DHCP pools automatically associate with an interface based on the network statement. The router now acts as a DHCP server, handing out addresses in the 192.168.10.0/24 subnet starting with 192.168.10.1.

```
R2(dhcp-config)#network 192.168.10.0 255.255.255.0
```

Configure the default router and domain name server for the network. Clients receive these settings via DHCP, along with an IP address.

```
R2(dhcp-config)#dns-server 192.168.11.5
R2(dhcp-config)#default-router 192.168.10.1
```

Note: There is not a DNS server at 192.168.11.5. You are configuring the command for practice only.

Because devices from the network 192.168.11.0/24 also request addresses from R2, a separate pool must be created to serve devices on that network. The commands are similar to the commands shown above:

```
R2(config)#ip dhcp pool R1Fa1
R2(dhcp-config)#network 192.168.11.0 255.255.255.0
R2(dhcp-config)#dns-server 192.168.11.5
R2(dhcp-config)#default-router 192.168.11.1
```

Step 3: Test DHCP

On PC1 and PC2 test whether each has received an IP address automatically. On each PC go to **Start -> Run -> cmd -> ipconfig**

What are the results of your test? ______________________________________

Why are these the results? ____

Step 4: Configure a helper address.

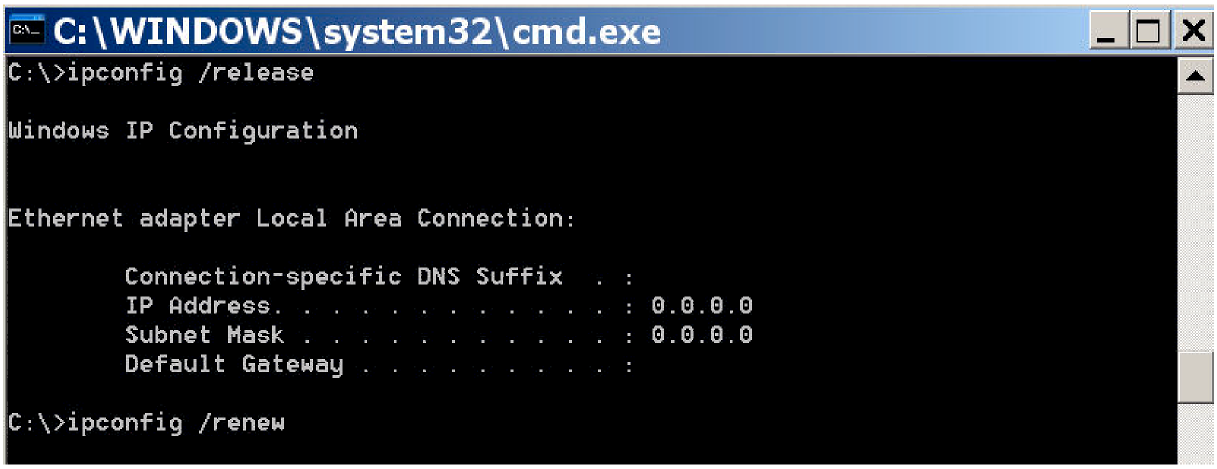
Network services such as DHCP rely on Layer 2 broadcasts to function. When the devices providing these services exist on a different subnet than the clients, they cannot receive the broadcast packets. Because the DHCP server and the DHCP clients are not on the same subnet, configure R1 to forward DHCP broadcasts to R2, which is the DHCP server, using the **ip helper-address** interface configuration command.

Notice that **ip helper-address** must be configured on each interface involved.

```
R1(config)#interface fa0/0
R1(config-if)#ip helper-address 10.1.1.2
R1(config)#interface fa0/1
R1(config-if)#ip helper-address 10.1.1.2
```

Step 5: Release and Renew the IP addresses on PC1 and PC2

Depending upon whether your PCs have been used in a different lab, or connected to the internet, they may already have learned an IP address automatically from a different DHCP server. We need to clear this IP address using the **ipconfig /release** and **ipconfig /renew** commands.



Step 6: Verify the DHCP configuration.

You can verify the DHCP server configuration in several different ways. Issue the command **ipconfig** on PC1 and PC2 to verify that they have now received an IP address dynamically. You can then issue commands on the router to get more information. The **show ip dhcp binding** command provides information on all currently assigned DHCP addresses. For instance, the following output shows that the IP address 192.168.10.11 has been assigned to MAC address 3031.632e.3537.6563. The IP lease expires on September 14, 2007 at 7:33 p.m.

```
R1#show ip dhcp binding
Bindings from all pools not associated with VRF:
IP address          Client-ID/            Lease expiration        Type
                    Hardware address/
                    User name
192.168.10.11       0063.6973.636f.2d30.  Sep 14 2007 07:33 PM    Automatic
                    3031.632e.3537.6563.
                    2e30.3634.302d.566c.
```



```
                    31
```

The **show ip dhcp pool** command displays information on all currently configured DHCP pools on the router. In this output, the pool **R1Fa0** is configured on R1. One address has been leased from this pool. The next client to request an address will receive 192.168.10.12.

```
R2#show ip dhcp pool
Pool R1Fa0 :
 Utilization mark (high/low)     : 100 / 0
 Subnet size (first/next)        : 0 / 0
 Total addresses                 : 254
 Leased addresses                : 1
 Pending event                   : none
 1 subnet is currently in the pool :
 Current index        IP address range                    Leased addresses
 192.168.10.12        192.168.10.1     - 192.168.10.254    1
```

The **debug ip dhcp server events** command can be extremely useful when troubleshooting DHCP leases with a Cisco IOS DHCP server. The following is the debug output on R1 after connecting a host. Notice that the highlighted portion shows DHCP giving the client an address of 192.168.10.12 and mask of 255.255.255.0

```
*Sep 13 21:04:18.072: DHCPD: Sending notification of DISCOVER:
*Sep 13 21:04:18.072:   DHCPD: htype 1 chaddr 001c.57ec.0640
*Sep 13 21:04:18.072:   DHCPD: remote id 020a0000c0a80b01010000000000
*Sep 13 21:04:18.072:   DHCPD: circuit id 00000000
*Sep 13 21:04:18.072: DHCPD: Seeing if there is an internally specified pool
class:
*Sep 13 21:04:18.072:   DHCPD: htype 1 chaddr 001c.57ec.0640
*Sep 13 21:04:18.072:   DHCPD: remote id 020a0000c0a80b01010000000000
*Sep 13 21:04:18.072:   DHCPD: circuit id 00000000
*Sep 13 21:04:18.072: DHCPD: there is no address pool for 192.168.11.1.
*Sep 13 21:04:18.072: DHCPD: Sending notification of DISCOVER:
R1#
*Sep 13 21:04:18.072:   DHCPD: htype 1 chaddr 001c.57ec.0640
*Sep 13 21:04:18.072:   DHCPD: remote id 020a0000c0a80a01000000000000
*Sep 13 21:04:18.072:   DHCPD: circuit id 00000000
*Sep 13 21:04:18.072: DHCPD: Seeing if there is an internally specified pool
class:
*Sep 13 21:04:18.072:   DHCPD: htype 1 chaddr 001c.57ec.0640
*Sep 13 21:04:18.072:   DHCPD: remote id 020a0000c0a80a01000000000000
*Sep 13 21:04:18.072:   DHCPD: circuit id 00000000
R1#
*Sep 13 21:04:20.072: DHCPD: Adding binding to radix tree (192.168.10.12)
*Sep 13 21:04:20.072: DHCPD: Adding binding to hash tree
*Sep 13 21:04:20.072: DHCPD: assigned IP address 192.168.10.12 to client
0063.6973.636f.2d30.3031.632e.3537.6563.2e30.3634.302d.566c.31.
*Sep 13 21:04:20.072: DHCPD: Sending notification of ASSIGNMENT:
*Sep 13 21:04:20.072:  DHCPD: address 192.168.10.12 mask 255.255.255.0
*Sep 13 21:04:20.072:   DHCPD: htype 1 chaddr 001c.57ec.0640
*Sep 13 21:04:20.072:   DHCPD: lease time remaining (secs) = 86400
*Sep 13 21:04:20.076: DHCPD: Sending notification of ASSIGNMENT:
*Sep 13 21:04:20.076:  DHCPD: address 192.168.10.12 mask 255.255.255.0
R1#
*Sep 13 21:04:20.076:   DHCPD: htype 1 chaddr 001c.57ec.0640
*Sep 13 21:04:20.076:   DHCPD: lease time remaining (secs) = 86400
```


Task 5: Configure Static and Default Routing

ISP uses static routing to reach all networks beyond R2. However, R2 translates private addresses into public addresses before sending traffic to ISP. Therefore, ISP must be configured with the public addresses that are part of the NAT configuration on R2. Enter the following static route on ISP:

```
ISP(config)#ip route 209.165.200.240 255.255.255.240 serial 0/0/1
```

This static route includes all addresses assigned to R2 for public use.

Configure a default route on R2 and propagate the route in OSPF.

```
R2(config)#ip route 0.0.0.0 0.0.0.0 209.165.200.226
R2(config)#router ospf 1
R2(config-router)#default-information originate
```

Allow a few seconds for R1 to learn the default route from R2 and then check the R1 routing table. Alternatively, you can clear the routing table with the **clear ip route** * command. A default route pointing to R2 should appear in the R1 routing table. Note that the static route that is configured on the ISP only routes to the public addresses that the R1 hosts will use after NAT is configured on R2. Until NAT is configured, the static route will lead to an unknown network, causing the pings from R1 to fail.

Task 6: Configure Static NAT

Step 1: Statically map a public IP address to a private IP address.

The inside server attached to R2 is accessible by outside hosts beyond ISP. Statically assign the public IP address 209.165.200.254 as the address for NAT to use to map packets to the private IP address of the inside server at 192.168.20.254.

```
R2(config)#ip nat inside source static 192.168.20.254 209.165.200.254
```

Step 2: Specify inside and outside NAT interfaces.

Before NAT can work, you must specify which interfaces are inside and which interfaces are outside.

```
R2(config)#interface serial 0/0/1
R2(config-if)#ip nat outside
R2(config-if)#interface fa0/0
R2(config-if)#ip nat inside
```

Note: If using a simulated inside server, assign the **ip nat inside** command to the loopback interface.

Step 3: Verify the static NAT configuration.

From ISP, ping the public IP address 209.165.200.254.

Task 7: Configure Dynamic NAT with a Pool of Addresses

While static NAT provides a permanent mapping between an internal address and a specific public address, dynamic NAT maps private IP addresses to public addresses. These public IP addresses come from a NAT pool.

Step 1: Define a pool of global addresses.

Create a pool of addresses to which matched source addresses are translated. The following command creates a pool named MY-NAT-POOL that translates matched addresses to an available IP address in the 209.165.200.241–209.165.200.246 range.

```
R2(config)#ip nat pool MY-NAT-POOL 209.165.200.241 209.165.200.246 netmask
255.255.255.248
```


Step 2: Create an extended access control list to identify which inside addresses are translated.

```
R2(config)#ip access-list extended NAT
R2(config-ext-nacl)#permit ip 192.168.10.0 0.0.0.255 any
R2(config-ext-nacl)#permit ip 192.168.11.0 0.0.0.255 any
```

Step 3: Establish dynamic source translation by binding the pool with the access control list.

A router can have more than one NAT pool and more than one ACL. The following command tells the router which address pool to use to translate hosts that are allowed by the ACL.

```
R2(config)#ip nat inside source list NAT pool MY-NAT-POOL
```

Step 4: Specify inside and outside NAT interfaces.

You have already specified the inside and outside interfaces for your static NAT configuration. Now add the serial interface linked to R1 as an inside interface.

```
R2(config)#interface serial 0/0/0
R2(config-if)#ip nat inside
```

Step 5: Verify the configuration.

Ping ISP from PC1 or the Fast Ethernet interface on R1 using extended **ping**. Then use the **show ip nat translations** and **show ip nat statistics** commands on R2 to verify NAT.

```
R2#show ip nat translations
Pro Inside global      Inside local       Outside local      Outside global
icmp 209.165.200.241:4 192.168.10.1:4     209.165.200.226:4  209.165.200.226:4
--- 209.165.200.241    192.168.10.1       ---                ---
--- 209.165.200.254    192.168.20.254     ---                ---

R2#show ip nat statistics
Total active translations: 2 (1 static, 1 dynamic; 0 extended)
Outside interfaces:
  Serial0/0/1
Inside interfaces:
  Serial0/0/0, Loopback0
Hits: 23  Misses: 3
CEF Translated packets: 18, CEF Punted packets: 0
Expired translations: 3
Dynamic mappings:
-- Inside Source
[Id: 1] access-list NAT pool MY-NAT-POOL refcount 1
 pool MY-NAT-POOL: netmask 255.255.255.248
        start 209.165.200.241 end 209.165.200.246
        type generic, total addresses 6, allocated 1 (16%), misses 0
Queued Packets: 0
```

To troubleshoot issues with NAT, you can use the **debug ip nat** command. Turn on NAT debugging and repeat the ping from PC1.

```
R2#debug ip nat
IP NAT debugging is on
R2#
*Sep 13 21:15:02.215: NAT*: s=192.168.10.11->209.165.200.241, d=209.165.200.226 [25]
*Sep 13 21:15:02.231: NAT*: s=209.165.200.226, d=209.165.200.241->192.168.10.11 [25]
*Sep 13 21:15:02.247: NAT*: s=192.168.10.11->209.165.200.241, d=209.165.200.226 [26]
*Sep 13 21:15:02.263: NAT*: s=209.165.200.226, d=209.165.200.241->192.168.10.11 [26]
```



```
*Sep 13 21:15:02.275: NAT*: s=192.168.10.11->209.165.200.241, d=209.165.200.226 [27]
*Sep 13 21:15:02.291: NAT*: s=209.165.200.226, d=209.165.200.241->192.168.10.11 [27]
*Sep 13 21:15:02.307: NAT*: s=192.168.10.11->209.165.200.241, d=209.165.200.226 [28]
*Sep 13 21:15:02.323: NAT*: s=209.165.200.226, d=209.165.200.241->192.168.10.11 [28]
*Sep 13 21:15:02.335: NAT*: s=192.168.10.11->209.165.200.241, d=209.165.200.226 [29]
*Sep 13 21:15:02.351: NAT*: s=209.165.200.226, d=209.165.200.241->192.168.10.11 [29]
R2#
```

Task 8: Configure NAT Overload

In the previous example, what would happen if you needed more than the six public IP addresses that the pool allows?

____

By tracking port numbers, NAT overloading allows multiple inside users to reuse a public IP address.

In this task, you will remove the pool and mapping statement configured in the previous task. Then you will configure NAT overload on R2 so that all internal IP addresses are translated to the R2 S0/0/1 address when connecting to any outside device.

Step 1: Remove the NAT pool and mapping statement.

Use the following commands to remove the NAT pool and the map to the NAT ACL.

```
R2(config)#no ip nat inside source list NAT pool MY-NAT-POOL
R2(config)#no ip nat pool MY-NAT-POOL 209.165.200.241 209.165.200.246 netmask
255.255.255.248
```

If you receive the following message, clear your NAT translations.

```
%Pool MY-NAT-POOL in use, cannot destroy
R2#clear ip nat translation *
```

Step 2: Configure PAT on R2 using the serial 0/0/1 interface public IP address.

The configuration is similar to dynamic NAT, except that instead of a pool of addresses, the **interface** keyword is used to identify the outside IP address. Therefore, no NAT pool is defined. The **overload** keyword enables the addition of the port number to the translation.

Because you already configured an ACL to identify which inside IP addresses to translate as well as which interfaces are inside and outside, you only need to configure the following:

```
R2(config)#ip nat inside source list NAT interface S0/0/1 overload
```

Step 3: Verify the configuration.

Ping ISP from PC1 or the Fast Ethernet interface on R1 using extended **ping**. Then use the **show ip nat translations** and **show ip nat statistics** commands on R2 to verify NAT.

```
R2#show ip nat translations
Pro Inside global      Inside local       Outside local      Outside global
icmp 209.165.200.225:6 192.168.10.11:6    209.165.200.226:6  209.165.200.226:6
--- 209.165.200.254    192.168.20.254     ---                ---

R2#show ip nat statistics
Total active translations: 2 (1 static, 1 dynamic; 1 extended)
Outside interfaces:
  Serial0/0/1
Inside interfaces:
```



```
  Serial0/0/0, Loopback0
Hits: 48  Misses: 6
CEF Translated packets: 46, CEF Punted packets: 0
Expired translations: 5
Dynamic mappings:
-- Inside Source
[Id: 2] access-list NAT interface Serial0/0/1 refcount 1
Queued Packets: 0
```

Note: In the previous task, you could have added the keyword **overload** to the **ip nat inside source list NAT pool MY-NAT-POOL** command to allow for more than six concurrent users.

Task 9: Document the Network

On each router, issue the **show run** command and capture the configurations.

```
R1#show run
<output omitted>
!
hostname R1
!
enable secret class
!
no ip domain lookup
!
interface FastEthernet0/0
 ip address 192.168.10.1 255.255.255.0
 ip helper-address 10.1.1.2
 no shutdown
!
interface FastEthernet0/1
 ip address 192.168.11.1 255.255.255.0
 ip helper-address 10.1.1.2
 no shutdown
!
interface Serial0/0/0
 ip address 10.1.1.1 255.255.255.252
 clock rate 125000
!
interface Serial0/0/1
 no ip address
 shutdown
!
router ospf 1
 network 10.1.1.0 0.0.0.3 area 0
 network 192.168.10.0 0.0.0.255 area 0
 network 192.168.11.0 0.0.0.255 area 0
!
!
banner motd ^C
***********************************
  !!!AUTHORIZED ACCESS ONLY!!!
***********************************
^C
!
line con 0
```



```
 exec-timeout 0 0
 password cisco
 logging synchronous
 login
line aux 0
 exec-timeout 0 0
 password cisco
 logging synchronous
 login
line vty 0 4
 exec-timeout 0 0
 password cisco
 logging synchronous
 login
!
end
```

R2#**show run**

```
!
hostname R2
!
!
enable secret class
!
no ip dhcp use vrf connected
ip dhcp excluded-address 192.168.10.1 192.168.10.10
ip dhcp excluded-address 192.168.11.1 192.168.11.10
!
ip dhcp pool R1Fa0
   network 192.168.10.0 255.255.255.0
   default-router 192.168.10.1
   dns-server 192.168.11.5
!
ip dhcp pool R1Fa1
   network 192.168.11.0 255.255.255.0
   dns-server 192.168.11.5
   default-router 192.168.11.1
!
no ip domain lookup
!
interface Loopback0
 ip address 192.168.20.254 255.255.255.0
 ip nat inside
 ip virtual-reassembly
!
!
!
interface Serial0/0/0
 ip address 10.1.1.2 255.255.255.252
 ip nat inside
 ip virtual-reassembly
!
interface Serial0/0/1
 ip address 209.165.200.225 255.255.255.252
 ip nat outside
 ip virtual-reassembly
```



```
 clock rate 125000
!
router ospf 1
 network 10.1.1.0 0.0.0.3 area 0
 network 192.168.20.0 0.0.0.255 area 0
 default-information originate
!
ip route 0.0.0.0 0.0.0.0 209.165.200.226
!
!
no ip http server
no ip http secure-server
ip nat inside source list NAT interface Serial0/0/1 overload
ip nat inside source static 192.168.20.254 209.165.200.254
!
ip access-list extended NAT
 permit ip 192.168.10.0 0.0.0.255 any
 permit ip 192.168.11.0 0.0.0.255 any
!
!
banner motd ^C
***********************************
  !!!AUTHORIZED ACCESS ONLY!!!
***********************************
^C
!
line con 0
 exec-timeout 0 0
 password cisco
 logging synchronous
 login
line aux 0
 exec-timeout 0 0
 password cisco
 logging synchronous
 login
line vty 0 4
 exec-timeout 0 0
 password cisco
 logging synchronous
 login
!
end
```

ISP#**show run**

```
<output omitted>
!
hostname ISP
!
enable secret class
!
no ip domain lookup
!
interface Serial0/0/1
```



```
 ip address 209.165.200.226 255.255.255.252
 no shutdown
!
!
!
ip route 209.165.200.240 255.255.255.240 Serial0/0/1
!
banner motd ^C
************************************
  !!!AUTHORIZED ACCESS ONLY!!!
************************************
^C
!
line con 0
 exec-timeout 0 0
 password cisco
 logging synchronous
 login
line aux 0
 exec-timeout 0 0
 password cisco
 logging synchronous
 login
line vty 0 4
password cisco
 logging synchronous
 login
!
end
```

Task 10: Clean Up

Erase the configurations and reload the routers. Disconnect and store the cabling. For PC hosts that are normally connected to other networks, such as the school LAN or the Internet, reconnect the appropriate cabling and restore the TCP/IP settings.

