LABORATORY 8: NETWORK ADDRESS TRANSLATION

Objectives

By the end of the laboratory, students will be able to

- capture IP packets and observe the Network Address Translation process.
- set up a web server in home LAN accessible from the internet.

Introduction:

IPv4 uses 32-bit IP addresses, giving maximum of 4.3 billions different IP addresses. Considering the world's population size and that many people carry more than one device, the addressing space provided by IPv4 is insufficient. The long term solution is IPv6, which is currently being implemented.

While IPv6 was under development, there was a need to slow down the depletion of IPv4 addresses. This led to the introduction of Network Address Translation (NAT). Using NAT, many devices in a private network can share one or a few public IP addresses giving accessibility to the internet. This helps to suppress the demand for public IP addresses.

NAT modifies the IP address in the IP packet header and port number in the Transport Layer protocol (TCP and UDP) header. For outgoing IP packets travelling from private network to public network, NAT translates the Source IP Address and Source Port Number. For incoming IP packets travelling from public network to private network, NAT translates the Destination IP Address and Destination Port Number. The translation is done by referring to the Address Translation Table in the router.

There are four forms of NAT: Static NAT, Dynamic NAT, Overloading and Overlapping. Overloading NAT, also known as "Port Address Translation" (PAT), is a single-address NAT whereby the NAT router translates all private IP addresses to a single public IP address. The Address Translation Table keeps track of both the IP address and layer-4 port number of IP packets. Both the IP address and port number are "translated" when an IP packet travels across the private-public network boundary.

In this lab experiment, we will observe how the PAT works in a wireless broadband router. We will also configure the broadband router to allow a web server in the private network to be accessible from the internet. Figure 8.1 shows the network setup for this lab experiment. It simulates a residential internet subscriber using a DSL modem (DSL modem0) to connect to the internet. A broadband router (Wireless Router0) is connected to the DSL modem, performing the network address translation function. There are two devices in the private network: a laptop for visiting web pages on the internet, and a web server hosting home page. The DSL modem is connected to the internet (the "Internet" cluster). Also connected to the "Internet" cluster are another web server hosting the web page www.CompanyA.com, and a PC ("Someone Else") acting as another internet user. Both of them have been pre-configured. The

"Internet" cluster includes a DHCP server issuing IP address to residential users, and a DNS server performing the domain name resolution.

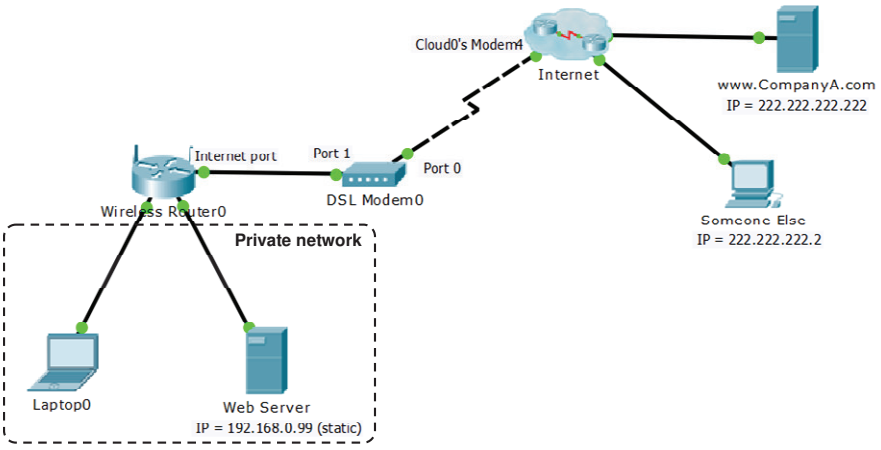


Figure 8.1 - A network for observing Network Address Translation.

Equipment:
Windows OS laptops with Cisco Packet Tracer installed.

Procedures:

1. Construction and Configuration of a Computer Network for observing Network Address Translation.

1.1 Launch the Packet Tracer Activity file ET0730_Lab8_NAT.pka, and you should obtain a partially configured "initial network" as shown in Figure 8.2. The initial network has all the required devices inserted. The "Internet" cluster, the web server for **www.CompanyA.com**, and the PC simulating a remote internet user "Someone Else" all have been pre-configured.

1.2 Referring to Figure 8.1, link up the devices. Table 8.1 lists the connections needed and the type of cable to be used for the connections.

Device A		**Device B**		**Type of cable**
Device Name	Interface	Device Name	Interface	
DSL Modem0	Port 0	"Internet" cluster	Cloud0's Modem4	Phone line
	Port 1	Wireless Router0	"Internet" port	UTP Straight-through
Wireless Router0	Ethernet 1	Laptop0	FastEthernet0	UTP Straight-through
	Ethernet 2	Web Server	FastEthernet0	UTP Straight-through

Table 8.1 – Required connections between devices.

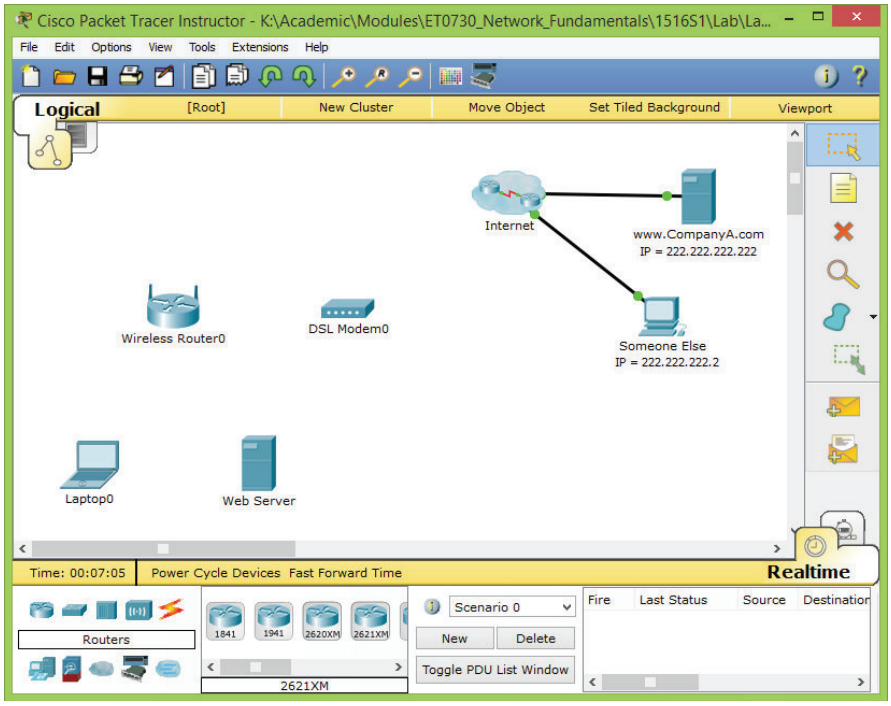


Figure 8.2 – The initial network for observing Network Address Translation.

1.3 In Step 1.4 (next step), you will configure Wireless Router0 using parameters shown in Table 8.2. The internet connection of Wireless Router0 (to public network) is configured to obtain IP address using DHCP. In other words, for the internet connection, Wireless Router0 acts as a **DHCP client**. You will also configure Wireless Router0 as a **DHCP server** for connection to private network. It will issue dynamic private IP address to hosts in the private network. Therefore, Wireless Router0 is both a DHCP client (for public network) and a DHCP server (for private network).

Parameter	**Value**
Internet connection type	Automatic configuration - DHCP
Default gateway for private network	192.168.0.1
DHCP IP Address Range	192.168.0.100 to 192.168.149
DNS Server's IP Address	200.200.200.2

Table 8.2 – Configuration parameters for Wireless Router0.

1.4 Configure the internet connection and DHCP service on the WRT300N router by carrying out the following steps.

1.4.1 Click on Wireless Router0.

1.4.2 Click "GUI" → "Setup". Expand the window to occupy the full screen.

1.4.3 The top part belongs to "Internet Setup". Make sure that the "Internet Connection Type" is set to "**Automatic Configuration – DHCP**" (see Figure 8.3). This step configures Wireless Router0 as DHCP client for its internet connection. When Wireless Router0 is connected to the "Internet" cluster (via the DSL modem), a DHCP server in the "Internet" cluster will issue a dynamic public IP address to the "internet" port of Wireless Router0. This IP address is not fixed, just like the IP address you obtain from your ISP when your home network is connected to the internet.

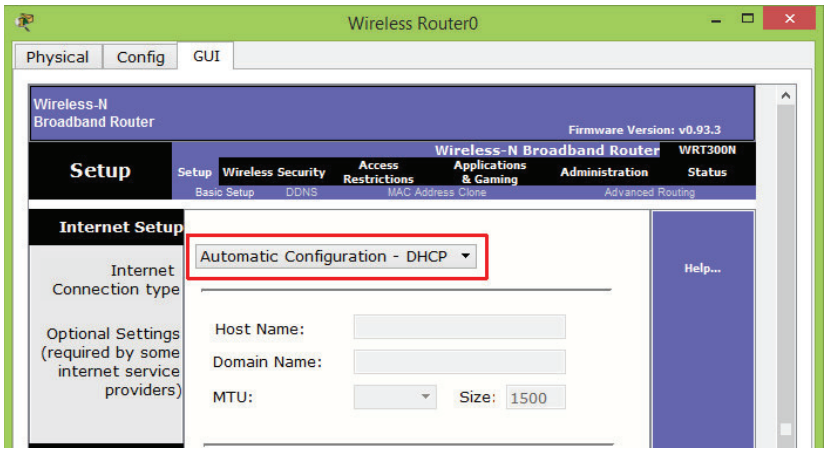


Figure 8.3 – Internet connection of Wireless Router0 is configured to obtain IP address using DHCP.

1.4.4 Under the "Network Setup" portion, make sure that the "IP Address" setting is 192.168.0.1 and subnet mask is 255.255.255.0.

1.4.5 In the textbox next to "Start IP Address:", enter 100 (i.e. Start IP address = 192.168.0.100).

1.4.6 Enter "50" for "Maximum number".

1.4.7 For "Static DNS 1:", enter 200.200.200.2. In the "Internet" cluster, a DNS server has been configured to provide the DNS service. The IP address of the DNS server is 200.200.200.2.

1.4.8 Click the "Save Settings" button at the bottom (may need to scroll down further to reveal the button) to save the configuration of the WRT300N Wireless Router.

1.4.9 Check that you observe the same result as shown in Figure 8.4.

Figure 8.4 – Internet connection and DHCP service configuration for Wireless Router.

1.5 Configure the "Web Server" in the private network with static IP address 192.168.0.99, subnet mask 255.255.255.0 and default gateway 192.168.0.1.

Question:

Why is it advisable to using static IP address for "Web Server"? Besides configuring the IP address manually, what is another possible method to issue a fixed IP address to this web server automatically?

Using static (fixed) IP address for web server will make it easier to be contacted by web clients.

Another method to issue static IP address to the web server automatically is to use the "DHCP Reservation" feature of Wireless Router0 (see Lab 4).

1.6 Configure Laptop0 to obtain its IP address automatically using DHCP from Wireless Router0.

1.6.1 Click on Laptop0's symbol, "Config" → "Global" → Settings". Click on the "Static" radio-button, wait for one second, and click the "DHCP" radio-button. Wait for a few seconds, and you should see some setting (grey text) appear in the textboxes of the "Gateway" and "DNS Server". This shows that laptop0 has successfully contacted Wireless Router0's DHCP service.

1.6.2 Verify the connectivity between Laptop0 and Wireless Router0, by issuing a `ping` command from Laptop0 to its default gateway 192.168.0.1.

1.7 Verify the connectivity between Laptop0 and Web Server.

1.8 Launch the web browser in Laptop0. Enter IP address of Web Server 192.168.0.99 as the URL. You should be able to see the web page hosted by Web Server, as shown in Figure 8.5.

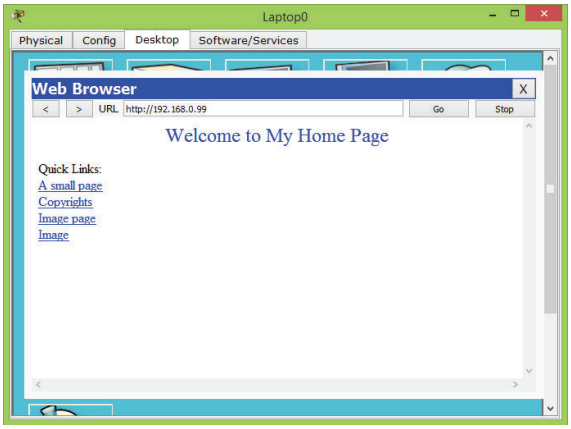


Figure 8.5 – The web page hosted by "Web Server".

1.9 Still at Laptop0, enter www.CompanyA.com as the URL. You should be able to see Company A's web page hosted by the web server at the far right (222.222.222.222). If you fail to see the web page, troubleshoot your network. Company A's web page is shown in Figure 8.6.

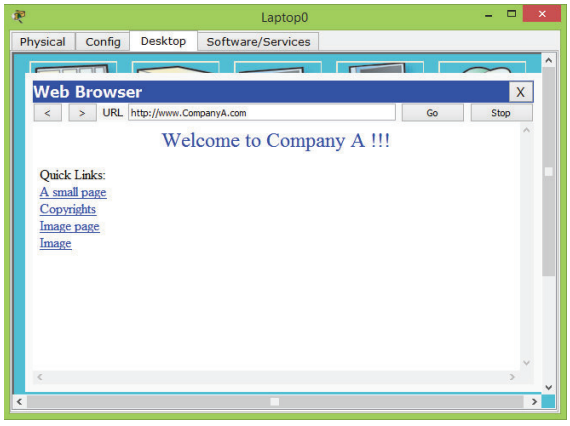


Figure 8.6 – Company A's web page at www.CompanyA.com.

2. Observe Network Address Translation.

2.1 Switch the Packet Tracer to “Simulation Mode”.

2.2 Click the “Show All/None” button once. This de-selects all protocols.

2.3 Click the “Edit Filters” button, then select “Ipv4” tab. There should not be any protocol selected.

2.4 Click on the “Misc” tab, then put a tick in the box next to “HTTP”. The rest should not be selected.

2.5 Click somewhere else to close the “Edit Filters” window.

2.6 Click on Laptop0. Select the “Desktop” tab, then select “Web Browser”. If the browser is still showing **www.CompanyA.com**, close it and re-launch the browser.

2.7 Enter ***www.CompanyA.com*** in the URL textbox. Click the “Go” button.

2.8 Minimise the Laptop0 window. Click the “Capture & Forward” button once. You should see a HTTP packet appearing at Laptop0. You should also see two “Info” boxes at the “Simulation Panel”, both of HTTP type.

2.9 At the Simulation Panel, click the topmost “Info” box of “HTTP” type. A window showing the PDU information will pop up, as shown in Figure 8.7 (the contents may be slightly different).

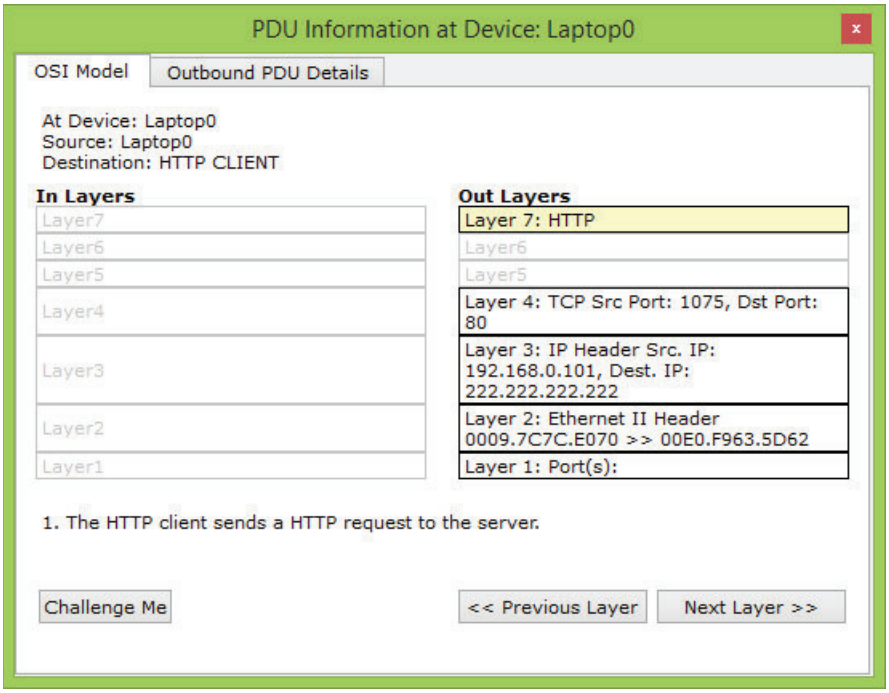


Figure 8.7 – PDU information of the HTTP “Info” box.

2.10 Click on “Layer 7: HTTP” of the “Out Layers” column (right-hand-side). A message appears at lower part of the window.

Question:

What is the message? Copy the message using the space provided below.

The HTTP client sends a HTTP request to the server.

2.11 Observe “Layer 4” of the “Out Layers” column (right-hand-side), and record down the following:

Question:

Layer 4 protocol: TCP

Source Port Number: 1075 (This value varies, Should be > 1023).

Destination Port Number: 80

2.12 Observe “Layer 3” of the “Out Layers” column (right-hand-side), and record down the following:

Question:

Source IP Address: 192.168.0.101 (This value varies, depending on the IP address issued to Laptop0 by router).

Destination IP Address: 222.222.222.222

Question:

Which device does the Source IP Address belong to?

Laptop0

Question:

Which device does the Destination IP Address belong to?

Web server hosting www.CompanyA.com.

2.13 Click the “Capture/Forward” button once. The HTTP Request packet will arrive at the router, Wireless Router0. Click on the “HTTP” info box. A window showing the PDU information will pop up, as shown in Figure 8.8 (the contents may be slightly different).

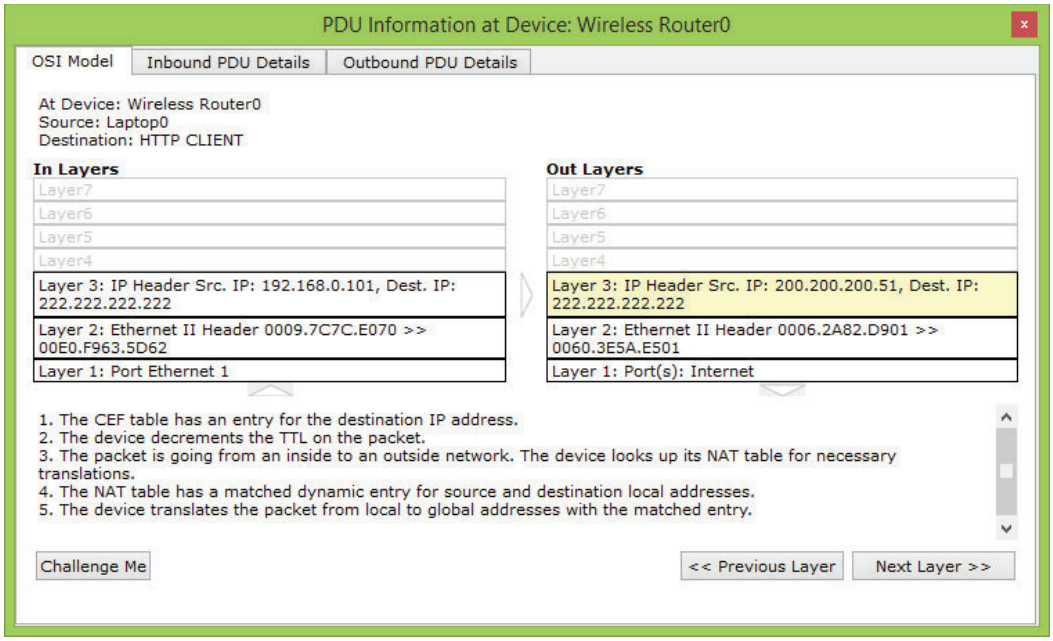


Figure 8.8 – PDU information of the HTTP "Info" box at Wireless Router0.

2.14 Observe "Layer 3" of both the "In Layers" (left column) and "Out Layers" (right column). Record the Source IP Addresses and Destination IP Addresses using the space provided below:

In Layers			Out Layers	
Source IP Address	192.168.0.101 (Varies, but should be 192.168.0.1xx)		Source IP Address	200.200.200.51 (Varies, but should be 200.200.200.x)
Destination IP Address	222.222.222.222		Destination IP Address	222.222.222.222

Question:

Comparing "In Layers" and "Out Layers", what do you observe?

The Source IP Address changes from 192.168.0.101 to 200.200.200.51.

Question:

What has the router Wireless Router0 done to the IP packet?

Network Address Translation on the Source IP Address field.

Question:

Which device and interface does the Source IP Address of "Out Layers" belong to? Is this a "private" or a "public" IP address?

Device: Wireless Router0

Interface: Internet port

"Private" or "Public" IP address? Public IP Address

2.15 Click on the "Inbound PDU Details" tab. Observe the "TCP" protocol's Source Port Number and Destination Port Number. Record the values using the space provided below. Then, click on the "Outbound PDU Details" tab. Observe the "TCP" protocol's Source Port Number and Destination Port Number. Record the values using the space provided below.

Inbound PDU Details			Outbound PDU Details	
Source Port Address	1075 (Varies, but should be >1023)		Source Port Address	1075 (Varies, but should be >1023)
Destination Port	80		Destination Port	80

2.16 Click the "Capture/Forward" button a few times (probably 4) slowly, until the HTTP Request packet arrives at the web server hosting **www.CompanyA.com**. Click on the "HTTP" info box. A window showing the PDU information will pop up, as shown in Figure 8.9 (the contents may be slightly different).

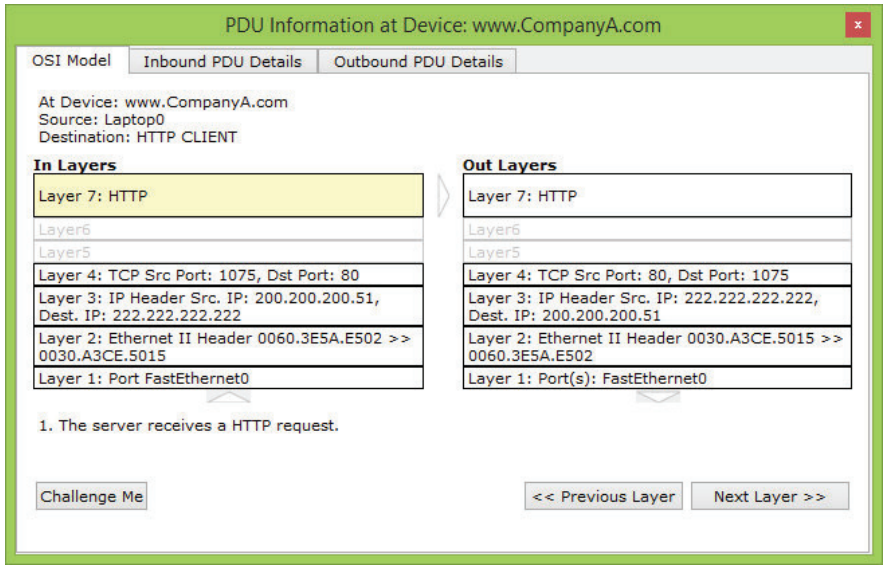


Figure 8.9 – PDU information of the HTTP "Info" box at the web server hosting www.CompanyA.com.

2.17 Click on "Layer 7: HTTP" of the "In Layers" column (left-hand-side). A message appears at lower part of the window.

Question:

What is the message? Copy the message using the space provided below.

The server receives a HTTP request.

2.18 Click on "Layer 7: HTTP" of the "Out Layers" column (right-hand-side). A message appears at lower part of the window.

Question:

What is the message? Copy the message using the space provided below.

The server sends back a HTTP reply to the client.

2.19 Observe "Layer 4" of both the "In Layers" (left column) and "Out Layers" (right column). Record the Source Port and Destination Port using the space provided below:

In Layers			Out Layers	
Source Port	1075 (Varies, but should be >1023)		Source Port	80
Destination Port	80		Destination Port	1075 (Varies, but should be >1023)

Question:

Comparing "In Layers" and "Out Layers", what do you observe?

The Source and Destination Port numbers are swapped.

2.20 Observe "Layer 3" of both the "In Layers" (left column) and "Out Layers" (right column). Record the Source IP Addresses and Destination IP Addresses using the space provided below:

In Layers			Out Layers	
Source IP Address	200.200.200.51 (Varies, but should be 200.200.200.x)		Source IP Address	222.222.222.222
Destination IP Address	222.222.222.222		Destination IP Address	200.200.200.51 (Varies, but should be 200.200.200.x)

Question:

Comparing “In Layers” and “Out Layers”, what do you observe?

The Source and Destination IP addresses are swapped..

Question:

Which device and interface does the Destination IP Address of "Out Layers" belong to? Is this a "private" or a "public" IP address?

Device: Wireless Router0

Interface: Internet port

"Private" or "Public" IP address? Public IP Address

2.21 Click the "Capture/Forward" button a few times (probably 4) slowly, until the HTTP Reply packet arrives at the router Wireless Router0. Click on the "HTTP" info box. A window showing the PDU information will pop up, as shown in Figure 8.10 (the contents may be slightly different).

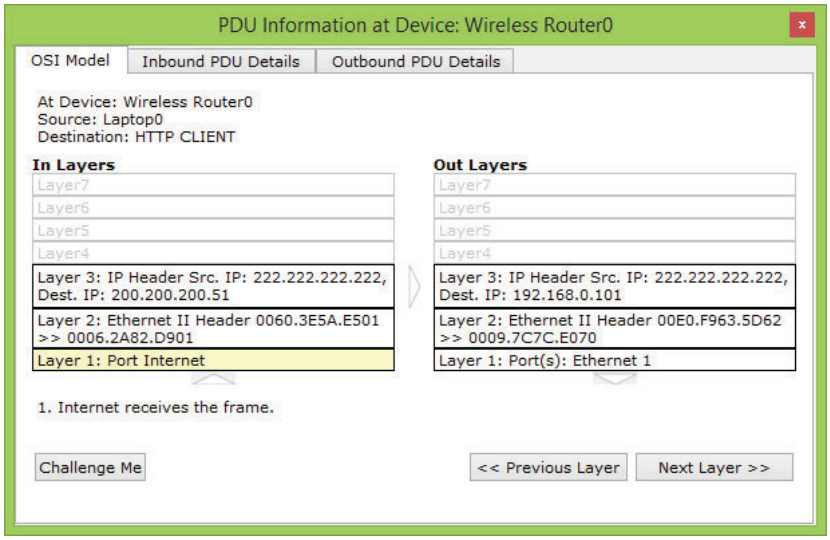


Figure 8.10 – PDU information of the HTTP "Info" box of IP packet returning to router Wireless Router0.

2.22 Observe "Layer 3" of both the "In Layers" (left column) and "Out Layers" (right column). Record the Source IP Addresses and Destination IP Addresses using the space provided below:

In Layers			Out Layers	
Source IP Address	222.222.222.222		Source IP Address	222.222.222.222
Destination IP Address	200.200.200.51 (Varies, but should be 200.200.200.x)		Destination IP Address	192.168.0.101 (Varies, but should be 192.168.0.1xx)

Question:

Comparing "In Layers" and "Out Layers", what do you observe?

The Destination IP Address changes from 200.200.200.51 to 192.168.0.101.

Question:

What has the router Wireless Router0 done to the IP packet?

Network Address Translation on the Destination IP Address field.

Question:

Which device and interface does the Destination IP Address of "Out Layers" belong to? Is this a "private" or a "public" IP address?

Device: Laptop0

Interface: FastEthernet port

"Private" or "Public" IP address? Private IP Address

2.23 Click the "Capture/Forward" button once. The HTTP Reply packet arrives at Laptop0 and displays a tick. Bring up the Laptop0 window. You should see the web page **www.CompanyA.com**.

2.24 Switch the Packet Tracer to "Realtime Mode".

3. Making Web Server in Private Network Accessible from the Internet.

3.1 From the PC "Someone Else", try to ping the router Wireless Router0. You should observe that the pinging fails, although the connectivity between the router and the PC is there. This happens because the router has been configured not to reply to any pinging.

Question:

Why do you think that the router has been configured to behave this way?

For network security reason.

3.2 Verify the connectivity between the web server in the private network and PC "Someone Else", by pinging from the web server to the PC (not the other way round—it will not work. Prove this if you are curious). The pinging should be successful, proving that there is indeed some connectivity between the router Wireless Router0 and PC (since the IP packet has to pass through the router to reach the web server).

3.3 Launch the web browser in the PC. Enter **www.CompanyA.com** as the URL. Click the "Go" button. You should be able to see the web page www.CompanyA.com.

3.4 Still at the PC, now enter IP address of Web Server 192.168.0.99 as the URL. Click the "Go" button.

Question:

Are you able to see the web page hosted on the web server?

No.

Question:

Is the IP address of Web Server a "private" or a "public" IP address?

Private IP Address.

Question:

PC "Someone Else" is a user in the public network. Do you think that a device in the public network should be allowed to contact a device in a private network? Why?

No.

There is security risk in exposing devices in the private network

to public network where the hackers are.

Question:

The web server in the private network is hosting a web page that other internet users should be able to visit. Unfortunately, the web server is using a private IP address 192.168.0.99 that is not accessible from outside networks. If internet users in the public network would like to visit the web page hosted by the web server, which device and which interface's IP address should be entered as the URL?

Wireless Router0's internet port.

Question:

What is the IP address of the device and interface that you gave as your answer in the previous question?

200.200.200.51 (varies, but should be 200.200.200.x).

3.5 Launch the web browser in the PC again. Enter the IP address that you gave as your answer in the previous question as the URL. Click the "Go" button. You should observe that you are still unable to see the web page hosted on the web server.

3.6 The web server in the private network is not accessible from outside because the IP packets are not forwarded to the web server. To do this,

you need to configure the router Wireless Router0 to forward TCP traffic destined for port 80 to the web server.

3.7 Configure the router Wireless Router0 (WRT300N) to forward TCP traffic destined for port 80 to the web server, by carrying out the following steps.

3.7.1 Click on Wireless Router0.

3.7.2 Click "GUI" → "Applications & Gaming". Click "Single Port Forwarding". Expand the window to occupy the full screen.

3.7.3 In the first entry line with empty textbox, enter the parameters as shown in Table 8.3. Your entries should look like Figure 8.11.

Parameter	Value
Application Name	Web server 2 (or any other name you like)
External Port	80
Internal Port	80
Protocol	Both
To IP Address	192.168.0.99
Enable	Yes (put a tick)

Table 8.3 – Single port forwarding to make the web server accessible from outside networks.

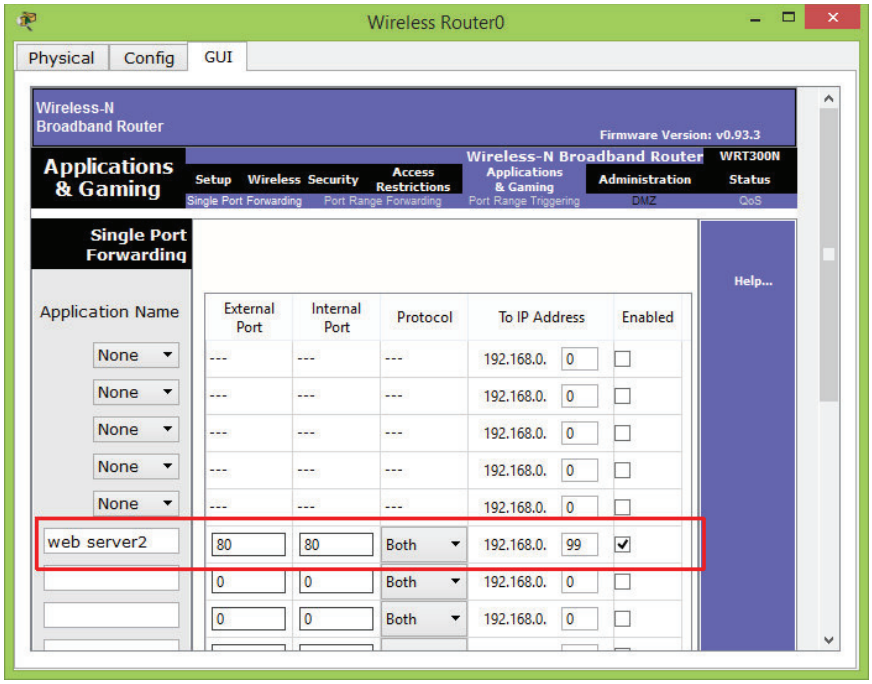


Figure 8.11 – Single port forwarding to make the web server accessible from outside networks.

3.7.4 Click the “Save Settings” button at the bottom (may need to scroll down further to reveal the button) to save the configuration of the WRT300N Wireless Router.

3.7.5 Close the router configuration window.

3.8 Launch the web browser in the PC “Someone Else” again. Enter the IP address of the router Wireless Router0’s internet interface as the URL. Click the “Go” button. You should be able to see the web page hosted on the web server now.

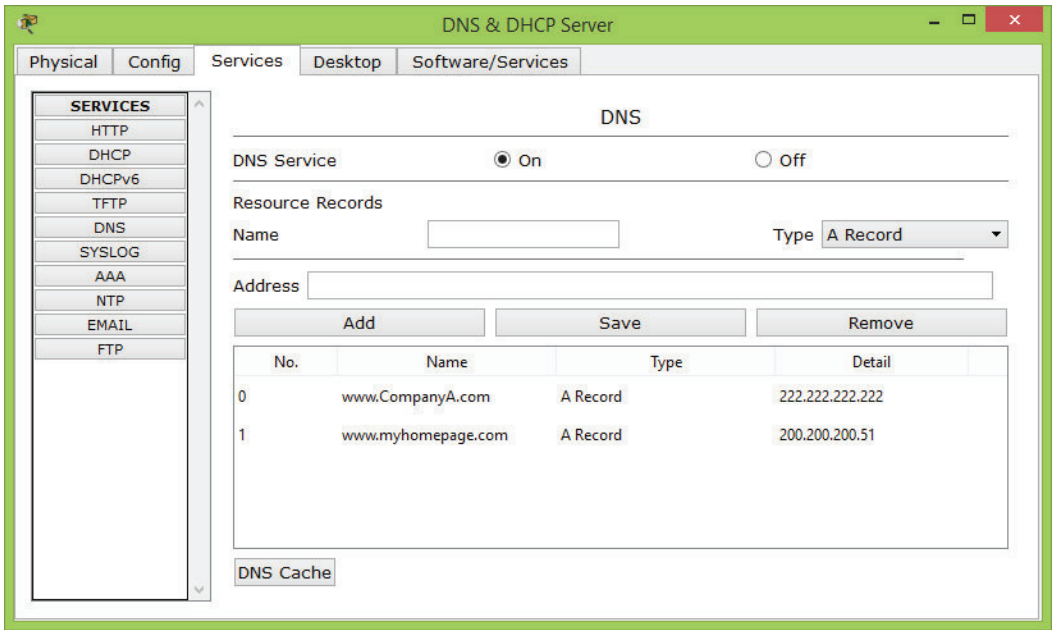
Question:

You can only enter the IP address of the router as the URL to visit the web page hosted by the web server. If you wish to use a domain name, such as **www.myhomepage.com**, as the URL, what configuration (and where) do you need to make?

Need to add an “A” record to the DNS database.

The DNS database is hosted by a server in the ‘Internet” cluster.

3.9 Carry out your answer to the previous question and verify that indeed you can now enter **www.myhomepage.com** as the URL to visit the web page.



Since the IP address of the router is not fixed, this approach of adding a record to the DNS database will not work in real world. The solution is either to pay more in order to get a fixed public IP address, or to use “Dynamic DNS”.