NATIONAL UNIVERSITY OF COMPUTER & EMERGING SCIENCE
Computer Networks Lab (CL307)
Lab Session 06

Application Layer Protocol

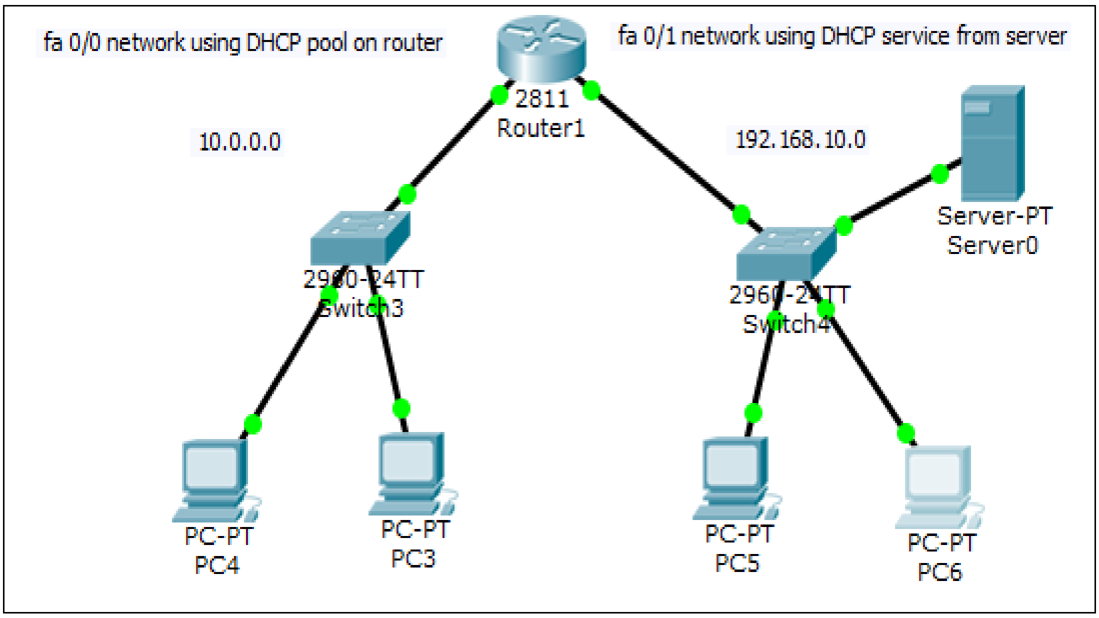
DHCP & DNS in Cisco Packet Tracer

DYNAMIC HOST CONFIGRATION PROTOCOL

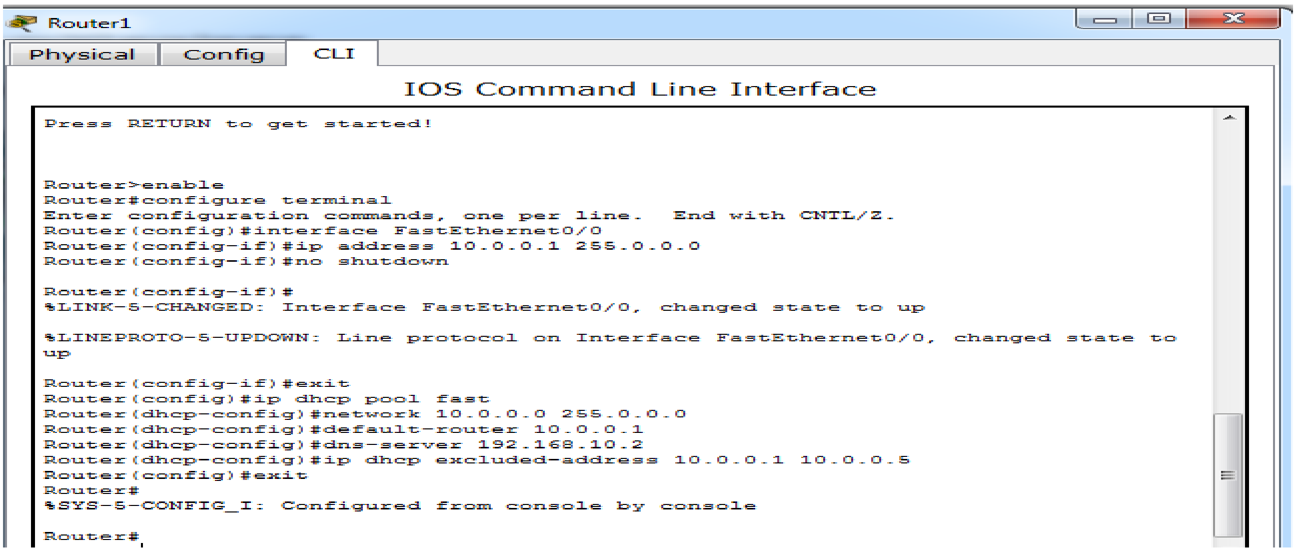
The Dynamic Host Configuration Protocol is used by computers for requesting Internet Protocol parameters, such as an IP address from a network server. The protocol operates based on the client-server model. DHCP is very common in all modern networks ranging in size from home networks to large campus networks and regional Internet service provider networks. Most residential network routers receive a globally unique IP address within the provider network. Within a local network, DHCP assigns a local IP address to devices connected to the local network.

When a computer or other networked device connects to a network, its DHCP client software in the operating system sends a broadcast query requesting necessary information. Any DHCP server on the network may service the request. The DHCP server manages a pool of IP addresses and information about client configuration parameters such as default gateway, domain name, the name servers, time servers. On receiving a request, the server may respond with specific information for each client, as previously configured by an administrator, or with a specific address and any other information valid for the entire network, and the time period for which the allocation (*lease*) is valid. A host typically queries for this information immediately after booting, and periodically thereafter before the expiration of the information. When an assignment is refreshed by the client computer, it initially requests the same parameter values, but may be assigned a new address from the server, based on the assignment policies set by administrators.

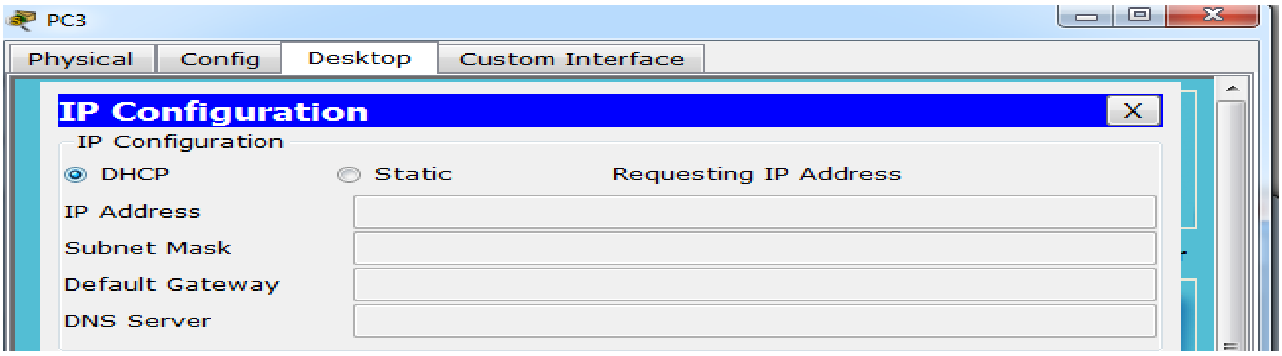
We can use DHCP service from router as well as from Server.

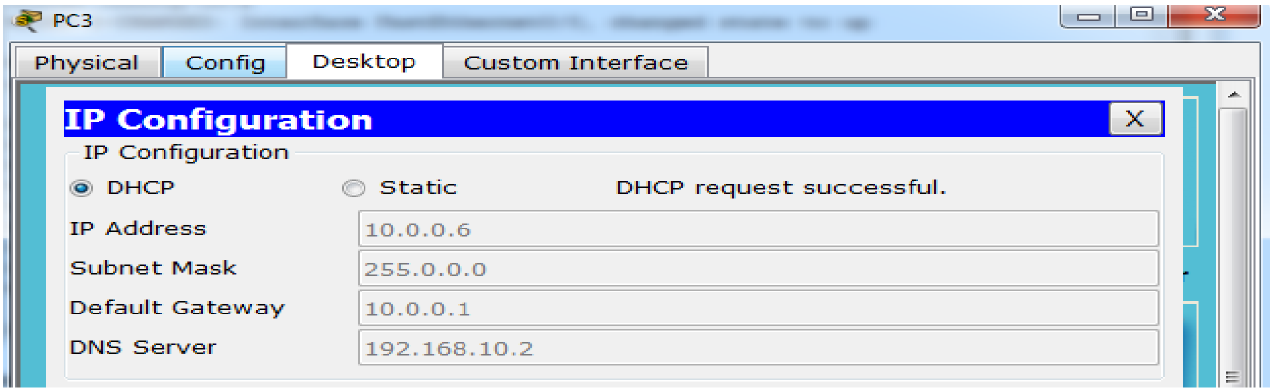


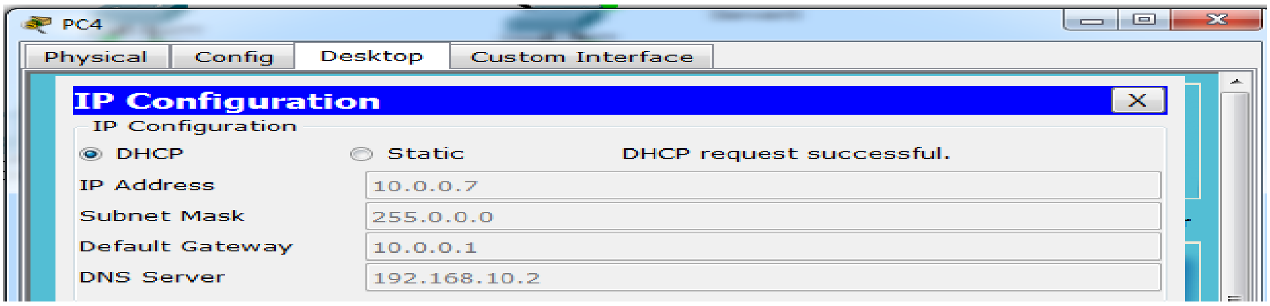
<u>Now configuring network on Fa 0/0.</u>



Now assigning IP to PC3 and PC4.







You can check the status of assigned IP addresses as shown below.

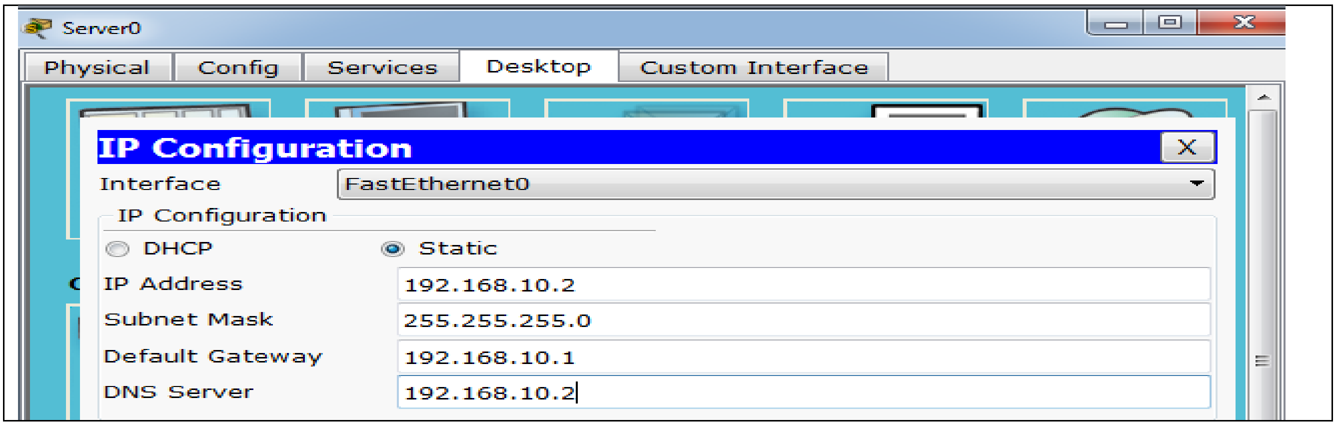
```
Router#
Router#show ip dhcp binding
IP address       Client-ID/              Lease expiration        Type
                 Hardware address
10.0.0.6         000A.F385.2E85           --                     Automatic
10.0.0.7         0060.5C58.2C01           --                     Automatic
```

Now configuring network on Fa 0/1.

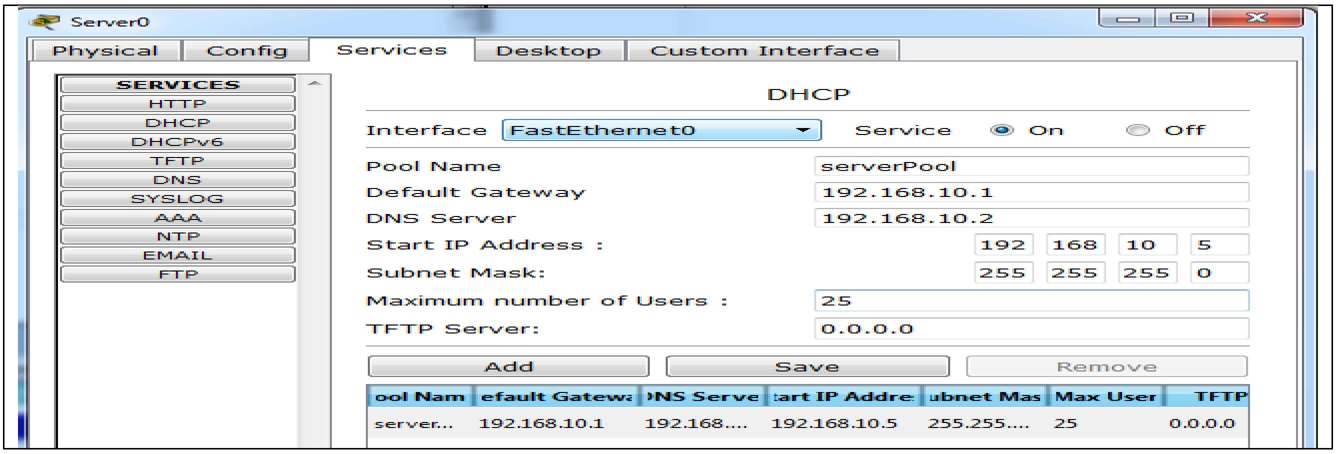
Click on router and assign IP address.

```
Router#
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#interface FastEthernet0/0
Router(config-if)#
Router(config-if)#exit
Router(config)#interface FastEthernet0/1
Router(config-if)#ip address 192.168.10.1 255.255.255.0
Router(config-if)#no shutdown

Router(config-if)#
%LINK-5-CHANGED: Interface FastEthernet0/1, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/1, changed state to
up
```

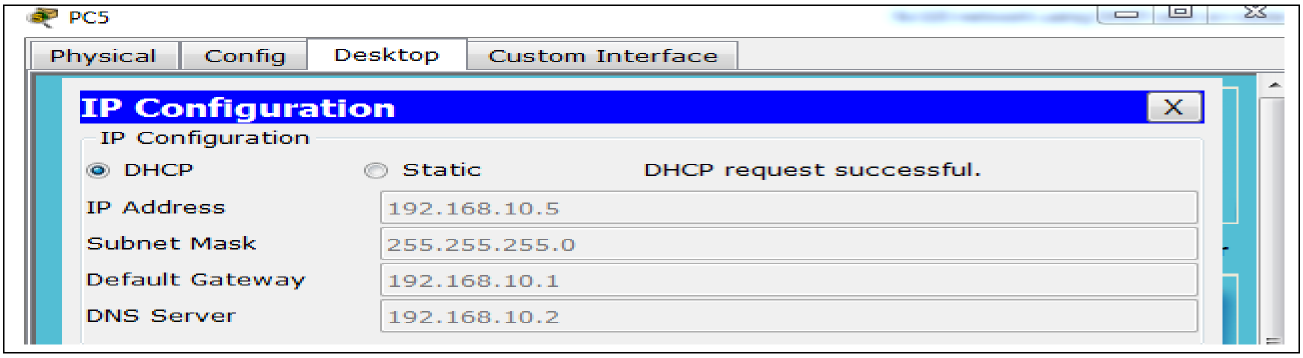
Click on server and assign IP address.

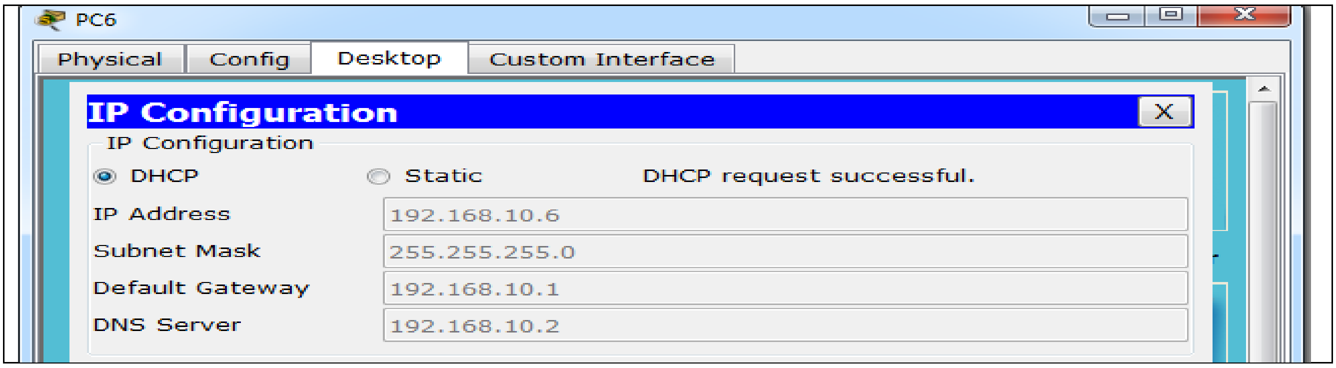


Now assigning DHCP pool on Server. Go to server →services →DHCP



Now assigning IP to PC5 and PC6.



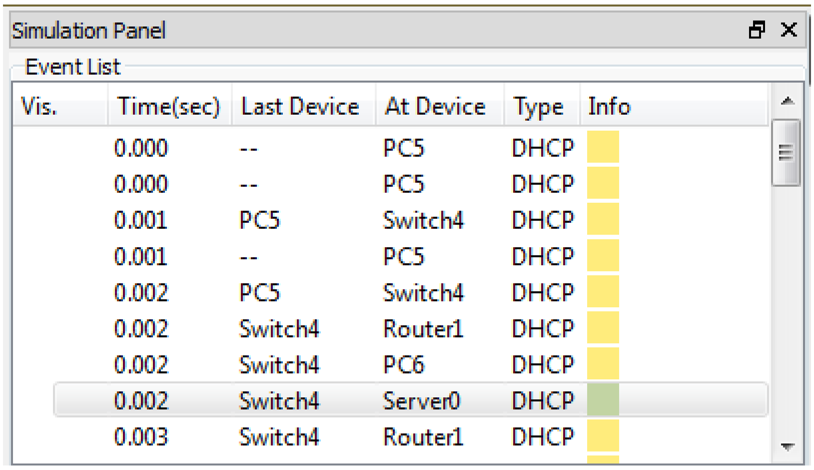


SIMULATION:

a) Now click on simulation icon in the right bottom of packet Tracer.

b) Now click on auto capture /play icon for packet capturing.

c) Click on the PC and go to Desktop →IP configuration → DHCP



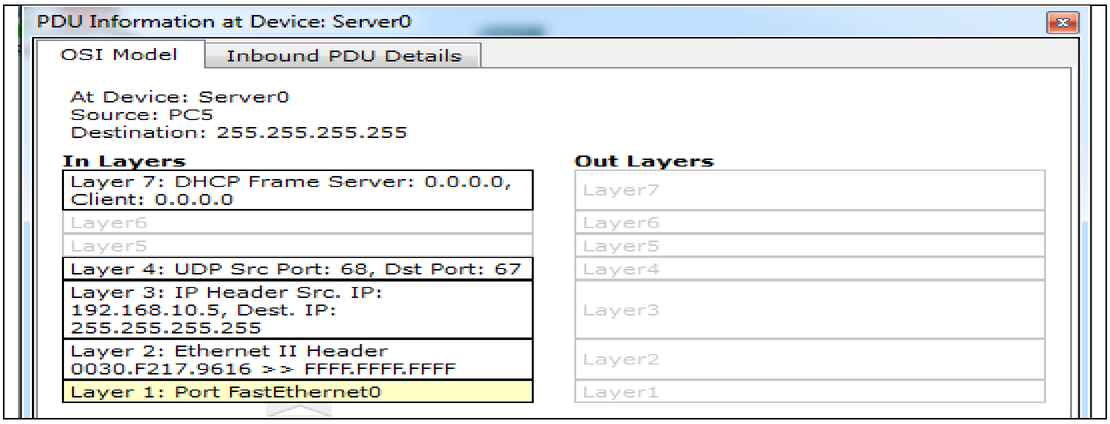
Simulation Panel

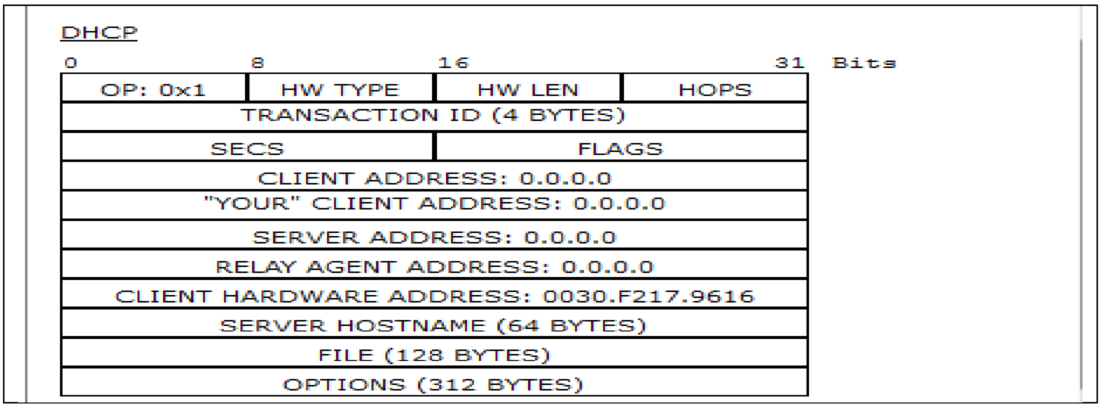
Event List

Vis.	Time(sec)	Last Device	At Device	Type	Info
	0.000	--	PC5	DHCP	
	0.000	--	PC5	DHCP	
	0.001	PC5	Switch4	DHCP	
	0.001	--	PC5	DHCP	
	0.002	PC5	Switch4	DHCP	
	0.002	Switch4	Router1	DHCP	
	0.002	Switch4	PC6	DHCP	
	0.002	Switch4	Server0	DHCP	
	0.003	Switch4	Router1	DHCP	

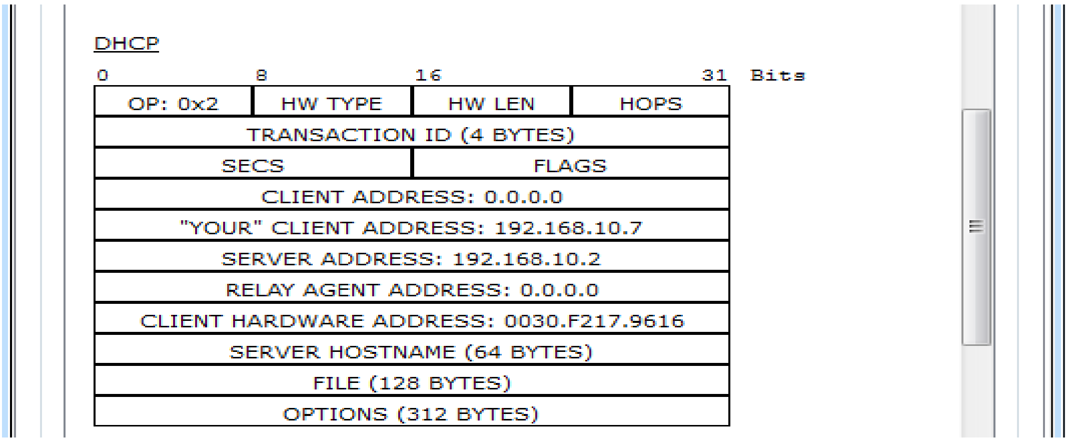
Now click on the DHCP packet see how it lease IP address.

Requesting



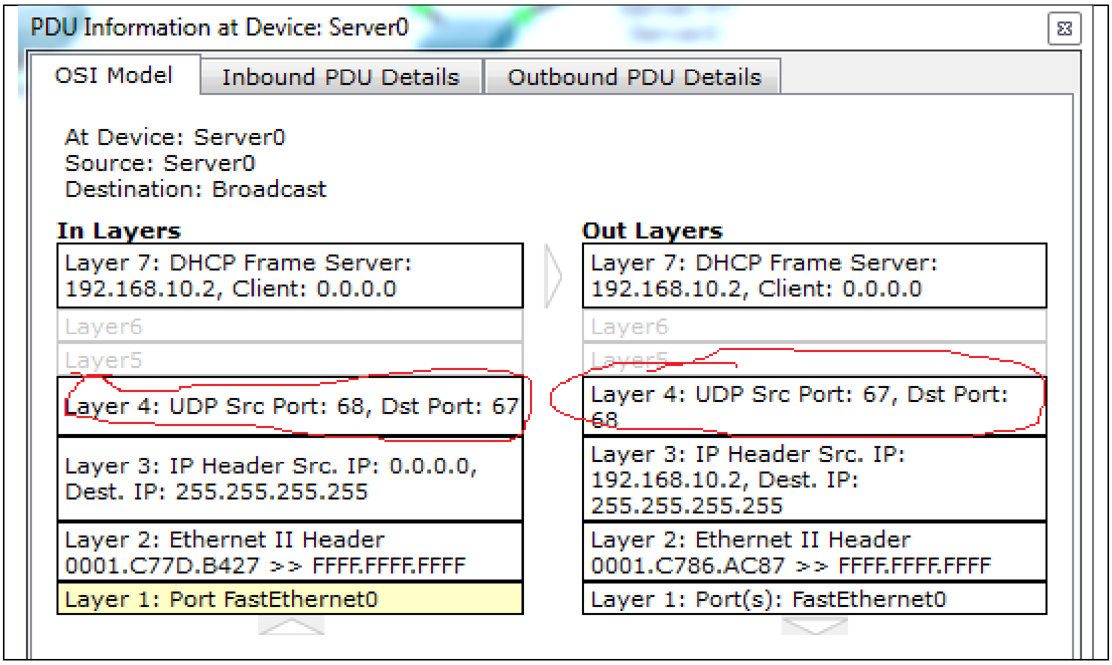


Leased.



a) **<u>Shows OSI layers involved in transmission.</u>**

The popped up window (below) will enable you to trace the content of the message through the OSI layer and what changes will occur at each layer (use next and previous buttons to trace each layer content).



Domain Name System

The Domain Name System (DNS) is a hierarchical distributed naming system for computers, services, or any resource connected to the Internet or a private network. It associates various information with

domain names assigned to each of the participating entities. Most prominently, it translates easily memorized domain names to the numerical IP addresses needed for the purpose of locating computer services and devices worldwide. The Domain Name System is an essential component of the functionality of the Internet.

An often-used analogy to explain the Domain Name System is that it serves as the phone book for the Internet by translating human-friendly computer hostnames into IP addresses. For example, the domain name www.example.com translates to the addresses 93.184.216.119 (IPv4) and 2606:2800:220:6d:26bf:1447:1097:aa7 (IPv6). Unlike a phone book, the DNS can be quickly updated, allowing a service's location on the network to change without affecting the end users, who continue to use the same host name. Users take advantage of this when they use meaningful Uniform Resource Locators (URLs), and e-mail addresses without having to know how the computer actually locates the services.

The Domain Name System distributes the responsibility of assigning domain names and mapping those names to IP addresses by designating authoritative name servers for each domain. Authoritative name servers are assigned to be responsible for their supported domains, and may delegate authority over sub domains to other name servers. This mechanism provides distributed and fault tolerant service and was designed to avoid the need for a single central database.Some common DNS record types are:

A record:

The A record is one of the most commonly used record types in any DNS system. An A record is actually an address record, which means it maps a fully qualified domain name (FQDN) to an IP address. For example, an A record is used to point a domain name, such as "google.com", to the IP address of Google's hosting server, "74.125.224.147".This allows the end user to type in a human-readable domain, while the computer can continue working with numbers. The name in the A record is the host for your domain, and the domain name is automatically attached to your name.

CNAME record:

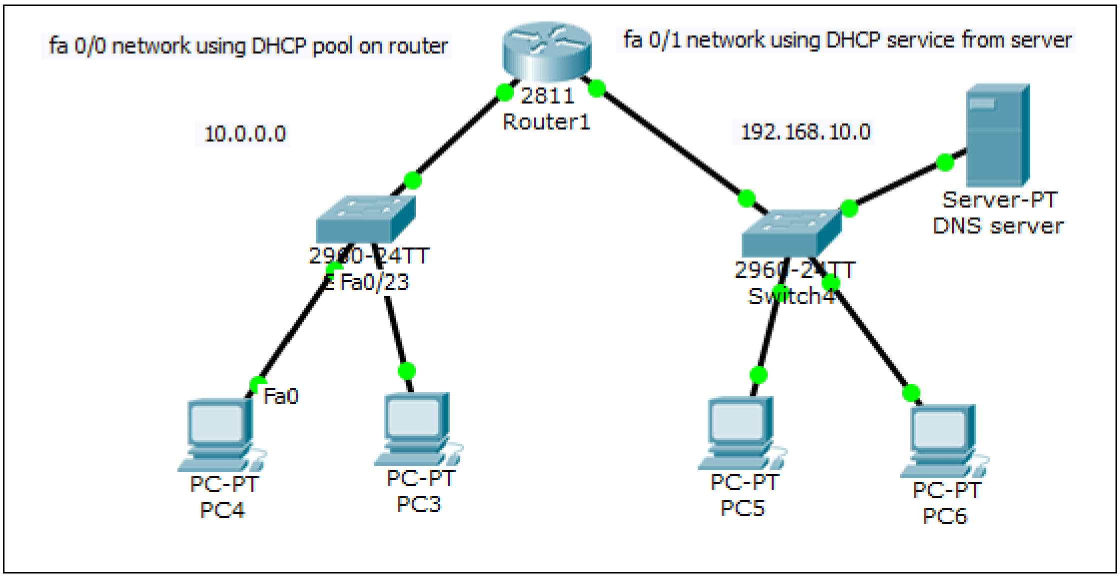
Canonical name records, or CNAME records, are often called alias records because they map an alias to the canonical name. When a name server finds a CNAME record, it replaces the name with the canonical name and looks up the new name. This allows pointing multiple systems to one IP without assigning an A record to each host name. It means that if you decide to change your IP address, you will only have to change one A record.

NS record:

An NS record identifies which DNS server is authoritative for a particular zone. The "NS" stands for "name server". NS records that do not exist on the apex of a domain are primarily used for splitting up the management of records on sub-domains.

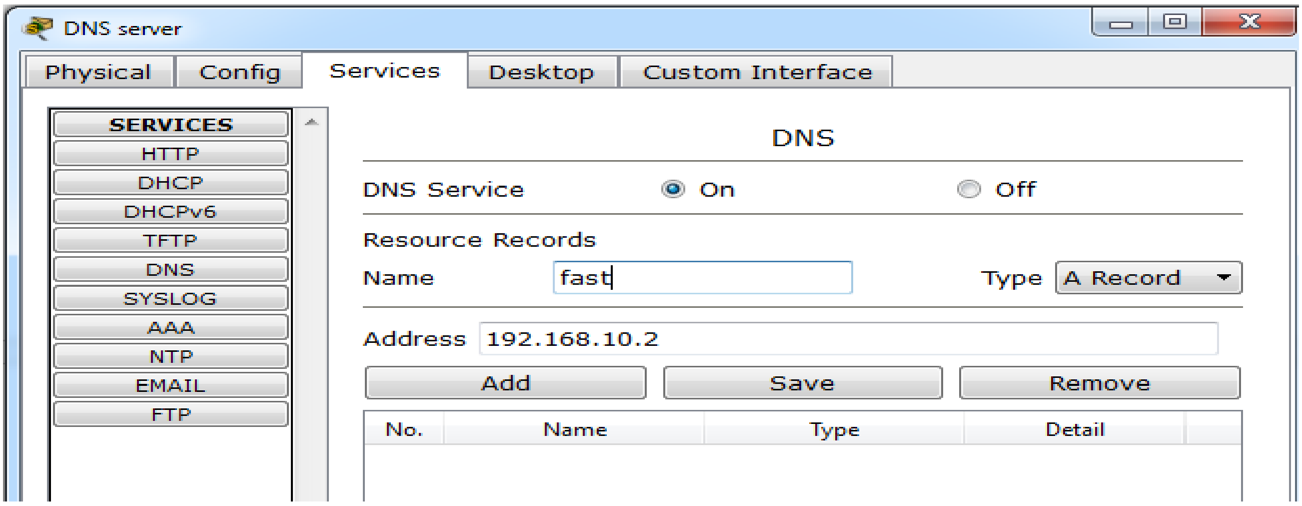
SOA record:

The SOA or Start of Authority record for a domain stores information about the name of the server that supplies the data for the zone, the administrator of the zone and the current version of the data. It also provides information about the number of seconds a secondary name server should wait before checking for updates or before retrying a failed zone transfer.

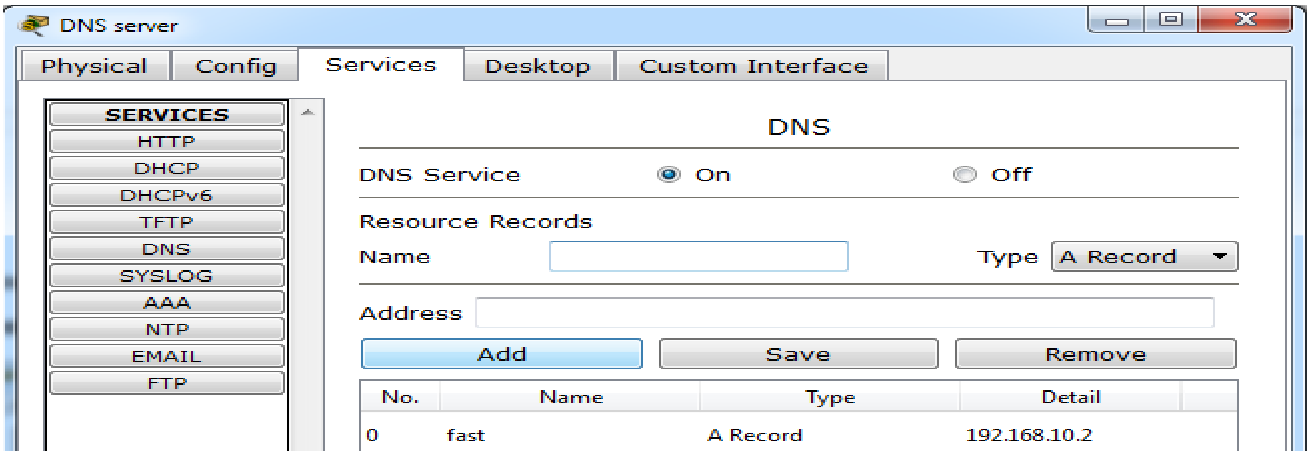


Now using the DNS service on Server0.Go to server →services →DNS

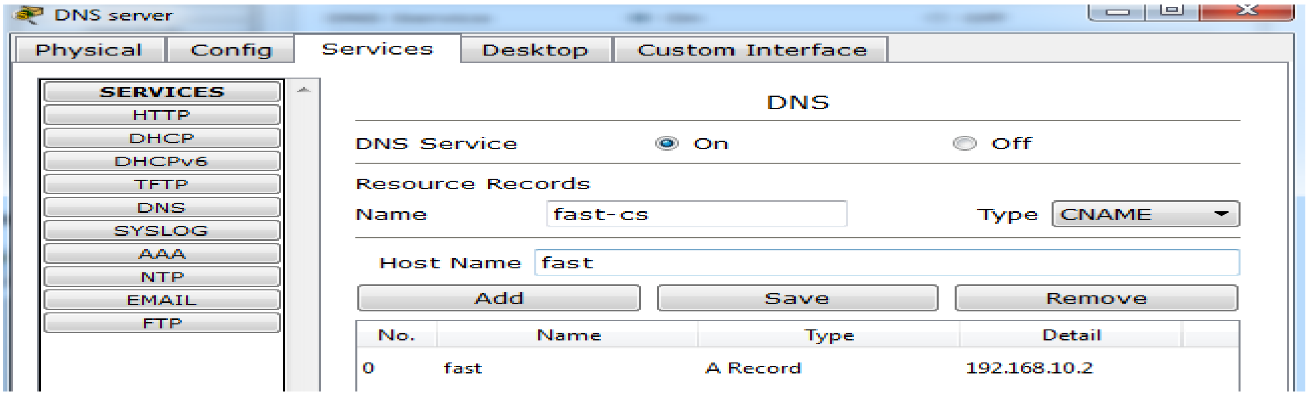
First we add A record.



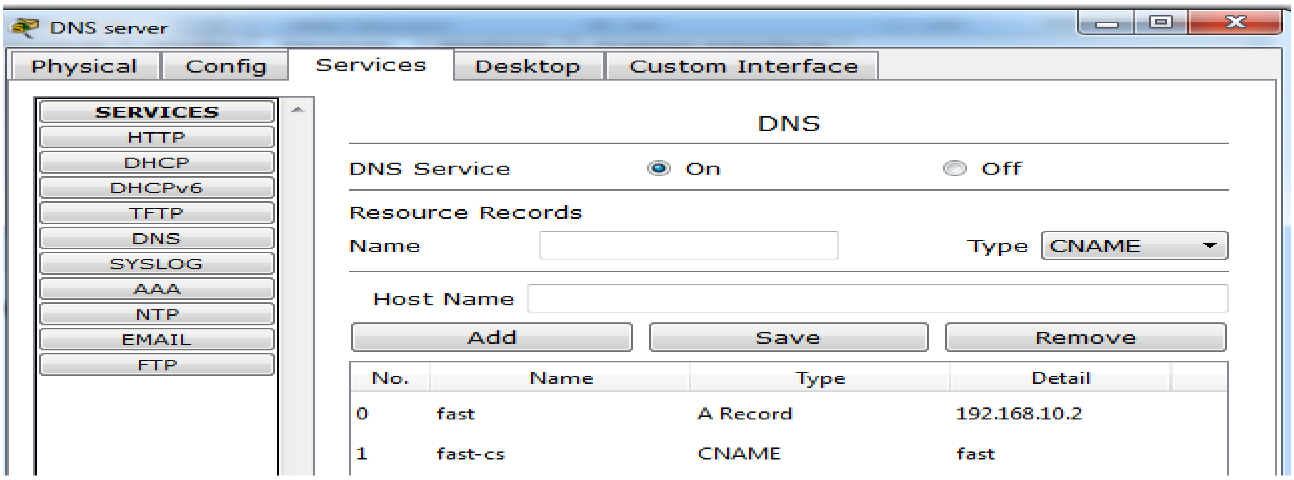
Now click on Add.



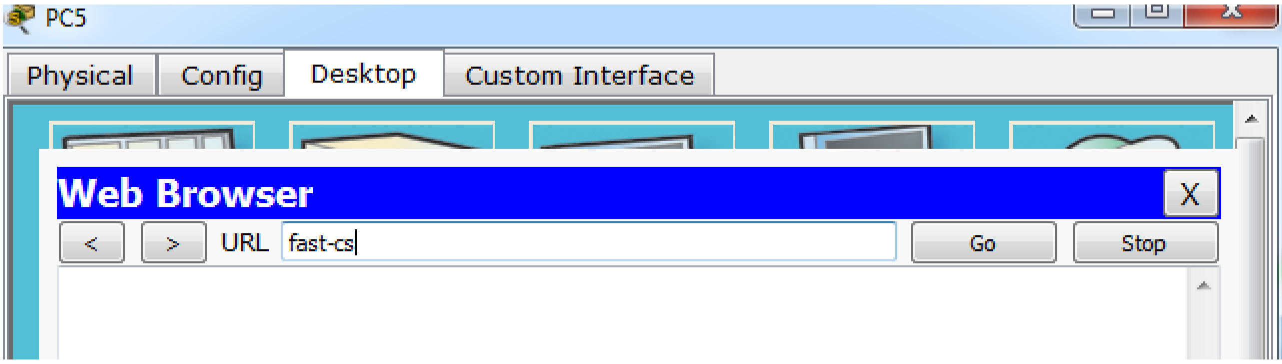
Now add Cname record.



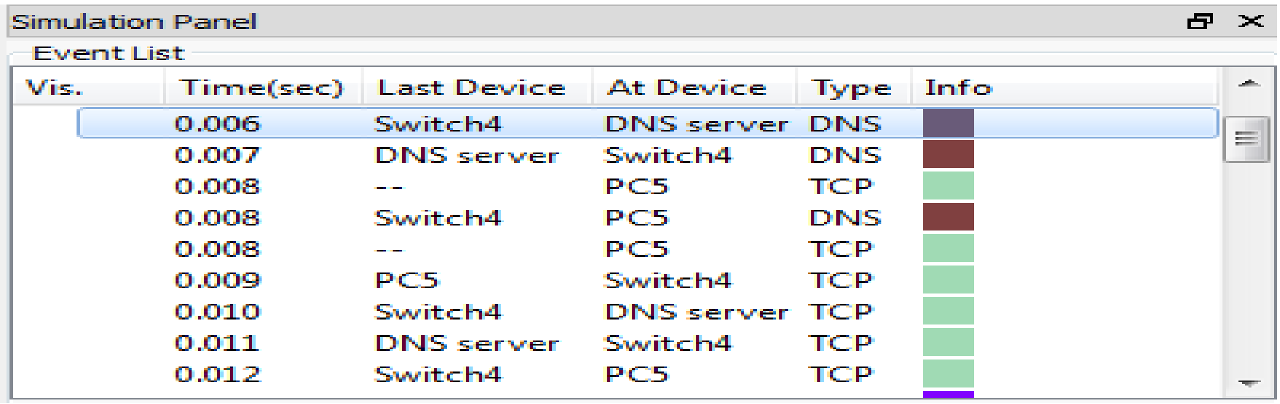
Now click on Add.



Now go to pc5 →Desktop →web browser → type fast-cs and see how DNS works.

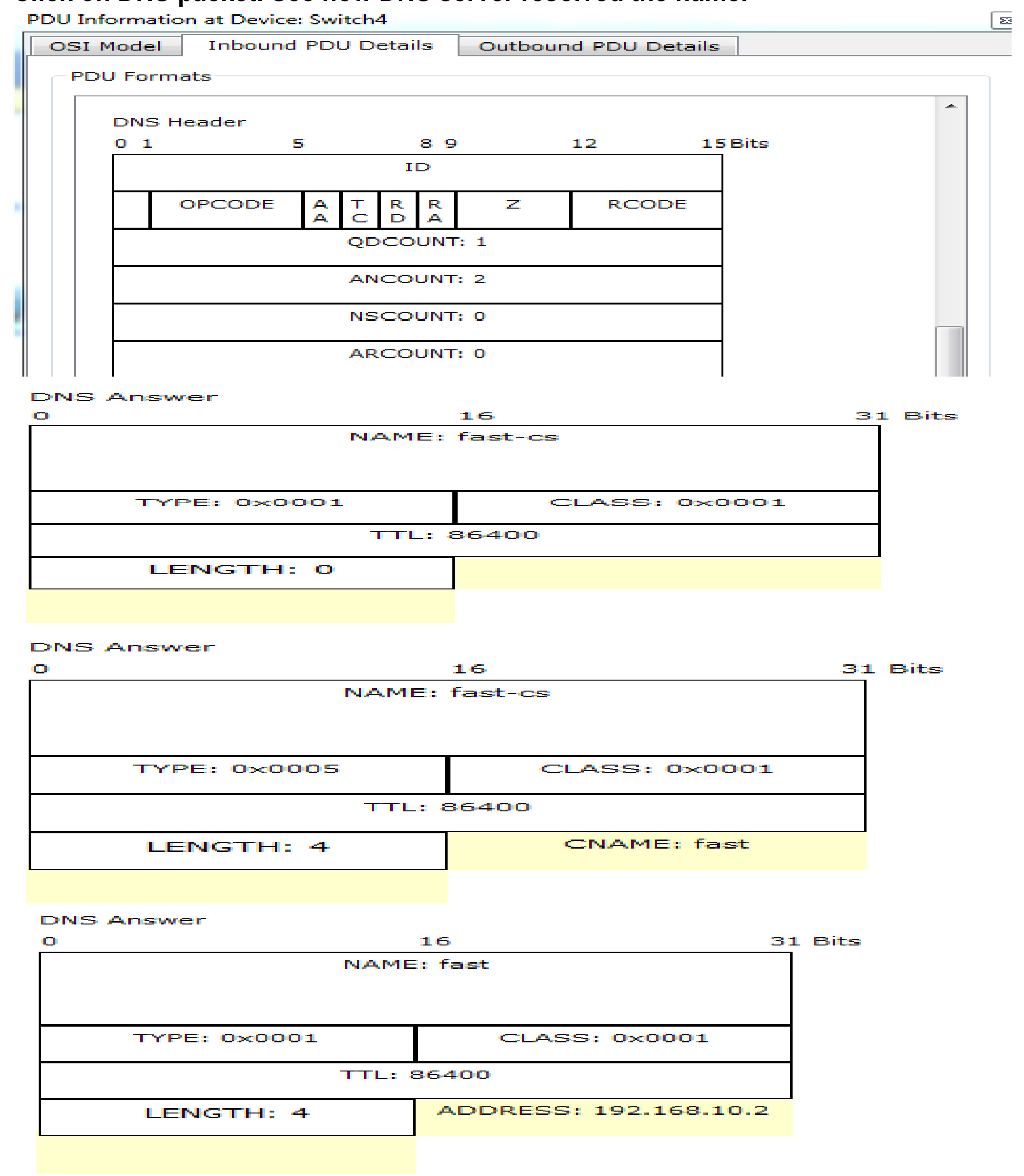


Start simulation.

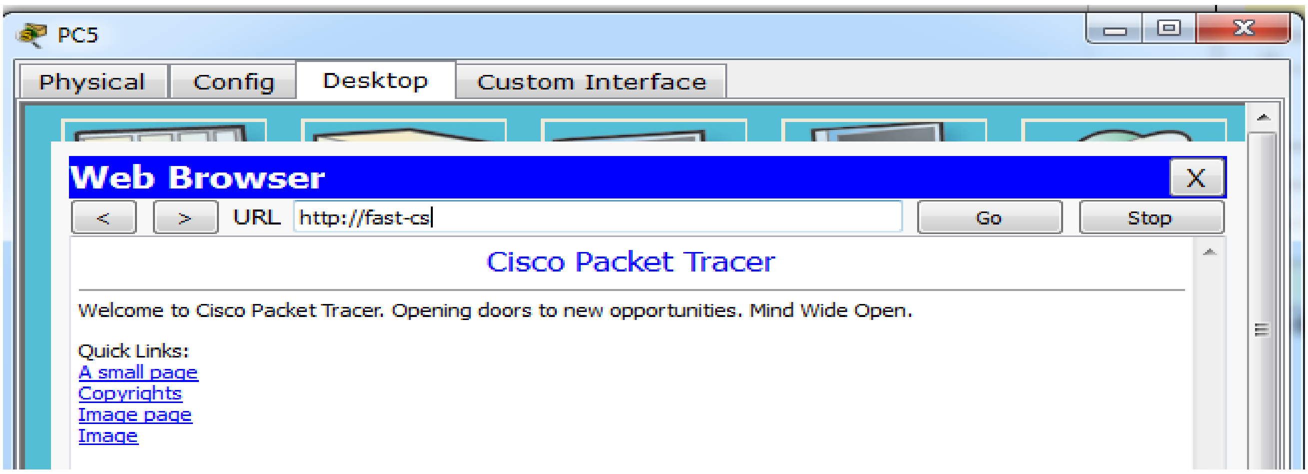


Vis.	Time(sec)	Last Device	At Device	Type	Info
	0.006	Switch4	DNS server	DNS	
	0.007	DNS server	Switch4	DNS	
	0.008	--	PC5	TCP	
	0.008	Switch4	PC5	DNS	
	0.008	--	PC5	TCP	
	0.009	PC5	Switch4	TCP	
	0.010	Switch4	DNS server	TCP	
	0.011	DNS server	Switch4	TCP	
	0.012	Switch4	PC5	TCP	

Click on DNS packet. See how DNS server resolved the name.



Now finally, required web page.



a) <u>**Shows OSI layers involved in transmission.**</u>

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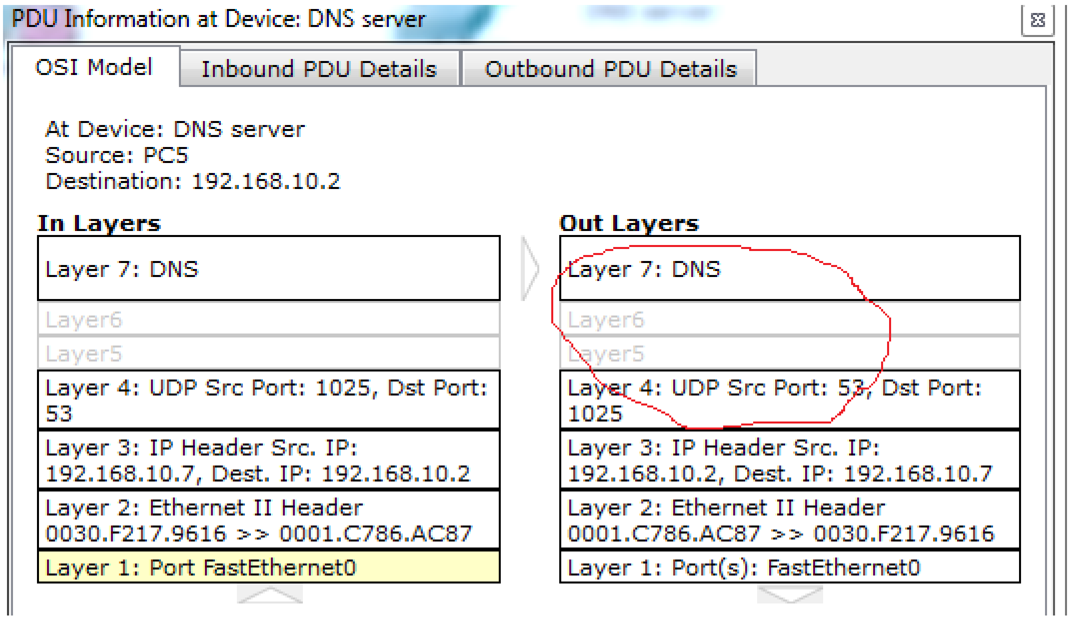
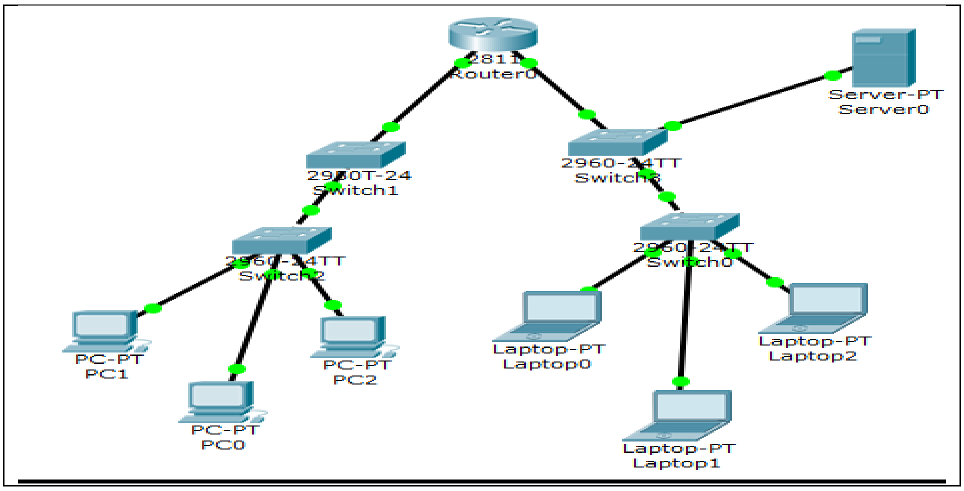


<u>**EXERCISE:**</u>



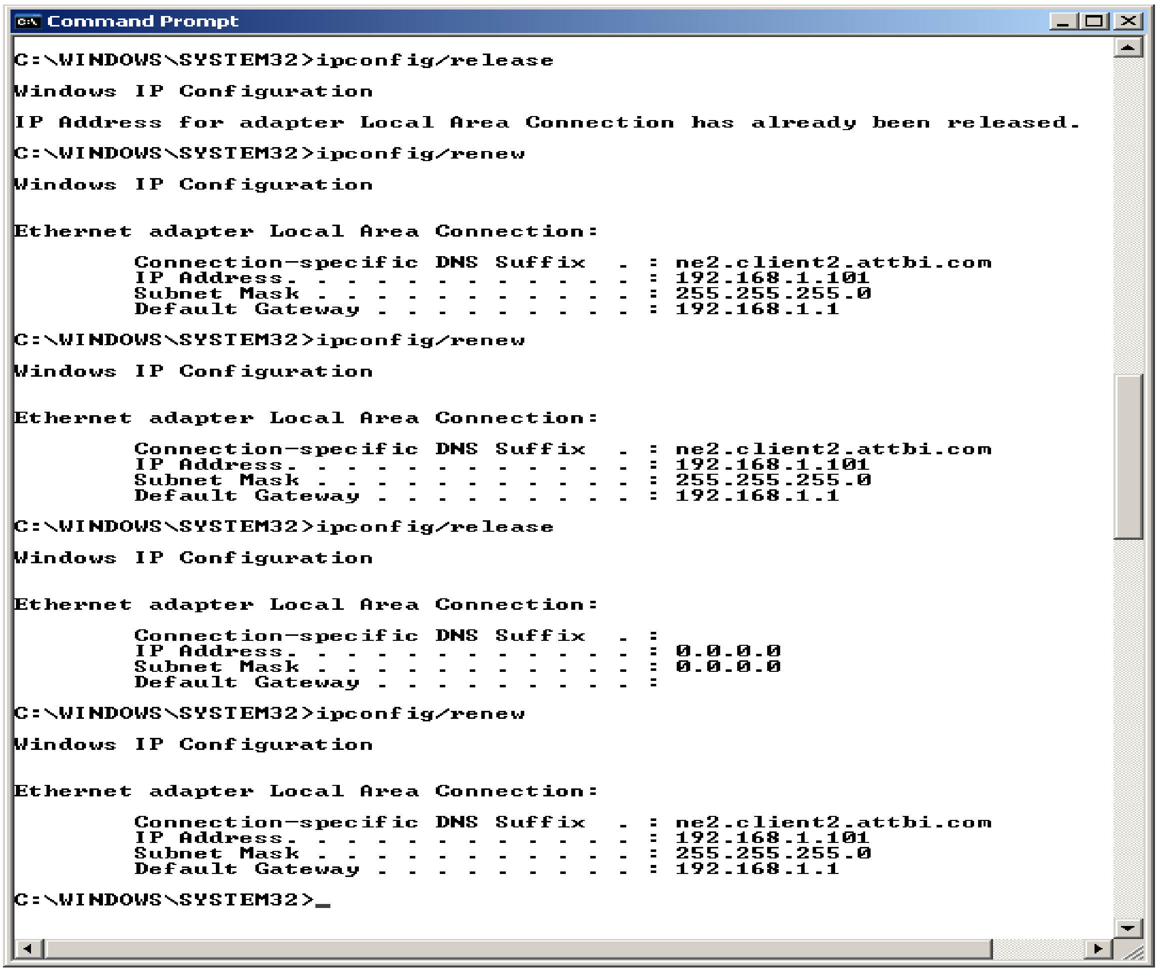
Try to implement the topology this topology using DHCP service from router and DNS from server.

DHCP & DNS in Wireshark

DHCP Experiment

In order to observe DHCP in action, we'll perform several DHCP-related commands and capture the DHCP messages exchanged as a result of executing these commands.
Do the following:

1. Begin by opening the Windows Command Prompt application (which can be found in your Accessories folder). As shown in Figure 1, enter "*ipconfig /release*". The executable for *ipconfig* is in C:\windows\system32. This command releases your current IP address, so that your host's IP address becomes 0.0.0.0.
2. Start up the Wireshark packet sniffer, as described in the introductory Wireshark lab and begin Wireshark packet capture.
3. Now go back to the Windows Command Prompt and enter "ipconfig /renew". This instructs your host to obtain a network configuration, including a new IP address. In Figure 1, the host obtains the IP address 192.168.1.108
4. Wait until the "ipconfig /renew" has terminated. Then enter the same command "ipconfig /renew" again.
5. When the second "ipconfig /renew" terminates, enter the command "ipconfig/release" to release the previously-allocated IP address to your computer.
6. Finally, enter "ipconfig /renew" to again be allocated an IP address for your computer.
7. Stop Wireshark packet capture.



```
Command Prompt

C:\WINDOWS\SYSTEM32>ipconfig/release
Windows IP Configuration
IP Address for adapter Local Area Connection has already been released.
C:\WINDOWS\SYSTEM32>ipconfig/renew
Windows IP Configuration

Ethernet adapter Local Area Connection:

        Connection-specific DNS Suffix  . : ne2.client2.attbi.com
        IP Address. . . . . . . . . . . . : 192.168.1.101
        Subnet Mask . . . . . . . . . . . : 255.255.255.0
        Default Gateway . . . . . . . . . : 192.168.1.1
C:\WINDOWS\SYSTEM32>ipconfig/renew
Windows IP Configuration

Ethernet adapter Local Area Connection:

        Connection-specific DNS Suffix  . : ne2.client2.attbi.com
        IP Address. . . . . . . . . . . . : 192.168.1.101
        Subnet Mask . . . . . . . . . . . : 255.255.255.0
        Default Gateway . . . . . . . . . : 192.168.1.1
C:\WINDOWS\SYSTEM32>ipconfig/release
Windows IP Configuration

Ethernet adapter Local Area Connection:

        Connection-specific DNS Suffix  . :
        IP Address. . . . . . . . . . . . : 0.0.0.0
        Subnet Mask . . . . . . . . . . . : 0.0.0.0
        Default Gateway . . . . . . . . . :
C:\WINDOWS\SYSTEM32>ipconfig/renew
Windows IP Configuration

Ethernet adapter Local Area Connection:

        Connection-specific DNS Suffix  . : ne2.client2.attbi.com
        IP Address. . . . . . . . . . . . : 192.168.1.101
        Subnet Mask . . . . . . . . . . . : 255.255.255.0
        Default Gateway . . . . . . . . . : 192.168.1.1

C:\WINDOWS\SYSTEM32>_
```

Figure 1 Command Prompt window showing sequence of ipconfig commands that you should enter.

Now let's take a look at the resulting Wireshark window. To see only the DHCP packets, enter into the filter field "bootp". (DHCP derives from an older protocol called BOOTP. Both BOOTP and DHCP use the same port numbers, 67 and 68. To see DHCP packets in the current version of Wireshark, you need to enter "bootp" and not "dhcp" in the filter.)

We see from Figure 2 that the first *ipconfig* renew command caused four DHCP packets to be generated: a DHCP Discover packet, a DHCP Offer packet, a DHCP Request packet, and a DHCP ACK packet.

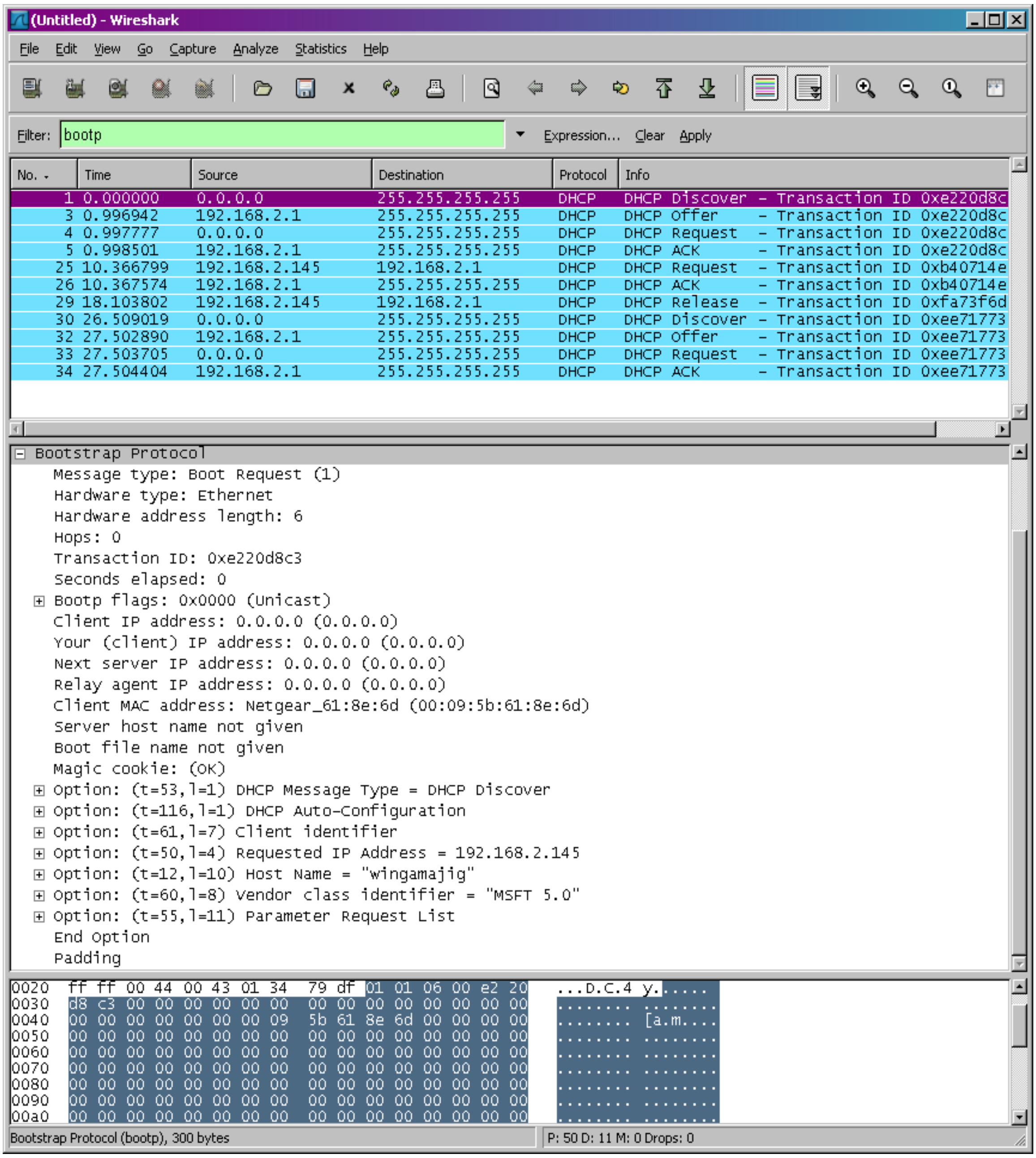


Figure 2 Wireshark window with first DHCP packet – the DHCP Discover packet – expanded.

Answer the following questions:

1. **Are DHCP messages sent over UDP or TCP?**
2. **What is the link-layer (e.g., Ethernet) address of your host?**
3. **What values in the DHCP discover message differentiate this message from the DHCP request message?**
4. **What is the value of the Transaction-ID in each of the first four (Discover/Offer/Request/ACK) DHCP messages? What are the values of the Transaction-ID in the second set (Request/ACK) set of DHCP messages? What is the purpose of the Transaction-ID field?**
5. **A host uses DHCP to obtain an IP address, among other things. But a host's IP address is not confirmed until the end of the four-message exchange! If the IP address is not set until the end of the four-message exchange, then what values are used in the IP datagrams in the four-message exchange? For each of the four DHCP messages (Discover/Offer/Request/ACK DHCP), indicate the source and destination IP addresses that are carried in the encapsulating IP datagram.**
6. **What is the IP address of your DHCP server?**
7. **What IP address is the DHCP server offering to your host in the DHCP Offer message? Indicate which DHCP message contains the offered DHCP address.**
8. **In the example screenshot in this assignment, there is no relay agent between the host and the DHCP server. What values in the trace indicate the absence of a relay agent? Is there a relay agent in your experiment? If so what is the IP address of the agent?**
9. **Explain the purpose of the lease time. How long is the lease time in your experiment?**

DNS EXPERIMENT:

The Domain Name System (DNS) translates hostnames to IP addresses, fulfilling a critical role in the Internet infrastructure. In this lab, we'll take a closer look at the client side of DNS. Recall that the client's role in the DNS is relatively simple – a client sends a *query* to its local DNS server, and receives a *response* back. From the DNS client's standpoint, however, the protocol is quite simple – a query is formulated to the local DNS server and a response is received from that server.

1. nslookup

In this lab, we'll make extensive use of the *nslookup* tool, which is available in most Linux/Unix and Microsoft platforms today. To run *nslookup* in Linux/Unix, you just type the *nslookup* command on the command line. To run it in Windows, open the Command Prompt and run *nslookup* on the command line.
In it is most basic operation, *nslookup* tool allows the host running the tool to query any specified DNS server for a DNS record. The queried DNS server can be a root DNS server, a top-level-domain DNS server, an authoritative DNS server, or an intermediate DNS server (see the textbook for definitions of these terms). To accomplish this task, *nslookup* sends a DNS query to the specified DNS server, receives a DNS reply from that same DNS server, and displays the result.

```
C:\>nslookup www.mit.edu
Server:  dns-prime.poly.edu
Address:  128.238.29.22

Name:    www.mit.edu
Address:  18.7.22.83


C:\>nslookup -type=NS mit.edu
Server:  dns-prime.poly.edu
Address:  128.238.29.22

Non-authoritative answer:
mit.edu nameserver = bitsy.mit.edu
mit.edu nameserver = strawb.mit.edu
mit.edu nameserver = w20ns.mit.edu

bitsy.mit.edu   internet address = 18.72.0.3
strawb.mit.edu  internet address = 18.71.0.151
w20ns.mit.edu   internet address = 18.70.0.160

C:\>nslookup www.aiit.or.kr bitsy.mit.edu
Server:  BITSY.MIT.EDU
Address:  18.72.0.3

Non-authoritative answer:
Name:    www.aiit.or.kr
Address:  218.36.94.200


C:\>_
```

The above screenshot shows the results of three independent *nslookup* commands (displayed in the Windows Command Prompt). In this example, the client host is located on the campus of Polytechnic University in Brooklyn, where the default local DNS server is dns-prime.poly.edu. When running *nslookup*, if no DNS server is specified, then *nslookup* sends the query to the default DNS server, which in this case is dns-prime.poly.edu. Consider the first command: Nslookup www.mit.edu

In words, this command is saying "please send me the IP address for the host www.mit.edu". As shown in the screenshot, the response from this command provides two pieces of information: (1) the name and IP address of the DNS server that provides the answer; and (2) the answer itself, which is the host name and IP address of www.mit.edu. Although the response came from the local DNS server at Polytechnic University, it is quite possible that this local DNS server iteratively contacted several other DNS servers to get the answer, as described in Section 2.4 of the textbook.
Now consider the second command: nslookup –type=NS mit.edu

In this example, we have provided the option "-type=NS" and the domain "mit.edu". This causes *nslookup* to send a query for a type-NS record to the default local DNS server. In words, the query is saying, "please send me the host names of the authoritative DNS for mit.edu". (When the –type option is not used, *nslookup* uses the default, which is to query for type A records.) The answer, displayed in the above screenshot, first indicates the DNS server that is providing the answer (which is the default local DNS server) along with three MIT name servers. Each of these servers is indeed an authoritative DNS server for the hosts on the MIT campus. However, nslookup also indicates that the answer is "non-authoritative," meaning that this answer came from the cache of some server rather than from an authoritative MIT DNS server. Finally, the answer also includes the IP addresses of the authoritative DNS servers at MIT. (Even though the type-NS query generated by nslookup did not explicitly ask for the IP addresses, the local DNS server returned these "for free" and nslookup displays the result.)

Now finally consider the third command:nslookup www.aiit.or.kr bitsy.mit.edu

In this example, we indicate that we want to the query sent to the DNS server bitsy.mit.edu rather than to the default DNS server (dns-prime.poly.edu). Thus, the query and reply transaction takes place directly between our querying host and bitsy.mit.edu. In this example, the DNS server bitsy.mit.edu provides the IP address of the host www.aiit.or.kr, which is a web server at the Advanced Institute of Information Technology (in Korea).
Now that we have gone through a few illustrative examples, you are perhaps wondering about the general syntax of nslookup commands.

The syntax is:nslookup –option1 –option2 host-to-find dns-server

In general, nslookup can be run with zero, one, two or more options. And as we have seen in the above examples, the dns-server is optional as well; if it is not supplied, the query is sent to the default local DNS server.
Now that we have provided an overview of nslookup, it is time for you to test drive it yourself. Do the following (and write down the results):

Now that we have provided an overview of nslookup, it is time for you to test drive it yourself. Do the following (and write down the results):

1. Run nslookup to obtain the IP address of a Web server in Asia. What is the IP address of that server?
2. Run nslookup to determine the authoritative DNS servers for a university in Europe.
3. Run nslookup so that one of the DNS servers obtained in Question 2 is queried for the mail servers for Yahoo! mail. What is its IP address?

Now that we are familiar with nslookup and ipconfig, we're ready to get down to some serious business. Let's first capture the DNS packets that are generated by ordinary Web-surfing activity.

- Use ipconfig to empty the DNS cache in your host.
- Open your browser and empty your browser cache. (With Internet Explorer, go to Tools menu and select Internet Options; then in the General tab select Delete Files.)
- Open Wireshark and enter "ip.addr == your_IP_address" into the filter, where you obtain your_IP_address with ipconfig. This filter removes all packets that neither originate nor are destined to your host.
- Start packet capture in Wireshark.
- With your browser, visit the Web page: http://www.ietf.org
- Stop packet capture.

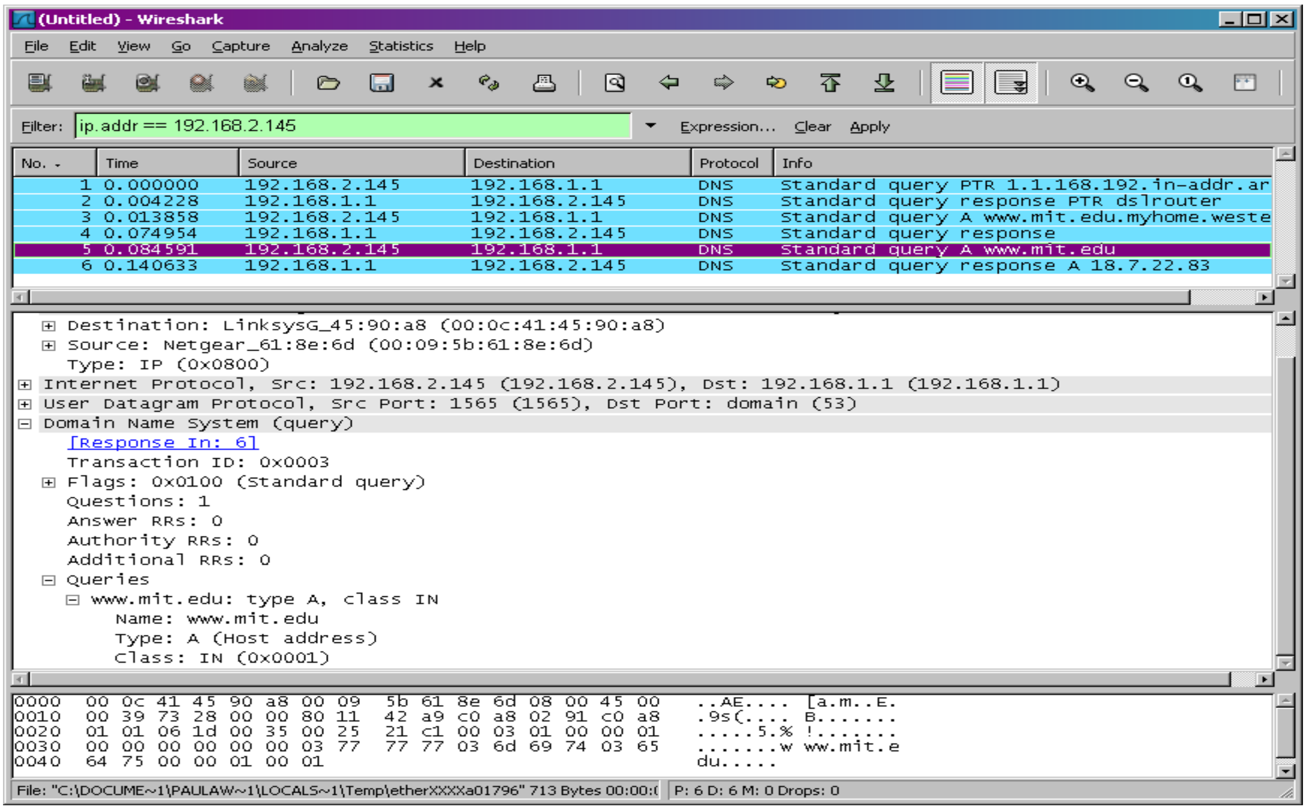
If you are unable to run Wireshark on a live network connection, you can download a packet trace file that was captured while following the steps above on one of the author's computers1. Answer the following questions. Whenever possible, when answering a question below, you should hand in a printout of the packet(s) within the trace that you used to answer the question asked. Annotate the printout2 to explain your answer. To print a packet, use File->Print, choose selected packet only, choose Packet summary line, and select the minimum amount of packet detail that you need to answer the question.

1. Locate the DNS query and response messages. Are then sent over UDP or TCP?
2. What is the destination port for the DNS query message? What is the source port of DNS response message?
3. To what IP address is the DNS query message sent? Use ipconfig to determine the IP address of your local DNS server. Are these two IP addresses the same?
4. Examine the DNS query message. What "Type" of DNS query is it? Does the query message contain any "answers"?
5. Examine the DNS response message. How many "answers" are provided? What do each of these answers contain?

Now let's play with nslookup.

- Start packet capture.
- Do an nslookup on www.mit.edu
- Stop packet capture.

You should get a trace that looks something like the following:



We see from the above screenshot that nslookup actually sent three DNS queries and received three DNS responses. For the purpose of this assignment, in answering the following questions, ignore the first two sets of queries/responses, as they are specific to nslookup and are not normally generated by standard Internet applications. You should instead focus on the last query and response messages.