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A MULTI-SITE NETWORK w. ADDRESS TRANSLATION

1. Introduction

1.1. Objectives

This work aims to illustrate the address translation between local IP addresses and one public IP address in a multi-site network.

1.2. Outcomes

By completing this work through step-by-step guideline, students will be able to understand:

- Configuration Steps for NAT Address Translation: show the step-by-step process for configuring Network Address Translation (NAT) on a router, including defining inside and outside interfaces, specifying NAT rules, and applying appropriate access control lists (ACLs).
- Network Access to a Server Behind NAT: shows how to access a server located behind a NAT device, including the use of static NAT to ensure that incoming requests are correctly routed to the server.
- Packet Address Translation: shows how packet address translation works during data transmission, including the translation of source and destination IP addresses and ports, and the implications for both internal and external communications.

2. Testbed setup

In this section, we develop a multi-site network including 2 sites at LTK campus and DiAn campus. The site's communications are established through interconnected routers provided by ISP. Each site is equipped with a limited number of public IP addresses at a very high cost.

2.1.   Network devices

Due to the geographical separation, each site has an internal network (access network). Each internal network forms a subnet (or access network) with a gateway router. The connections among gateway routers are provided by ISP with public IP addresses. The network scheme is illustrated in Figure 2.1.

In each site, the hosts will serve as the end device, capable of sending and receiving data while the switches broadcastly connect these hosts together. The local IP addresses are managed by a DHCP server. To demonstrate the remote (external) access connection, each site has a web HTTP server.

The router acts as a gateway router that connects the subnet to external networks and is responsible to translate the local IP address to a limited set (a pool) of public IP addresses. To keep the demo simple, we assume each gateway has only one public IP address.

Figure 2.1 Two site network system with an inter-connected router
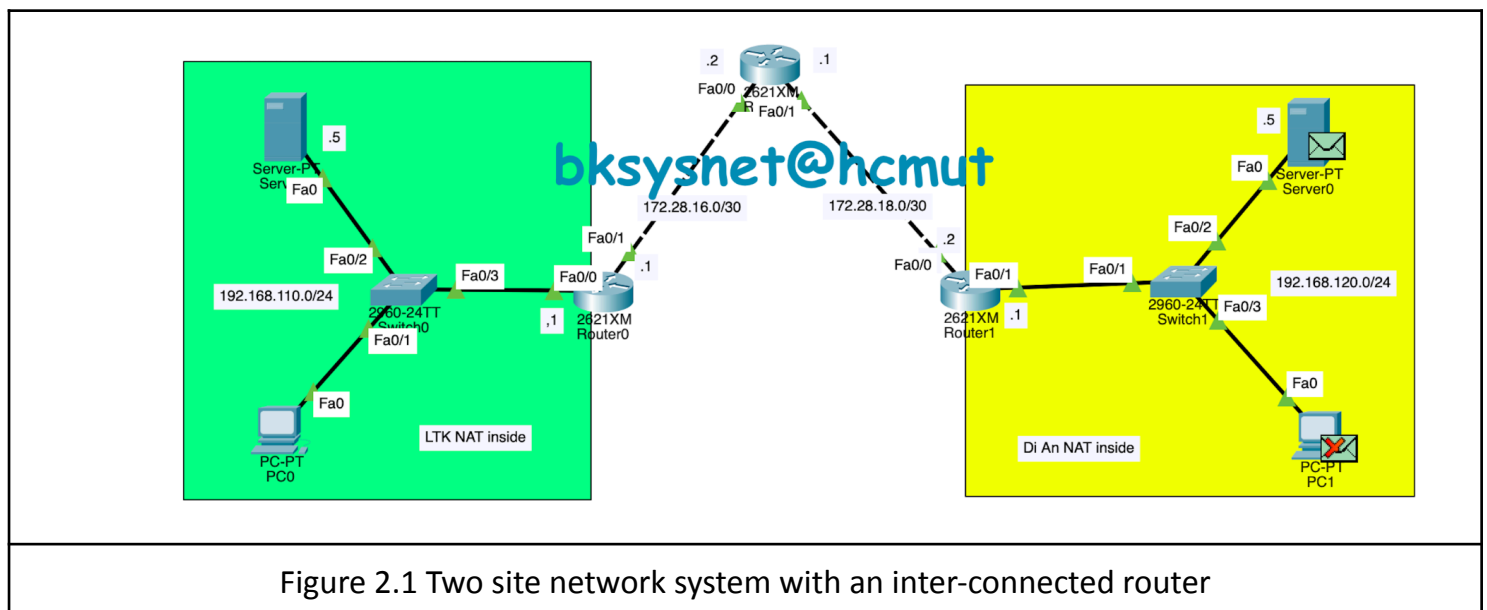
2.2.   Device configuration

2.2.1.   Configure server with a static IP address and DHCP, HTTP service

On each site, we enable HTTP service on the server.

Setup the static IP addresses

Site LTK	Site DiAn
Server 1 IP : 192.168.110.5 Server 1 netmask: 255.255.255.0 Server 1 default gateway: 192.168.110.1	Server 0 IP : 192.168.120.5 Server 0 netmask: 255.255.255.0 Server 0 default gateway: 192.168.120.1

Setup the DHCP service

Site LTK	Site DiAn
Server 1 Interface : FastEthernet0 Server 1 Pool Name: serverPool Server 1 Default gateway: 192.168.110.1 Server 1 Start IP Address: 192.168.110.100 Server 1 Subnet Mask: 255.255.255.0 Server 1 Max No User: 100	Server 0 Interface : FastEthernet0 Server 0 Pool Name: serverPool Server 0 Default gateway: 192.168.110.1 Server 0 Start IP Address: 192.168.120.100 Server 0 Subnet Mask: 255.255.255.0 Server 0 Max No User: 100
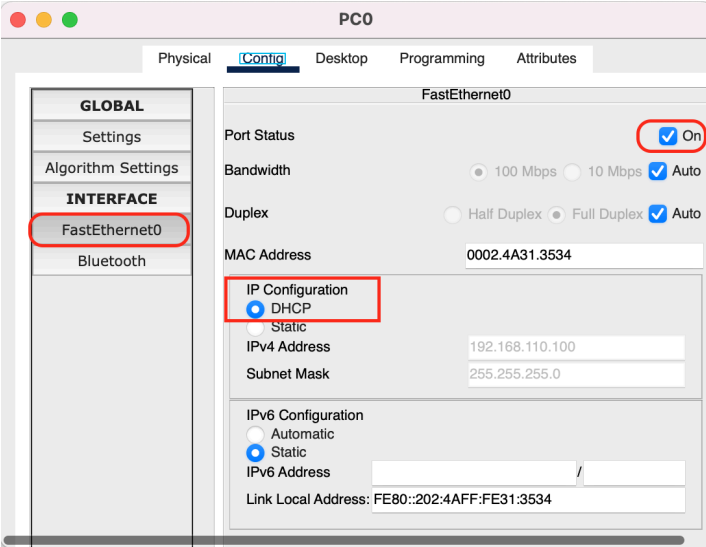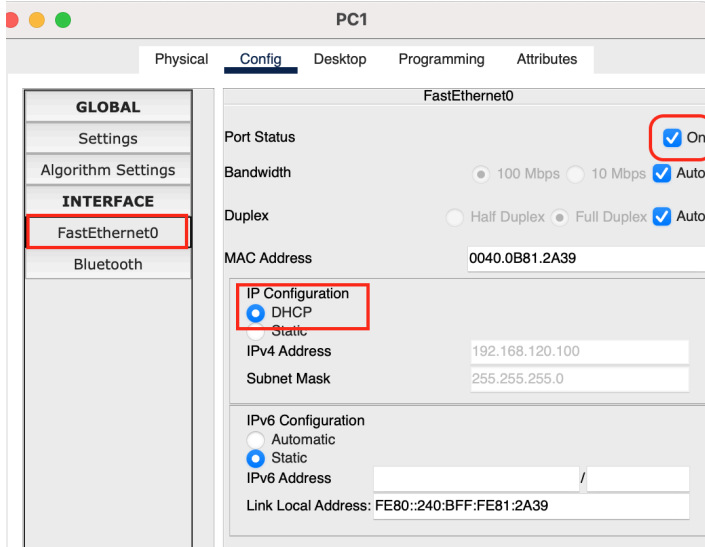
2.2.2. Configure PCs in DHCP client mode

On each PC, we enable DHCP (client) mode in the tab Config>Interface>FastEthernet0

PC 0	PC 1

2.2.3. Configure routers

Configure gateway router at site LTK

```
Would you like to enter the initial configuration dialog? [yes/no]: no
Router>en
Router#configure terminal
Router(config)#interface FastEthernet 0/0
Router(config-if)#ip address 192.168.110.1 255.255.255.0
Router(config-if)#ip nat inside
Router(config-if)#no shutdown

Router(config)#interface FastEthernet 0/1
Router(config-if)#ip address 172.28.16.1 255.255.255.252
Router(config-if)#ip nat outside
Router(config-if)#no shutdown
Router(config-if)#exit

Router(config)#access-list 1 permit 172.28.16.0 0.0.0.3
Router(config)#access-list 1 permit 192.168.110.0 0.0.0.255
```

```
Router(config)#ip nat inside source list 1 interface FastEthernet 0/1 overload
Router(config)#ip nat inside source static tcp 192.168.110.5 80 172.28.16.1 1111
Router(config)#ip nat outside source static tcp 172.28.16.1 1111 192.168.110.5 80

Router(config)#router ospf 6000
Router(config-router)#network 172.28.16.0 0.0.0.3 area 0
Router(config-router)#exit
Router(config)#exit
Router#wr
Building configuration...
[OK]
```

Configure gateway router at site DiAn

```
Would you like to enter the initial configuration dialog? [yes/no]: no
Router>en
Router#configure terminal
Router(config)#interface FastEthernet0/1
Router(config-if)#ip address 192.168.120.1 255.255.255.0
Router(config-if)#ip nat inside
Router(config-if)#no shutdown

Router(config)#interface FastEthernet0/0
Router(config-if)# ip address 172.28.18.2 255.255.255.252
Router(config-if)#ip nat outside
Router(config-if)#no shutdown
Router(config-if)#exit

Router(config)#access-list 1 permit 172.28.18.0 0.0.0.3
Router(config)#access-list 1 permit 192.168.120.0 0.0.0.255

Router(config)#ip nat inside source list 1 interface FastEthernet 0/0 overload
Router(config)#ip nat outside source static tcp 172.28.18.2 2222 192.168.120.5 80
Router(config)#ip nat inside source static tcp 192.168.120.5 80 172.28.18.2 2222

Router(config)#router ospf 6000
Router(config-router)#network 172.28.18.0 0.0.0.3 area 0
Router(config-router)#exit
Router(config)#exit
Router#wr
Building configuration...
[OK]
```

Configure inter-connected routers

```
Would you like to enter the initial configuration dialog? [yes/no]: no
Router>en
Router#configure terminal
Router(config)#interface FastEthernet0/0
Router(config-if)#ip address 172.28.16.2 255.255.255.252
Router(config-if)#no shutdown

Router(config)#interface FastEthernet0/1
Router(config-if)# ip address 172.28.18.1 255.255.255.252
Router(config-if)#no shutdown
Router(config-if)#exit

Router(config)#router ospf 6000
Router(config-router)#network 172.28.16.0 0.0.0.3 area 0
Router(config-router)#network 172.28.18.0 0.0.0.3 area 0
Router(config-router)#exit
Router(config)#exit
Router#wr
Building configuration...
[OK]
```

2.2.4. Verify the address translation configuration

Verify the configuration of the gateway router at site LTK:

```
Router>en
Router#show ip nat statistics
Total translations: 1 (1 static, 0 dynamic, 0 extended)
Outside Interfaces: FastEthernet0/1
Inside Interfaces: FastEthernet0/0
Hits: 0  Misses: 0
Expired translations: 0
Dynamic mappings:


Router#show access-lists 1
Standard IP access list 1
    permit 172.28.16.0 0.0.0.3
    permit 192.168.110.0 0.0.0.255
```

```
Router#show ip nat translations
Pro  Inside global      Inside local       Outside local      Outside global
tcp 172.28.16.1:1111   192.168.110.5:80   ---                ---
tcp ---                ---                192.168.110.5:80   172.28.16.1:1111
```

For each gateway router, we need to verify the inside and outside interfaces, access list and static NAT address translations.

Verify the configuration of the gateway router at site DiAn:

```
Router>en
Router#show ip nat statistics
Total translations: 1 (1 static, 0 dynamic, 0 extended)
Outside Interfaces: FastEthernet0/0
Inside Interfaces: FastEthernet0/1
Hits: 0  Misses: 0
Expired translations: 0
Dynamic mappings:

Router#show access-lists 1
Standard IP access list 1
    permit 172.28.18.0 0.0.0.3
    permit 192.168.120.0 0.0.0.255

Router#show ip nat translations
Pro  Inside global      Inside local       Outside local      Outside global
tcp 172.28.18.2:2222   192.168.120.5:80   ---                ---
tcp ---                ---                192.168.120.5:80   172.28.18.2:2222
```

For each gateway router, we need to verify the inside and outside interfaces, access list and static NAT address translations.

3. Packet Tracing

In this section, we perform external access through address mapping into the site's internal web server. On each PC, we access through the gateway router public IP address with static NAT port mapping. In each access, the NAT service will automatically translate between the inside and outside through an entry in the NAT address translation table.

Figure 3.1 shows the successful web browser accesses and the content of NAT address translation table.

In the following sections, we perform a tracing of the packet sending from PC0 at the site LTK to the HTTP web server at the site DiAn. We show the address translation progress at the gateway router by comparing the addresses between the NAT inside area and the NAT outside area.

From outside of the site LTK, the HTTP web server can be accessed at **http://172.28.16.1:1111**.

From outside of the site DiAn, the HTTP web server can be accessed at **http://172.28.18.2:2222**.
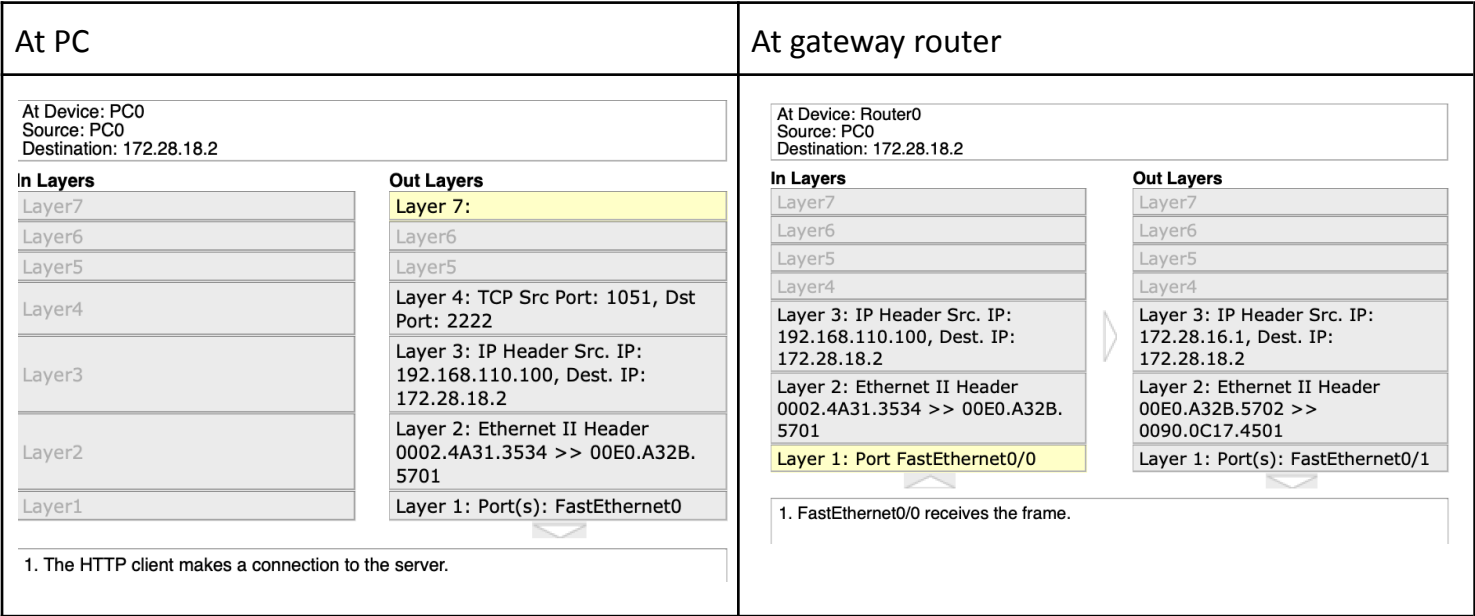

Figure 3.1 Web access from PCs and the NAT address translations
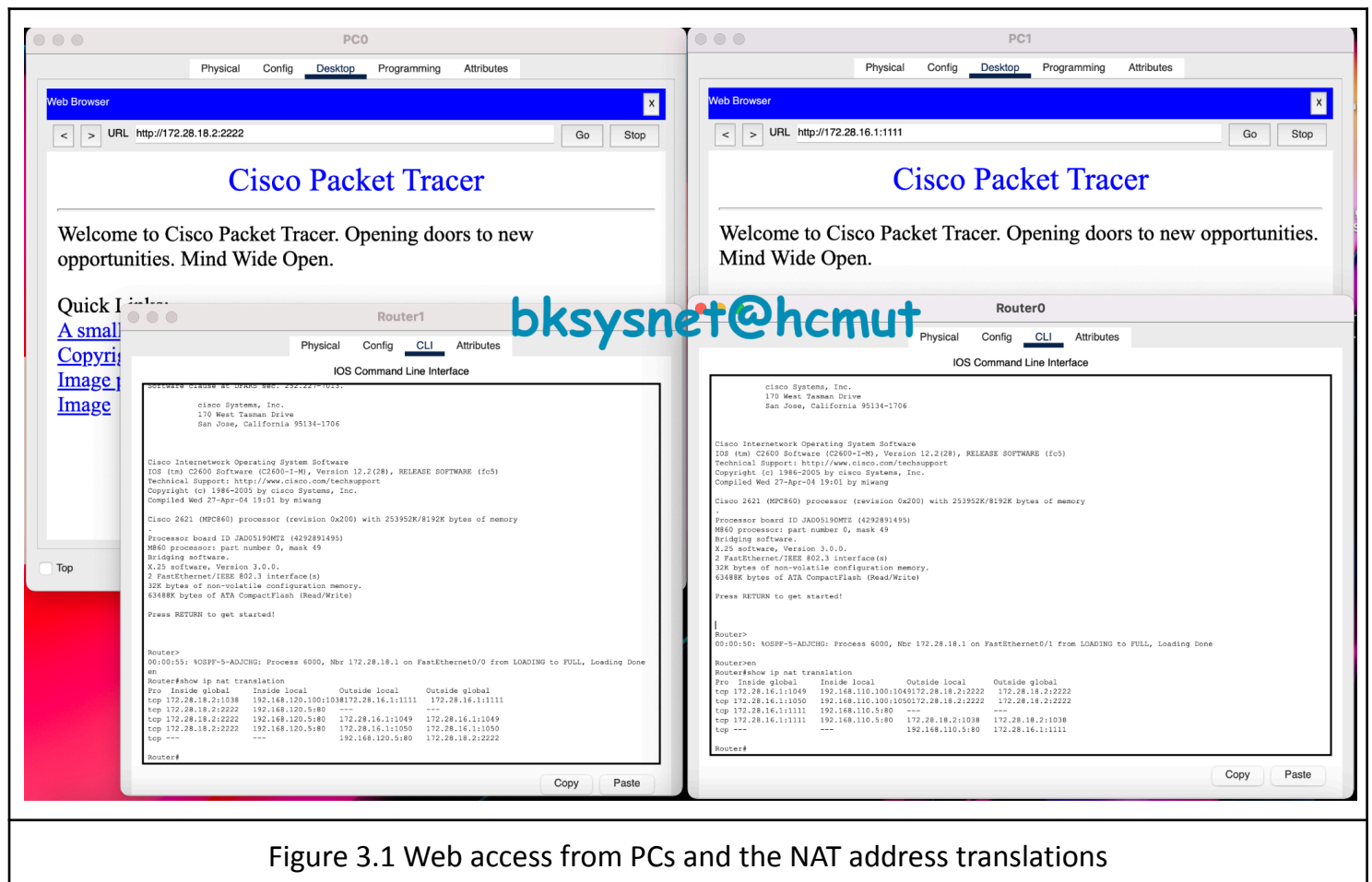
3.1. Site LTK

The NAT address translation table:

```
Router>en
Router#show ip nat translation
Pro  Inside global     Inside local       Outside local      Outside global
tcp 172.28.16.1:1050   192.168.110.100:1050172.28.18.2:2222   172.28.18.2:2222
tcp 172.28.16.1:1051   192.168.110.100:1051172.28.18.2:2222   172.28.18.2:2222
tcp 172.28.16.1:1111   192.168.110.5:80   ---                 ---
tcp 172.28.16.1:1111   192.168.110.5:80   172.28.18.2:1038    172.28.18.2:1038
tcp ---                ---                192.168.110.5:80     172.28.16.1:1111
```
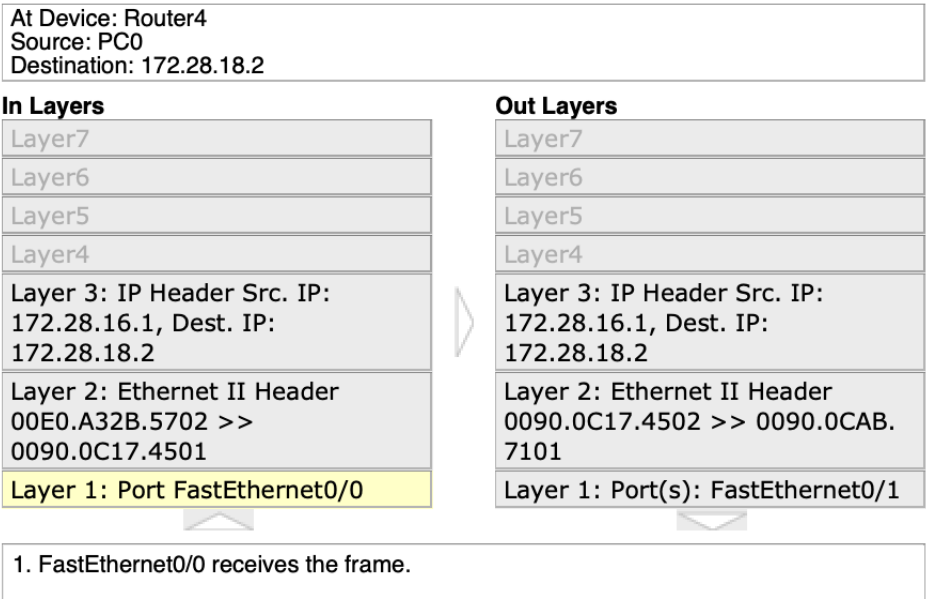
The packet address is translated the source addresses from inside 192.168.110.100 to 172.28.16.1

At PC	At gateway router

At PC

At Device: PC0
Source: PC0
Destination: 172.28.18.2

In Layers
- Layer7
- Layer6
- Layer5
- Layer4
- Layer3
- Layer2
- Layer1

Out Layers
- Layer 7:
- Layer6
- Layer5
- Layer 4: TCP Src Port: 1051, Dst Port: 2222
- Layer 3: IP Header Src. IP: 192.168.110.100, Dest. IP: 172.28.18.2
- Layer 2: Ethernet II Header 0002.4A31.3534 >> 00E0.A32B.5701
- Layer 1: Port(s): FastEthernet0

1. The HTTP client makes a connection to the server.

At gateway router

At Device: Router0
Source: PC0
Destination: 172.28.18.2

In Layers
- Layer7
- Layer6
- Layer5
- Layer4
- Layer 3: IP Header Src. IP: 192.168.110.100, Dest. IP: 172.28.18.2
- Layer 2: Ethernet II Header 0002.4A31.3534 >> 00E0.A32B.5701
- Layer 1: Port FastEthernet0/0

Out Layers
- Layer7
- Layer6
- Layer5
- Layer4
- Layer 3: IP Header Src. IP: 172.28.16.1, Dest. IP: 172.28.18.2
- Layer 2: Ethernet II Header 00E0.A32B.5702 >> 0090.0C17.4501
- Layer 1: Port(s): FastEthernet0/1

1. FastEthernet0/0 receives the frame.

3.2. At the interconnected router

The packet addresses are public addresses: 172.28.16.1 and 172.28.18.2

```
At Device: Router4
Source: PC0
Destination: 172.28.18.2
```

In Layers	Out Layers
Layer7	Layer7
Layer6	Layer6
Layer5	Layer5
Layer4	Layer4
Layer 3: IP Header Src. IP: 172.28.16.1, Dest. IP: 172.28.18.2	Layer 3: IP Header Src. IP: 172.28.16.1, Dest. IP: 172.28.18.2
Layer 2: Ethernet II Header 00E0.A32B.5702 >> 0090.0C17.4501	Layer 2: Ethernet II Header 0090.0C17.4502 >> 0090.0CAB.7101
Layer 1: Port FastEthernet0/0	Layer 1: Port(s): FastEthernet0/1

```
1. FastEthernet0/0 receives the frame.
```

3.3. Site DiAn

The NAT address translation table

```
Router#show ip nat translation
Pro  Inside global      Inside local      Outside local      Outside global
tcp 172.28.18.2:1038    192.168.120.100:1038172.28.16.1:1111   172.28.16.1:1111
tcp 172.28.18.2:2222    192.168.120.5:80   ---                ---
tcp 172.28.18.2:2222    192.168.120.5:80   172.28.16.1:1050   172.28.16.1:1051
tcp 172.28.18.2:2222    192.168.120.5:80   172.28.16.1:1051   172.28.16.1:1051
tcp ---                 ---                192.168.120.5:80   172.28.18.2:2222
```

The packet address is translated the destination addresses from inside 172.28.18.2 to 192.168.120.5

At gateway router	At server

At gateway router

At Device: Router1
Source: PC0
Destination: 172.28.18.2

In Layers

Layer7
Layer6
Layer5
Layer4
Layer 3: IP Header Src. IP: 172.28.16.1, Dest. IP: 172.28.18.2
Layer 2: Ethernet II Header 0090.0C17.4502 >> 0090.0CAB.7101
Layer 1: Port FastEthernet0/0

Out Layers

Layer7
Layer6
Layer5
Layer4
Layer 3: IP Header Src. IP: 172.28.16.1, Dest. IP: 192.168.120.5
Layer 2: Ethernet II Header 0090.0CAB.7102 >> 00D0.BCCC.D1D1
Layer 1: Port(s): FastEthernet0/1

1. FastEthernet0/0 receives the frame.

At server

At Device: Server0
Source: PC0
Destination: 172.28.18.2

In Layers

Layer7
Layer6
Layer5
Layer 4: TCP Src Port: 1051, Dst Port: 80
Layer 3: IP Header Src. IP: 172.28.16.1, Dest. IP: 192.168.120.5
Layer 2: Ethernet II Header 0090.0CAB.7102 >> 00D0.BCCC.D1D1
Layer 1: Port FastEthernet0

Out Layers

Layer7
Layer6
Layer5
Layer 4: TCP Src Port: 80, Dst Port: 1051
Layer 3: IP Header Src. IP: 192.168.120.5, Dest. IP: 172.28.16.1
Layer 2: Ethernet II Header 00D0.BCCC.D1D1 >> 0090.0CAB.7102
Layer 1: Port(s): FastEthernet0

4. Conclusions

In this work, we perform the address translation between the inside NAT address and outside NAT address. We verify the address translation at each gateway router of both sites LTK and DiAn. The address translations are examined at each router hop associated with the NAT address translation table entries. This packet tracing helps illustrate the NAT address translation in the course CO3093 and CO3094 at HCMUT.