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Computer Networks Lab (CO3094)

Report (Semester 211)

COMPUTER NETWORK DESIGN FOR BUILDING OF A BANK

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1 Requirements Analysis

1.1 Requirements

1.1.1 Functional requirements

- 3 local area networks: one for the headquarters, and two for the branches in Nha Trang and Da Nang
- Wide area network connecting from the headquarters to the branches
- Use new technologies for network infrastructures 100/1000 Mbps wired and wireless connections
- **Headquarters**: 100 workstations, 5 servers, 12 network devices or more with security devices
- **Branches**: 50 workstations, 3 servers, 5 network devices or more with security devices

1.1.2 Non-functional requirements

- The network is organized according to the VLAN structure
- Use both **licensed** and **open-source** software, office applications, client-server applications, multimedia and database
- **High security**: System must be able to prevent network attacks like DDoS, MiTM,...
- **Robust**: Handle all inputs, expected and unexpected
- **Scalable**: The network can be extended by adding more devices
- **Total upload, download**: Servers: 500 MB/day; Workstations: 100 MB/day; WiFi: 50 MB/day
- **Growth rate**: At least 20% every 5 years

1.2 Checklist

- Hardware availability
- Hardware location and distribution

1.3 High Load Areas

It is expected that a lot of operations are executed at the servers, thus a lot of data will go through this area. High load areas should be at where the server density is the highest.

1.4 Network Structure

We will use the tree-topology with a central switch as the root node, connecting to the smaller networks. These smaller networks will make use of star-topology as there are multiple devices connecting to a common router.

1.5 Wireless Coverage

- The wireless design at the HQ is similar to the design at the branches
- Preferably, each floor will have one wireless AP
- APs are connected to routers so as to provide DHCP capability
- Up to 253 users can be connected to the standard channel 1–2.412GHz
- Use WPA2-PSK with AES for authentication
- Forbid pinging local subnet devices from another subnet

2 Network Blueprint

2.1 Recommended Equipment

The following choice of hardware is based on the devices available in Cisco Packet Tracer.

2.1.1 Router: CISCO2911/K9

- Quantity: 3
- Specification: 3 Gigabit Ethernet Port, 4 Serial Port, 4 Fast Ethernet Port
- Ethernet connects the switches and routers in the same area
- Serial connects to devices in other areas

Figure 1: Router CISCO2911/K9

2.1.2 Switches: 2960 24TT

- Quantity: 17
- Specification: 24 Fast Ethernet Port, 2 Gigabit Ethernet Port
- To provide the DHCP services, each headquarter or branch will need 1 switch
- For headquarter, we need 5 switches for 100 workstations
- For branches, we need 3 switches for each branch correspond to 50 workstations
- A switch at each branch or headquarter to connect the servers to router

Figure 2: Switch 2960 24TT

2.1.3 Access point: WRT300N

- Quantity: 3
- Specification: 2.4GHz channel WPA2-PSK built-in DHCP server
- Provide wireless connection through WPA-PSK authentication

Figure 3: Access point WRT 300N

2.1.4 DHCP Server

- Quantity: 3
- Specification: Static IP procide DHCP service.

2.1.5 Server

- Quantity: 11
- Specification: 5 servers for Headquarter, 3 for each branch

2.1.6 Cables

Figure 4: Straight-through copper cable

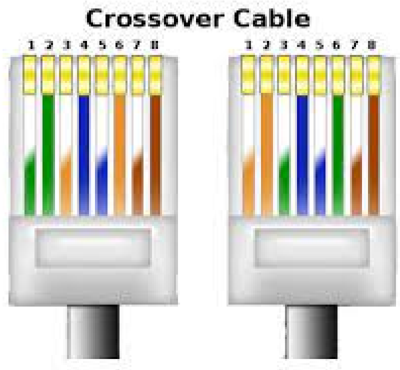


Figure 5: Crossover copper cable

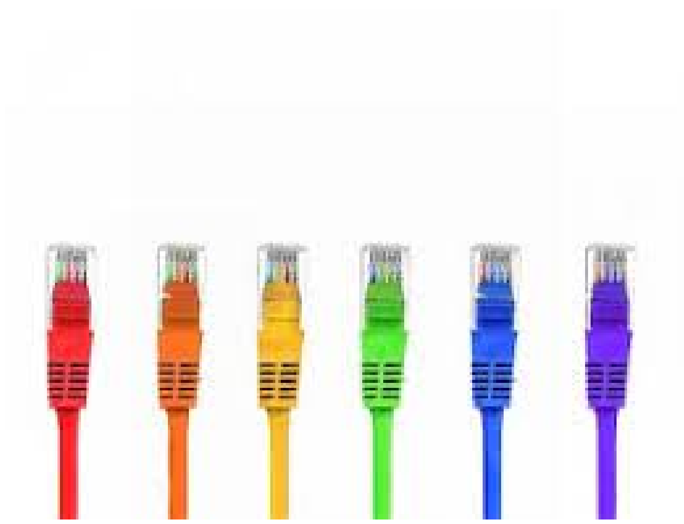


Figure 6: Leased line cable

2.2 IP Address Table

2.2.1 Headquarter

VLAN	Dept	Network ID	Default Gateway	Internet side IP
10	IT/Work Station	10.0.10.0/24	10.0.10.1/24	200.0.0.1/30
50	IT/Server	10.0.50.0/24	10.0.50.1/24	200.0.0.1/30
N.A	IT/Wireless	192.168.0.0/24	192.168.0.1/24	10.0.1.2/30
N.A	HQ Gateway router - Wireless Router	10.0.1.0/30	10.0.1.1/30	200.0.0.1/30
N.A	HQ Gateway router serial link 0	10.0.0.1/30	N.A	N.A
N.A	HQ Gateway router serial link 1	10.0.0.5/30	N.A	N.A

2.2.2 Nha Trang branch

VLAN	Dept	Network ID	Default Gateway	Internet side IP
10	IT/Work Station	10.1.10.0/24	10.1.10.1/24	200.0.1.1/30
50	IT/Server	10.1.50.0/24	10.1.50.1/24	200.0.1.1/30
N.A	IT/Wireless	192.168.0.0/24	192.168.0.1/24	10.1.1.2/30
N.A	NT Gateway router - Wireless Router	10.1.1.0/30	10.1.1.1/30	200.0.1.1/30
N.A	NT Gateway router serial link 0	10.0.0.2/30	N.A	N.A

2.2.3 Da Nang branch

VLAN	Dept	Network ID	Default Gateway	Internet side IP
10	IT/Work Station	10.2.10.0/24	10.2.10.1/24	200.0.2.1/30
50	IT/Server	10.2.50.0/24	10.2.50.1/24	200.0.2.1/30
N.A	IT/Wireless	192.168.0.0/24	192.168.0.1/24	10.2.1.2/30
N.A	NT Gateway router - Wireless Router	10.2.1.0/30	10.2.1.1/30	200.0.2.1/30
N.A	NT Gateway router serial link 0	10.0.0.6/30	N.A	N.A

3 Network Throughput, Bandwidth and Safety Parameters

The parameters of the flow and load of the system (about 80% at peak hours 9h-11h and 15h-16h) can be shared for Headquarter and Branches as follows:

- Servers used for updates, web access, database access, ... The total upload and download capacity is about 500 MB / day.
- Each workstation is used for Web browsing, document downloads, customer transactions, ... The total upload and download capacity is about 100 MB / day.
- WiFi-connected laptop for customers' accesses about 50 MB / day.

3.1 Headquarter

3.1.1 Server

The total peak hours time in a days is 3 hours (9h-11h and 15h-16h) and may consume up to 80%.

$$Bandwidth = \frac{5 * 500 * 0.8}{3 * 3600} * 8 = 1.481Mbps$$

$$Throughput = \frac{5 * 500}{8 * 3600} * 8 = 0.694Mbps$$

3.1.2 Workstation

Assume each workstation will work 8 hours a day

$$Bandwidth = \frac{100 * 100 * 0.8}{3 * 3600} * 8 = 5.926Mbps$$

$$Throughput = \frac{100 * 100}{8 * 3600} * 8 = 2.778Mbps$$

3.1.3 User

Assume that the number of customers in one day is about 200 customers, and in peak time is 150 customers. Also, assume that each user access Wifi 8 hours a day.

$$Bandwidth = \frac{150 * 50}{3 * 3600} * 8 = 5.556Mbps$$

$$Throughput = \frac{200 * 50}{8 * 3600} * 8 = 2.778Mbps$$

3.1.4 Total

$$Bandwidth = 1.481 + 5.926 + 5.556 = 12.963Mbps$$

$$Throughput = 0.694 + 2.778 + 2.778 = 6.25Mbps$$

3.2 Safety parameters

To ensure for the next 10 years, we need to consider the rate 20% per five years. The first 5 years, the number of customer will still not increase and this number will increase in the next 5 years.

$$Bandwidth = 12.963 * 1.2 = 15.556Mbps$$

$$Throughput = 6.25 * 1.2 = 7.5Mbps$$

3.3 Branch

3.3.1 Server

The total peak hours time in a days is 3 hours (9h-11h and 15h-16h) and may consume up to 80%.

$$Bandwidth = \frac{3 * 500 * 0.8}{3 * 3600} * 8 = 0.889Mbps$$

$$Throughput = \frac{3 * 500}{8 * 3600} * 8 = 0.417Mbps$$

3.3.2 Workstation

Assume each workstation will work 8 hours a day

$$Bandwidth = \frac{50 * 100 * 0.8}{3 * 3600} * 8 = 2.963Mbps$$

$$Throughput = \frac{50 * 100}{8 * 3600} * 8 = 1.389Mbps$$

3.3.3 User

Assume that the number of customers in one day is about 140 customers, and in peak time is 70 customers. Also, assume that each user access Wifi 8 hours a day.

$$Bandwidth = \frac{70 * 50}{3 * 3600} * 8 = 2.593Mbps$$

$$Throughput = \frac{140 * 50}{8 * 3600} * 8 = 2.778Mbps$$

3.3.4 Total

$$Bandwidth = 0.889 + 2.963 + 2.593 = 6.445Mbps$$

$$Throughput = 0.417 + 1.389 + 2.778 = 4.584Mbps$$

3.4 Safety parameters

To ensure for the next 10 years, we need to consider the rate 20% per five years. The first 5 years, the number of customer will still not increase and this number will increase in the next 5 years.

$$Bandwidth = 6.445 * 1.2 = 7.734Mbps$$

$$Throughput = 4.584 * 1.2 = 5.501Mbps$$

4 Packet Tracer Design

For the core of the network of the given bank, we use three main routers each for the HQ and the two branches. Moreover, we use 17 switches to provide intranet access to each device and provide DHCP availability.

We define two VLANs for the entire network:

- **VLAN 10** for workstations
- **VLAN 50** for servers

As per requirement, we restrict all wireless devices connected to an AP to be able to ping only the devices connected to the same AP. Moreover, we restrict that all the other devices in the same or different area cannot ping the wireless devices.

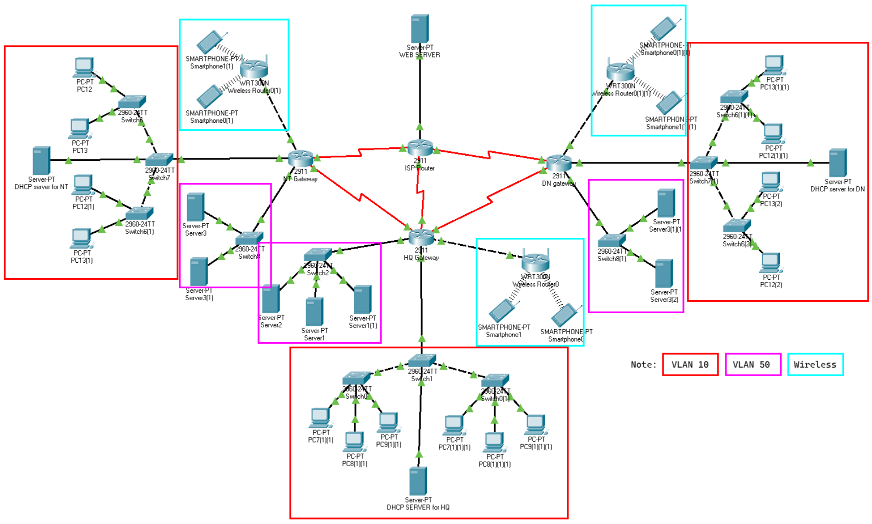


Figure 7: Topological diagram of the whole network

Note: This diagram does not contain all the network devices due to the poor runtime optimization of Packet Tracer. This diagram is scaled down, however the principle and structure of the network should still hold.

4.1 Switch and VLAN Configuration

Here, we provide a sample configuration for the HQ. For the switches in **VLAN 10**, we configure as follows.

First, we define **VLAN 10** using the CLI.

```
en
conf t
vlan 10
name WorkStationHQ
int range f0/1-24
sw mode access
sw access vlan 10
int GigabitEthernet0/1
sw mode access
sw access vlan 10
sw mode trunk
exit
```

```
end
```

Then, to have the switch provide DHCP service, we use the following commands.

```
en
conf t
int range f0/1-24
sw mode trunk
int range GigabitEthernet0/1-2
sw mode access
sw access vlan 10
exit
end
```

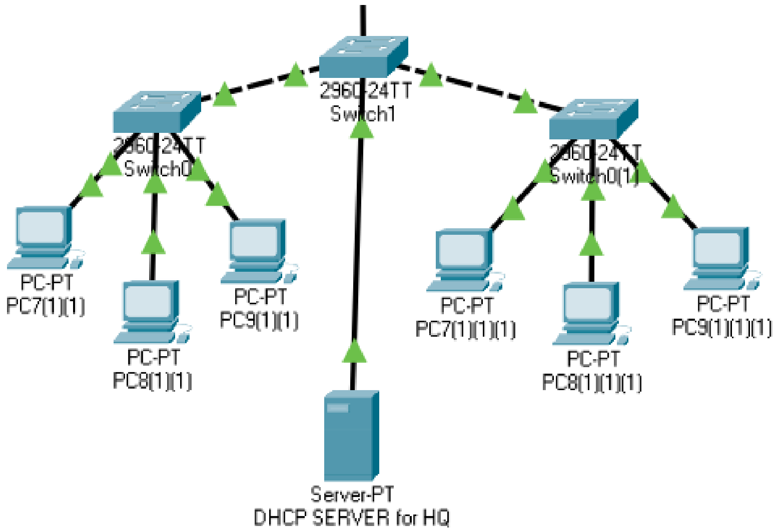


Figure 8: VLAN 10 setup of HQ

Now we will configure **VLAN 50**.

```
en
conf t
vlan 50
name ServerHQ
int range f0/1-24
sw mode access
sw access vlan 50
int GigabitEthernet0/1
sw mode access
sw access vlan 50
exit
end
```

And that is all for the configurations of the network at HQ. The same procedure applies with NT and DN branches. We only need to change name and interface range.

4.2 Wireless Router Configuration

We connect to the default gateway address of the AP to begin configuration. This address is usually 10.0.1.1, but it can also change if the device has subnet discovery.

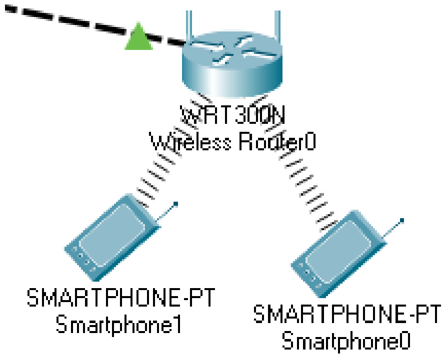


Figure 9: Wireless router setup at HQ

Then we configure the AP using its GUI. We set the IP address of the AP and the subnet mask as in the picture. Then we enable the DHCP server, set the start IP address and the maximum number of users.

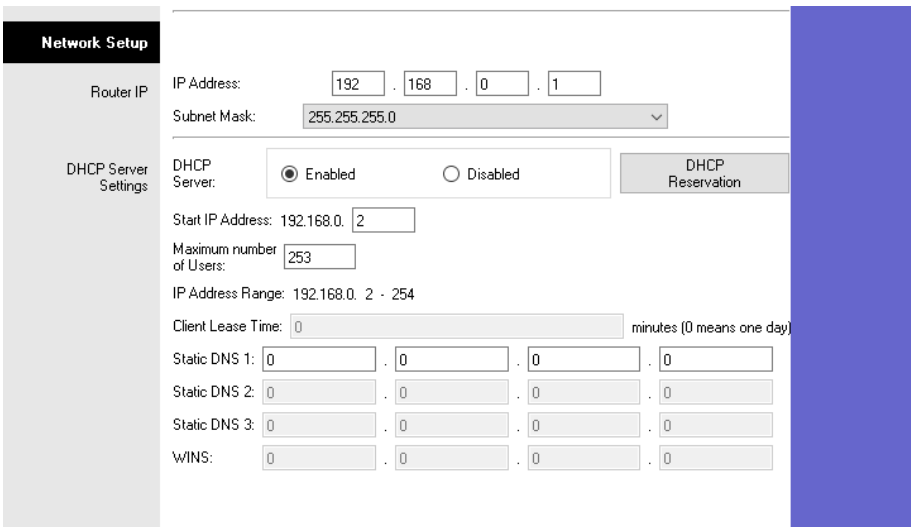


Figure 10: Wireless router setup for HQ

And that is the DHCP configuration at the HQ. The same procedure applies with NT and DN branches.

4.3 OSPF Protocol Setup

With the use of OSPF protocol, we can manage the connection between the HQ and the branches.

We use the following commands for the gateway routers at HQ, 2 branches and the ISP router.

```
en
conf t
router ospf ID
area AREA
```

where ID depends on the area.

We assign AREA = 0 as these routers are of the backbone area; ID = 1 for the HQ, 2 for the NT branch, and 3 for the DN branch.

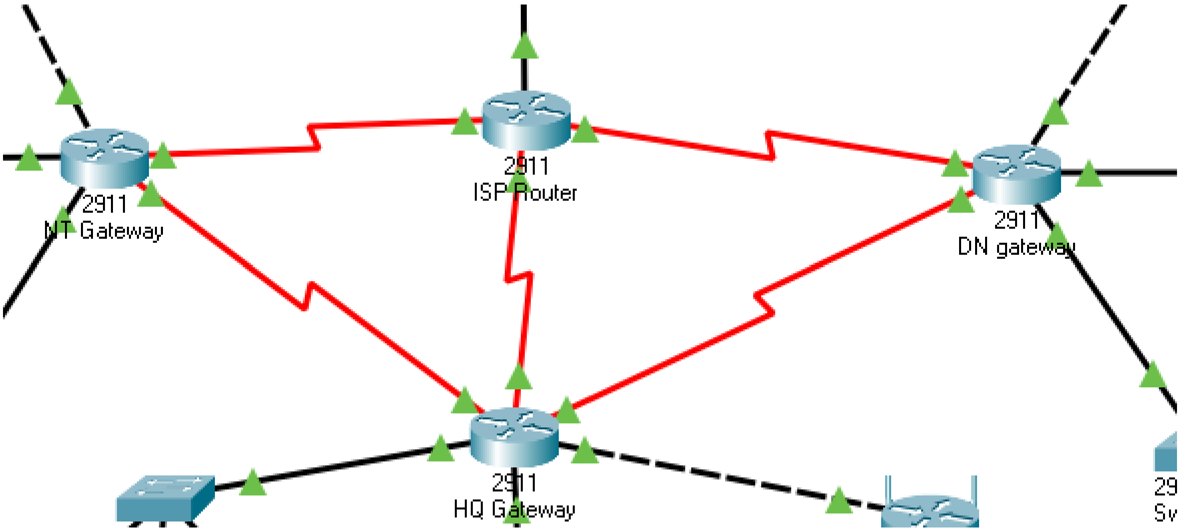


Figure 11: Core network devices

4.4 Security Setup

In order to restrict the activity at the APs, we use access control list (ACL) to prevent a ping from reaching hosts on other area networks.

We will use the following commands for the 3 gateway routers of the bank.

```
en
conf t
ip access-list standard BBBank
deny 10.0.1.2 0.0.0.0
deny 10.1.1.2 0.0.0.0
deny 10.2.1.2 0.0.0.0
permit 10.0.0.0 0.255.255.255
deny any
exit
```

We continue by applying the ACL to the workstations

```
int GigabitEthernet0/0
ip access-group BBBank out
exit
```

Now we apply the ACL to the servers

```
int GigabitEthernet0/1
ip access-group BBBank out
exit
```

With that done, we can save this config

```
copy running-config startup-config
write
```

We will now verify our configuration on ACL.
Firstly, we check the router's interface access-list policy

```
Router>show ip interface GigabitEthernet0/0
GigabitEthernet0/0 is up, line protocol is up (connected)
  Internet address is 10.0.10.1/24
  Broadcast address is 255.255.255.255
  Address determined by setup command
  MTU is 1500 bytes
  Helper address is not set
  Directed broadcast forwarding is disabled
  Outgoing access list is BBBank
  Inbound  access list is not set
  Proxy ARP is enabled
  Security level is default
  Split horizon is enabled
  ICMP redirects are always sent
  ICMP unreachables are always sent
  ICMP mask replies are never sent
  IP fast switching is disabled
  IP fast switching on the same interface is disabled
  IP Flow switching is disabled
  IP Fast switching turbo vector
  IP multicast fast switching is disabled
  IP multicast distributed fast switching is disabled
  Router Discovery is disabled
  IP output packet accounting is disabled
  IP access violation accounting is disabled
  TCP/IP header compression is disabled
  RTP/IP header compression is disabled
  Probe proxy name replies are disabled
  Policy routing is disabled
  Network address translation is disabled
  BGP Policy Mapping is disabled
  Input features: MCI Check
  WCCP Redirect outbound is disabled
  WCCP Redirect inbound is disabled
  WCCP Redirect exclude is disabled
```

Figure 12: ACL policy for the workstations at HQ

```
Router>show ip interface GigabitEthernet0/1
GigabitEthernet0/1 is up, line protocol is up (connected)
  Internet address is 10.0.50.1/24
  Broadcast address is 255.255.255.255
  Address determined by setup command
  MTU is 1500 bytes
  Helper address is not set
  Directed broadcast forwarding is disabled
  Outgoing access list is BBBank
  Inbound  access list is not set
  Proxy ARP is enabled
  Security level is default
  Split horizon is enabled
  ICMP redirects are always sent
  ICMP unreachables are always sent
  ICMP mask replies are never sent
  IP fast switching is disabled
  IP fast switching on the same interface is disabled
  IP Flow switching is disabled
  IP Fast switching turbo vector
  IP multicast fast switching is disabled
  IP multicast distributed fast switching is disabled
  Router Discovery is disabled
  IP output packet accounting is disabled
  IP access violation accounting is disabled
  TCP/IP header compression is disabled
  RTP/IP header compression is disabled
  Probe proxy name replies are disabled
  Policy routing is disabled
  Network address translation is disabled
  BGP Policy Mapping is disabled
  Input features: MCI Check
  WCCP Redirect outbound is disabled
  WCCP Redirect inbound is disabled
  WCCP Redirect exclude is disabled
```

Figure 13: ACL policy for the servers at HQ

Then we check the ACL group conditions

```
Router#show ip access-lists BBBank
Standard IP access list BBBank
    deny host 10.0.1.2
    deny host 10.1.1.2
    deny host 10.2.1.2
    permit 10.0.0.0 0.255.255.255
    deny any
```

Figure 14: IP access list of group BBBank

5 System Tests

5.1 Ping Test

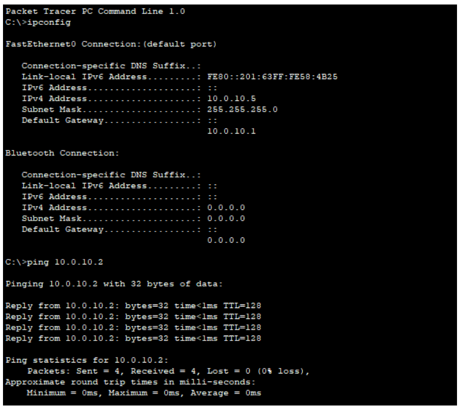


Figure 15: Ping between workstations at HQ

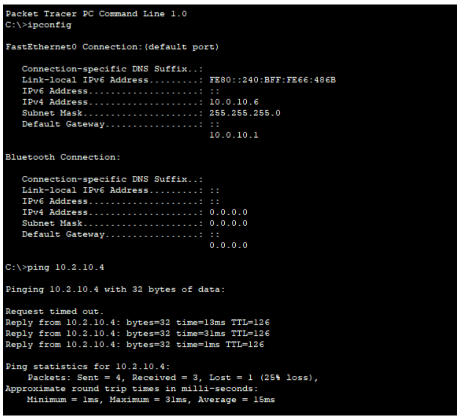


Figure 16: Ping from HQ workstation to DN workstation

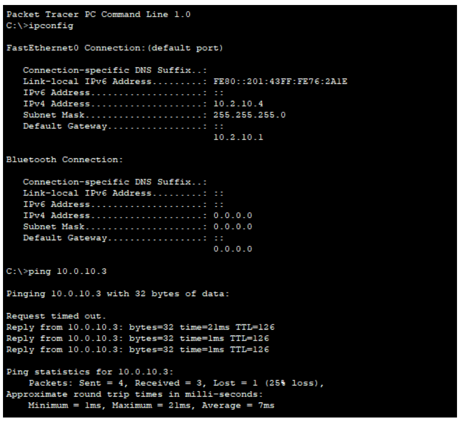
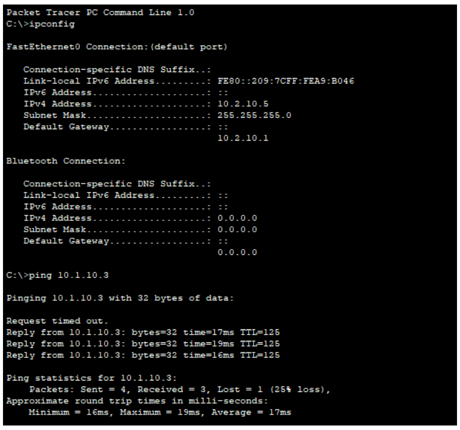
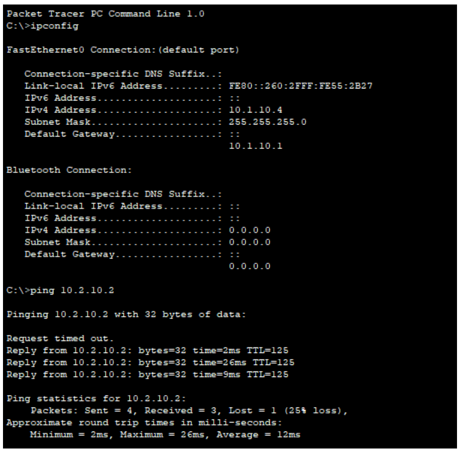


Figure 17: Ping from DN workstation to HQ workstation



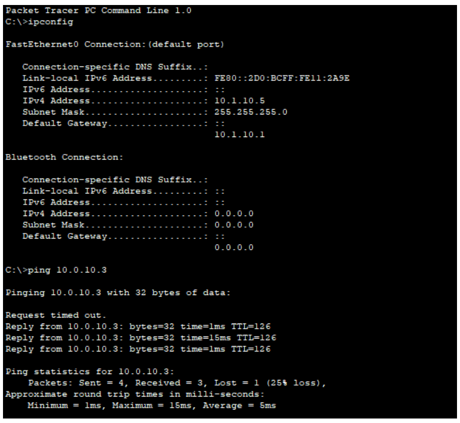
```
Packet Tracer PC Command Line 1.0
C:\>ipconfig

FastEthernet0 Connection:(default port)

   Connection-specific DNS Suffix..:
   Link-local IPv6 Address.........: FE80::209:7CFF:FEA9:B046
   IPv6 Address....................: ::
   IPv4 Address....................: 10.2.10.5
   Subnet Mask.....................: 255.255.255.0
   Default Gateway.................: ::
                                     10.2.10.1

Bluetooth Connection:

   Connection-specific DNS Suffix..:
   Link-local IPv6 Address.........: ::
   IPv6 Address....................: ::
   IPv4 Address....................: 0.0.0.0
   Subnet Mask.....................: 0.0.0.0
   Default Gateway.................: ::
                                     0.0.0.0

C:\>ping 10.1.10.3

Pinging 10.1.10.3 with 32 bytes of data:

Request timed out.
Reply from 10.1.10.3: bytes=32 time=17ms TTL=125
Reply from 10.1.10.3: bytes=32 time=19ms TTL=125
Reply from 10.1.10.3: bytes=32 time=16ms TTL=125

Ping statistics for 10.1.10.3:
    Packets: Sent = 4, Received = 3, Lost = 1 (25% loss),
Approximate round trip times in milli-seconds:
    Minimum = 16ms, Maximum = 19ms, Average = 17ms
```

Figure 18: Ping from DN workstation to NT workstation



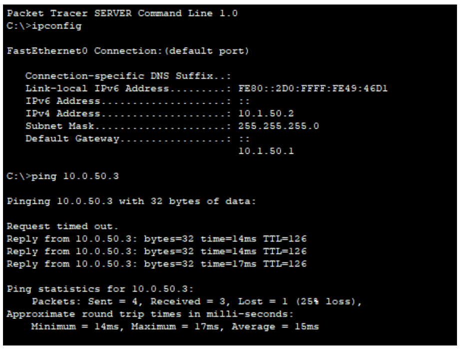
```
Packet Tracer PC Command Line 1.0
C:\>ipconfig

FastEthernet0 Connection:(default port)

   Connection-specific DNS Suffix..:
   Link-local IPv6 Address.........: FE80::260:2FFF:FE55:2B27
   IPv6 Address....................: ::
   IPv4 Address....................: 10.1.10.4
   Subnet Mask.....................: 255.255.255.0
   Default Gateway.................: ::
                                     10.1.10.1

Bluetooth Connection:

   Connection-specific DNS Suffix..:
   Link-local IPv6 Address.........: ::
   IPv6 Address....................: ::
   IPv4 Address....................: 0.0.0.0
   Subnet Mask.....................: 0.0.0.0
   Default Gateway.................: ::
                                     0.0.0.0

C:\>ping 10.2.10.2

Pinging 10.2.10.2 with 32 bytes of data:

Request timed out.
Reply from 10.2.10.2: bytes=32 time=2ms TTL=125
Reply from 10.2.10.2: bytes=32 time=26ms TTL=125
Reply from 10.2.10.2: bytes=32 time=9ms TTL=125

Ping statistics for 10.2.10.2:
    Packets: Sent = 4, Received = 3, Lost = 1 (25% loss),
Approximate round trip times in milli-seconds:
    Minimum = 2ms, Maximum = 26ms, Average = 12ms
```

Figure 19: Ping from NT workstation to DN workstation



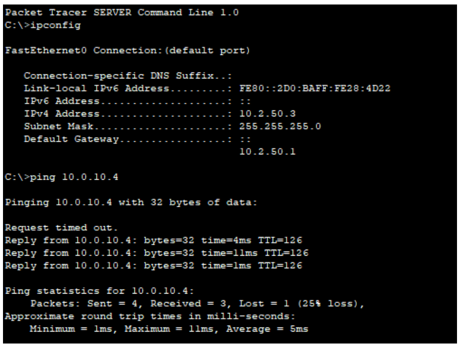
```
Packet Tracer PC Command Line 1.0
C:\>ipconfig

FastEthernet0 Connection:(default port)

   Connection-specific DNS Suffix..:
   Link-local IPv6 Address.........: FE80::2D0:BCFF:FE11:2A9E
   IPv6 Address....................: ::
   IPv4 Address....................: 10.1.10.5
   Subnet Mask.....................: 255.255.255.0
   Default Gateway.................: ::
                                     10.1.10.1

Bluetooth Connection:

   Connection-specific DNS Suffix..:
   Link-local IPv6 Address.........: ::
   IPv6 Address....................: ::
   IPv4 Address....................: 0.0.0.0
   Subnet Mask.....................: 0.0.0.0
   Default Gateway.................: ::
                                     0.0.0.0

C:\>ping 10.0.10.3

Pinging 10.0.10.3 with 32 bytes of data:

Request timed out.
Reply from 10.0.10.3: bytes=32 time=1ms TTL=126
Reply from 10.0.10.3: bytes=32 time=15ms TTL=126
Reply from 10.0.10.3: bytes=32 time=1ms TTL=126

Ping statistics for 10.0.10.3:
    Packets: Sent = 4, Received = 3, Lost = 1 (25% loss),
Approximate round trip times in milli-seconds:
    Minimum = 1ms, Maximum = 15ms, Average = 5ms
```

Figure 20: Ping from NT workstation to HQ workstation



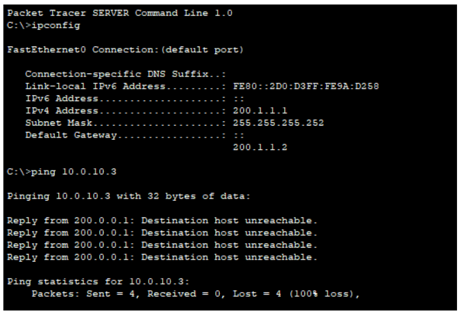
```
Packet Tracer SERVER Command Line 1.0
C:\>ipconfig

FastEthernet0 Connection:(default port)

   Connection-specific DNS Suffix..:
   Link-local IPv6 Address.........: FE80::2D0:FFFF:FE49:46D1
   IPv6 Address....................: ::
   IPv4 Address....................: 10.1.50.2
   Subnet Mask.....................: 255.255.255.0
   Default Gateway.................: ::
                                     10.1.50.1

C:\>ping 10.0.50.3

Pinging 10.0.50.3 with 32 bytes of data:

Request timed out.
Reply from 10.0.50.3: bytes=32 time=14ms TTL=126
Reply from 10.0.50.3: bytes=32 time=14ms TTL=126
Reply from 10.0.50.3: bytes=32 time=17ms TTL=126

Ping statistics for 10.0.50.3:
    Packets: Sent = 4, Received = 3, Lost = 1 (25% loss),
Approximate round trip times in milli-seconds:
    Minimum = 14ms, Maximum = 17ms, Average = 15ms
```

Figure 21: Ping from NT server to HQ server



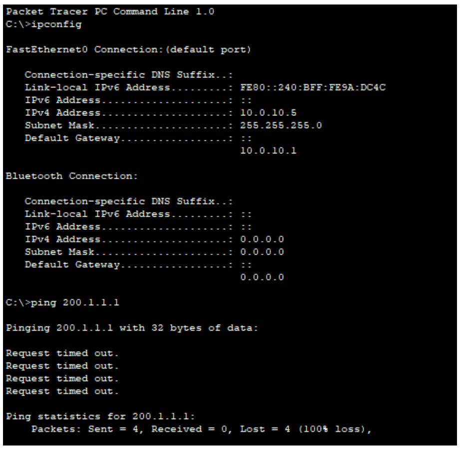
```
Packet Tracer SERVER Command Line 1.0
C:\>ipconfig

FastEthernet0 Connection:(default port)

   Connection-specific DNS Suffix..:
   Link-local IPv6 Address.........: FE80::2D0:BAFF:FE28:4D22
   IPv6 Address....................: ::
   IPv4 Address....................: 10.2.50.3
   Subnet Mask.....................: 255.255.255.0
   Default Gateway.................: ::
                                     10.2.50.1

C:\>ping 10.0.10.4

Pinging 10.0.10.4 with 32 bytes of data:

Request timed out.
Reply from 10.0.10.4: bytes=32 time=4ms TTL=126
Reply from 10.0.10.4: bytes=32 time=11ms TTL=126
Reply from 10.0.10.4: bytes=32 time=1ms TTL=126

Ping statistics for 10.0.10.4:
    Packets: Sent = 4, Received = 3, Lost = 1 (25% loss),
Approximate round trip times in milli-seconds:
    Minimum = 1ms, Maximum = 11ms, Average = 5ms
```

Figure 22: Ping from DN server to HQ workstation



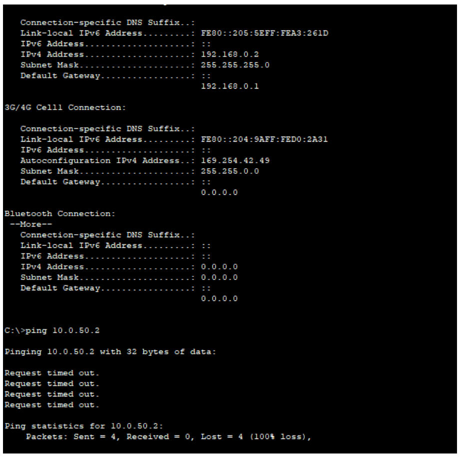
```
Packet Tracer SERVER Command Line 1.0
C:\>ipconfig

FastEthernet0 Connection:(default port)

   Connection-specific DNS Suffix..:
   Link-local IPv6 Address.........: FE80::2D0:D3FF:FE9A:D258
   IPv6 Address....................: ::
   IPv4 Address....................: 200.1.1.1
   Subnet Mask.....................: 255.255.255.252
   Default Gateway.................: ::
                                     200.1.1.2

C:\>ping 10.0.10.3

Pinging 10.0.10.3 with 32 bytes of data:

Reply from 200.0.0.1: Destination host unreachable.
Reply from 200.0.0.1: Destination host unreachable.
Reply from 200.0.0.1: Destination host unreachable.
Reply from 200.0.0.1: Destination host unreachable.

Ping statistics for 10.0.10.3:
    Packets: Sent = 4, Received = 0, Lost = 4 (100% loss),
```

Figure 23: Ping from internet to HQ workstation



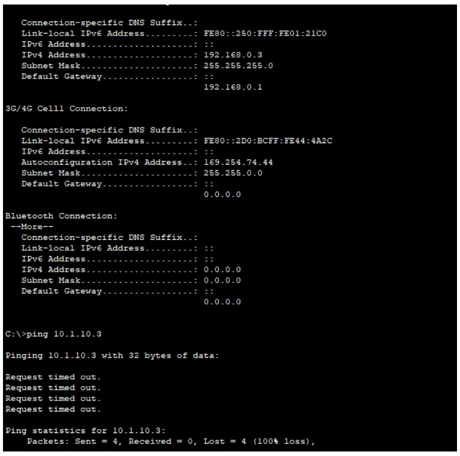
```
Packet Tracer PC Command Line 1.0
C:\>ipconfig

FastEthernet0 Connection:(default port)

   Connection-specific DNS Suffix..:
   Link-local IPv6 Address.........: FE80::240:BFF:FE9A:DC4C
   IPv6 Address....................: ::
   IPv4 Address....................: 10.0.10.5
   Subnet Mask.....................: 255.255.255.0
   Default Gateway.................: ::
                                     10.0.10.1

Bluetooth Connection:

   Connection-specific DNS Suffix..:
   Link-local IPv6 Address.........: ::
   IPv6 Address....................: ::
   IPv4 Address....................: 0.0.0.0
   Subnet Mask.....................: 0.0.0.0
   Default Gateway.................: ::
                                     0.0.0.0

C:\>ping 200.1.1.1

Pinging 200.1.1.1 with 32 bytes of data:

Request timed out.
Request timed out.
Request timed out.
Request timed out.

Ping statistics for 200.1.1.1:
    Packets: Sent = 4, Received = 0, Lost = 4 (100% loss),
```

Figure 24: Ping from HQ workstation to internet



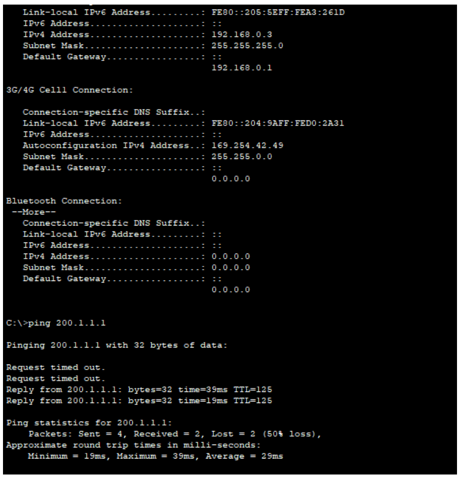
```
   Connection-specific DNS Suffix..:
   Link-local IPv6 Address.........: FE80::205:5EFF:FEA3:261D
   IPv6 Address....................: ::
   IPv4 Address....................: 192.168.0.2
   Subnet Mask.....................: 255.255.255.0
   Default Gateway.................: ::
                                     192.168.0.1

3G/4G Celll Connection:

   Connection-specific DNS Suffix..:
   Link-local IPv6 Address.........: FE80::204:9AFF:FED0:2A31
   IPv6 Address....................: ::
   Autoconfiguration IPv4 Address..: 169.254.42.49
   Subnet Mask.....................: 255.255.0.0
   Default Gateway.................: ::
                                     0.0.0.0

Bluetooth Connection:
 --More--
   Connection-specific DNS Suffix..:
   Link-local IPv6 Address.........: ::
   IPv6 Address....................: ::
   IPv4 Address....................: 0.0.0.0
   Subnet Mask.....................: 0.0.0.0
   Default Gateway.................: ::
                                     0.0.0.0


C:\>ping 10.0.50.2

Pinging 10.0.50.2 with 32 bytes of data:

Request timed out.
Request timed out.
Request timed out.
Request timed out.

Ping statistics for 10.0.50.2:
    Packets: Sent = 4, Received = 0, Lost = 4 (100% loss),
```

Figure 25: Ping from HQ phone to HQ server



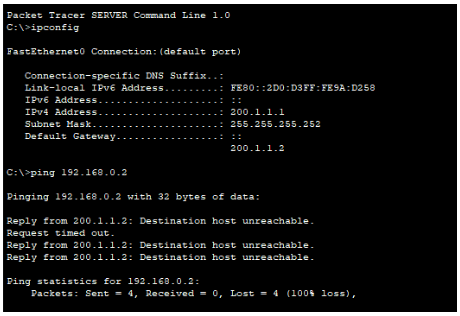
```
   Connection-specific DNS Suffix..:
   Link-local IPv6 Address.........: FE80::250:FFF:FE01:21C0
   IPv6 Address....................: ::
   IPv4 Address....................: 192.168.0.3
   Subnet Mask.....................: 255.255.255.0
   Default Gateway.................: ::
                                     192.168.0.1

3G/4G Celll Connection:

   Connection-specific DNS Suffix..:
   Link-local IPv6 Address.........: FE80::2D0:BCFF:FE44:4A2C
   IPv6 Address....................: ::
   Autoconfiguration IPv4 Address..: 169.254.74.44
   Subnet Mask.....................: 255.255.0.0
   Default Gateway.................: ::
                                     0.0.0.0

Bluetooth Connection:
 --More--
   Connection-specific DNS Suffix..:
   Link-local IPv6 Address.........: ::
   IPv6 Address....................: ::
   IPv4 Address....................: 0.0.0.0
   Subnet Mask.....................: 0.0.0.0
   Default Gateway.................: ::
                                     0.0.0.0


C:\>ping 10.1.10.3

Pinging 10.1.10.3 with 32 bytes of data:

Request timed out.
Request timed out.
Request timed out.
Request timed out.

Ping statistics for 10.1.10.3:
    Packets: Sent = 4, Received = 0, Lost = 4 (100% loss),
```

Figure 26: Ping from HQ phone to NT workstation



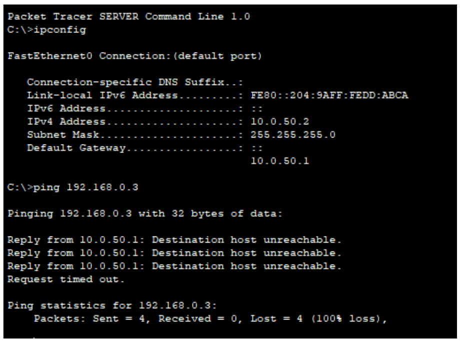
```
   Link-local IPv6 Address.........: FE80::205:5EFF:FEA3:261D
   IPv6 Address....................: ::
   IPv4 Address....................: 192.168.0.3
   Subnet Mask.....................: 255.255.255.0
   Default Gateway.................: ::
                                     192.168.0.1

3G/4G Cell1 Connection:

   Connection-specific DNS Suffix..:
   Link-local IPv6 Address.........: FE80::204:9AFF:FED0:2A31
   IPv6 Address....................: ::
   Autoconfiguration IPv4 Address..: 169.254.42.49
   Subnet Mask.....................: 255.255.0.0
   Default Gateway.................: ::
                                     0.0.0.0

Bluetooth Connection:
 --More--
   Connection-specific DNS Suffix..:
   Link-local IPv6 Address.........: ::
   IPv6 Address....................: ::
   IPv4 Address....................: 0.0.0.0
   Subnet Mask.....................: 0.0.0.0
   Default Gateway.................: ::
                                     0.0.0.0


C:\>ping 200.1.1.1

Pinging 200.1.1.1 with 32 bytes of data:

Request timed out.
Request timed out.
Reply from 200.1.1.1: bytes=32 time=39ms TTL=125
Reply from 200.1.1.1: bytes=32 time=19ms TTL=125

Ping statistics for 200.1.1.1:
    Packets: Sent = 4, Received = 2, Lost = 2 (50% loss),
Approximate round trip times in milli-seconds:
    Minimum = 19ms, Maximum = 39ms, Average = 29ms
```

Figure 27: Ping from HQ phone to internet



```
Packet Tracer SERVER Command Line 1.0
C:\>ipconfig

FastEthernet0 Connection:(default port)

   Connection-specific DNS Suffix..:
   Link-local IPv6 Address.........: FE80::2D0:D3FF:FE9A:D258
   IPv6 Address....................: ::
   IPv4 Address....................: 200.1.1.1
   Subnet Mask.....................: 255.255.255.252
   Default Gateway.................: ::
                                     200.1.1.2

C:\>ping 192.168.0.2

Pinging 192.168.0.2 with 32 bytes of data:

Reply from 200.1.1.2: Destination host unreachable.
Request timed out.
Reply from 200.1.1.2: Destination host unreachable.
Reply from 200.1.1.2: Destination host unreachable.

Ping statistics for 192.168.0.2:
    Packets: Sent = 4, Received = 0, Lost = 4 (100% loss),
```

Figure 28: Ping from internet to NT phone



```
Packet Tracer SERVER Command Line 1.0
C:\>ipconfig

FastEthernet0 Connection:(default port)

   Connection-specific DNS Suffix..:
   Link-local IPv6 Address.........: FE80::204:9AFF:FEDD:ABCA
   IPv6 Address....................: ::
   IPv4 Address....................: 10.0.50.2
   Subnet Mask.....................: 255.255.255.0
   Default Gateway.................: ::
                                     10.0.50.1

C:\>ping 192.168.0.3

Pinging 192.168.0.3 with 32 bytes of data:

Reply from 10.0.50.1: Destination host unreachable.
Reply from 10.0.50.1: Destination host unreachable.
Reply from 10.0.50.1: Destination host unreachable.
Request timed out.

Ping statistics for 192.168.0.3:
    Packets: Sent = 4, Received = 0, Lost = 4 (100% loss),
```

Figure 29: Ping from HQ server to HQ phone

You might have noticed that the first try of some ping commands fails. That is due to the switches not having a route cached.

5.2 Traceroute Test

```
Packet Tracer PC Command Line 1.0
C:\>tracert 10.0.10.3

Tracing route to 10.0.10.3 over a maximum of 30 hops:

  1   0 ms      0 ms      0 ms      10.2.10.1
  2   0 ms      1 ms      1 ms      10.0.0.5
  3   *         0 ms      0 ms      10.0.10.3

Trace complete.
```

Figure 30: Tracert from DN workstation to HQ workstation

```
Packet Tracer PC Command Line 1.0
C:\>tracert 10.0.10.5

Tracing route to 10.0.10.5 over a maximum of 30 hops:

  1   0 ms      0 ms      0 ms      10.1.10.1
  2   14 ms     1 ms      1 ms      10.0.0.1
  3   *         0 ms      1 ms      10.0.10.5

Trace complete.
```

Figure 31: Tracert from NT workstation to HQ workstation

```
C:\>tracert 10.1.10.2

Tracing route to 10.1.10.2 over a maximum of 30 hops:

  1   17 ms     31 ms     16 ms     192.168.0.1
  2   *         *         *         Request timed out.
  3   *         *         *         Request timed out.
  4   *         *         *         Request timed out.
  5   *         *         *         Request timed out.
  6   *         *         *         Request timed out.
  7   *         *         *         Request timed out.
  8   *         *         *         Request timed out.
  9   *         *         *         Request timed out.
  10   *         *         *         Request timed out.
  11   *         *         *         Request timed out.
  12   *         *         *         Request timed out.
  13   *         *         *         Request timed out.
  14   *         *         *         Request timed out.
  15   *         *         *         Request timed out.
  16   *         *         *         Request timed out.
  17   *         *         *         Request timed out.
  18   *         *         *         Request timed out.
  19   *         *         *         Request timed out.
  20   *         *         *         Request timed out.
  21   *         *         *         Request timed out.
  22   *         *         *         Request timed out.
  23   *         *         *         Request timed out.
  24   *         *         *         Request timed out.
  25   *         *         *         Request timed out.
  26   *         *         *         Request timed out.
  27   *         *         *         Request timed out.
  28   *         *         *         Request timed out.
  29   *         *         *         Request timed out.
  30   *         *         *         Request timed out.

Trace complete.
```

Figure 32: Tracert from HQ phone to NT workstation

5.3 MAC Address Table and OSPF IP Table

```
Switch>show mac address-table
          Mac Address Table
-------------------------------------------

Vlan    Mac Address       Type        Ports
----    -----------       --------    -----

   1    000b.bee8.87b8    DYNAMIC     Fa0/2
   1    0060.5c04.4e1a    DYNAMIC     Fa0/1
  10    0001.6358.4b25    DYNAMIC     Fa0/2
  10    0003.e4cd.53a8    DYNAMIC     Fa0/2
  10    0004.9aad.7901    DYNAMIC     Gig0/1
```

Figure 33: MAC address table of workstation switch at HQ

```
Switch>show mac address-table
          Mac Address Table
-------------------------------------------

Vlan    Mac Address       Type        Ports
----    -----------       --------    -----

   1    000b.be72.c8e6    DYNAMIC     Fa0/2
   1    000c.8555.e91a    DYNAMIC     Fa0/1
   1    0060.5c61.3c01    DYNAMIC     Gig0/2
   1    00d0.9725.03b2    DYNAMIC     Fa0/2
```

Figure 34: MAC address table of workstation switch at NT branch

```
Switch>show mac address-table
          Mac Address Table
-------------------------------------------

Vlan    Mac Address       Type        Ports
----    -----------       --------    -----

   1    0030.f2a9.9097    DYNAMIC     Fa0/1
   1    0090.0c67.5882    DYNAMIC     Fa0/2
   1    00e0.f793.3680    DYNAMIC     Gig0/2
```

Figure 35: MAC address table of workstation switch at DN branch

```
Router>show ip route ospf
     10.0.0.0/8 is variably subnetted, 16 subnets, 3 masks
O       10.1.1.0 [110/65] via 10.0.0.2, 00:29:01, Serial0/0/0
O       10.1.10.0 [110/65] via 10.0.0.2, 00:29:01, Serial0/0/0
O       10.1.50.0 [110/65] via 10.0.0.2, 00:29:01, Serial0/0/0
O       10.2.1.0 [110/65] via 10.0.0.6, 00:29:01, Serial0/0/1
O       10.2.10.0 [110/65] via 10.0.0.6, 00:29:01, Serial0/0/1
O       10.2.50.0 [110/65] via 10.0.0.6, 00:29:01, Serial0/0/1
     200.0.1.0/30 is subnetted, 1 subnets
O       200.0.1.0 [110/128] via 10.0.0.2, 00:29:01, Serial0/0/0
                  [110/128] via 200.0.0.2, 00:29:01, Serial0/1/0
     200.0.2.0/30 is subnetted, 1 subnets
O       200.0.2.0 [110/128] via 10.0.0.6, 00:29:01, Serial0/0/1
                  [110/128] via 200.0.0.2, 00:29:01, Serial0/1/0
     200.1.1.0/30 is subnetted, 1 subnets
O       200.1.1.0 [110/65] via 200.0.0.2, 00:29:01, Serial0/1/0
```

Figure 36: OSPF IP table at HQ

```
Router>show ip route ospf
     10.0.0.0/8 is variably subnetted, 15 subnets, 3 masks
O       10.0.0.4 [110/128] via 10.0.0.1, 00:29:29, Serial0/0/0
O       10.0.1.0 [110/65] via 10.0.0.1, 00:29:29, Serial0/0/0
O       10.0.10.0 [110/65] via 10.0.0.1, 00:29:29, Serial0/0/0
O       10.0.50.0 [110/65] via 10.0.0.1, 00:29:29, Serial0/0/0
O       10.2.1.0 [110/129] via 200.0.1.2, 00:29:19, Serial0/0/1
                 [110/129] via 10.0.0.1, 00:29:19, Serial0/0/0
O       10.2.10.0 [110/129] via 200.0.1.2, 00:29:19, Serial0/0/1
                  [110/129] via 10.0.0.1, 00:29:19, Serial0/0/0
O       10.2.50.0 [110/129] via 200.0.1.2, 00:29:19, Serial0/0/1
                  [110/129] via 10.0.0.1, 00:29:19, Serial0/0/0
     200.0.0.0/30 is subnetted, 1 subnets
O       200.0.0.0 [110/128] via 200.0.1.2, 00:29:29, Serial0/0/1
                  [110/128] via 10.0.0.1, 00:29:29, Serial0/0/0
     200.0.2.0/30 is subnetted, 1 subnets
O       200.0.2.0 [110/128] via 200.0.1.2, 00:29:29, Serial0/0/1
     200.1.1.0/30 is subnetted, 1 subnets
O       200.1.1.0 [110/65] via 200.0.1.2, 00:29:29, Serial0/0/1
```

Figure 37: OSPF IP table at NT branch

```
Router>show ip route ospf
     10.0.0.0/8 is variably subnetted, 15 subnets, 3 masks
O       10.0.0.0 [110/128] via 10.0.0.5, 00:29:46, Serial0/0/0
O       10.0.1.0 [110/65] via 10.0.0.5, 00:29:46, Serial0/0/0
O       10.0.10.0 [110/65] via 10.0.0.5, 00:29:46, Serial0/0/0
O       10.0.50.0 [110/65] via 10.0.0.5, 00:29:46, Serial0/0/0
O       10.1.1.0 [110/129] via 200.0.2.2, 00:29:36, Serial0/0/1
                 [110/129] via 10.0.0.5, 00:29:36, Serial0/0/0
O       10.1.10.0 [110/129] via 200.0.2.2, 00:29:36, Serial0/0/1
                  [110/129] via 10.0.0.5, 00:29:36, Serial0/0/0
O       10.1.50.0 [110/129] via 200.0.2.2, 00:29:36, Serial0/0/1
                  [110/129] via 10.0.0.5, 00:29:36, Serial0/0/0
     200.0.0.0/30 is subnetted, 1 subnets
O       200.0.0.0 [110/128] via 200.0.2.2, 00:29:36, Serial0/0/1
                  [110/128] via 10.0.0.5, 00:29:36, Serial0/0/0
     200.0.1.0/30 is subnetted, 1 subnets
O       200.0.1.0 [110/128] via 200.0.2.2, 00:29:36, Serial0/0/1
     200.1.1.0/30 is subnetted, 1 subnets
O       200.1.1.0 [110/65] via 200.0.2.2, 00:29:36, Serial0/0/1
```

Figure 38: OSPF IP table at DN branch

The MAC address tables and OSPF IP tables are not anywhere near complete because they are the entries currently cached in the devices. These tables will expand as more transactions go through these devices.

6 Results and Conclusions

6.1 Re-evaluation of the design

6.1.1 Reliability

- The message sent by network devices are receivable to the receivers.
- Our system might have packet loss. This might be occurred in the first route or ping because the network need to fill the MAC table of the switch. After this time, our system will deliver packets more easier with less packet loss.

6.1.2 Easy to Upgrade

- Each subnet in a single networkcan provide up to 253 users, so our system can add and remove devices easily.
- When we want to add new branch to the network, we just add and configure new router corresponding to that branch. Then, connect to Headquarter router through WAN links.

6.1.3 Diversity of Supporting Software

Not only the Ethernet connection, our network system also provide wireless router for the wireless devices to access the Internet.

6.1.4 Scalability

- The use of network equipment from Cisco helps us to have better technical support, more stable equipment, and especially in Cisco products that are often integrated, available new technologies.
- For the problem of bandwidth, with the increment rate of 20% per 5 years so when we will safety factor of 20% to make sure the network can have good performance for the next 10 years.

6.1.5 Safety

- Support the mechanism to restrict IP address to come in and out of the Internet
- Servers are placed in a separate switch with their own VLANs and they connect to gateway routers through a separate port. Since this, our system can implement network configurations to enhance the network's security more conveniently.
- Providing security for wireless network by applying ACL tables to limit the access from wireless devices to other devices
- Applying mechanism to prevent the wireless devices ping to other devices.
- Sensitive data is kept confidential when there are packet theft attacks

6.2 Remaining Problems

6.2.1 Security

- Although the ACL limit the IP from wireless access to ping other devices, this can also restrict the inter Network to receive message when the servers ping to the Internet
- The wifi password might be easy to guess

6.2.2 Scalability

- Our network system can support up to 15 branches, so in the future, if the bank have more branches, there should be another enhancement in the network to adapt the scalability of the bank.
- Serial link for inter-branch may cause bottleneck problem when the bank grower bigger.

6.3 Development Orientation

- Enhance security of the network to protect customer's data.
- Implement the ping from the Inter Network to Web server
- Conduct a detailed actual survey of the lines, structure of the wall and floor to install the equipment
- Use professional security measures, build a network security room to detect and resolve situations in real time
- Find the ways to improve the network when the bank grow bigger with the lowest cost with the good performance. A bank usually have a long life span, so we need to make the network to have a long life span as most as possible with the easiest maintenance.

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