Simulation on IPv6

By

Maisarah Bt. Mohamad Aminuddin

Dissertation submitted in partial fulfillment of
the requirements for the
Bachelor of Technology (Hons)
(Information & Communication Technology)

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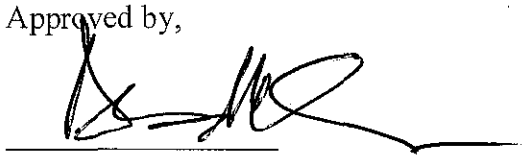
Approved by,



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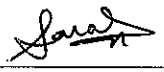
JULY 2006

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.



MAISARAH BT. MOHAMAD AMINUDDIN

ABSTRACT

This report is to have an insight on the final year project of simulation on IPv6. The report explains the background on the current issues that the world is facing with IPv6. Besides that, it states the problem on why this topic has been chosen as a final year project by the student. In this report, the students will also include the results and discussion from the survey that have been conducted.

For this project the student will need to construct a simulation of IPv6 as well as a simple IPv6 test bed. The project will need to have some equipment in order to have the simulation and the test bed. Some literature reviews are presented in order to identify what have others have said or discovered about the topic on IPv6. The literature review will also help the student to have a better understanding on what is needed to be done for the project.

ACKNOWLEDGEMENT

The author would like to express her greatest gratitude firstly to the Almighty, for giving her the ideas and strength to complete this report on time. Without His help and blessing, the author could not have completed the report on time.

Next what would have the author done without the help of these people who has contribute their time and their support for her. Her gratefulness goes out to her Supervisor, Mr. Abdullah Sani, for guiding her throughout the completion of this report. The author would like to thank Mr. Ruslan, Data Communication Lab Technician, for his help in providing the tools and equipment for the test bed. Besides that, she would also like to thank all of her lecturers and friends who had helped her in contributing some ideas and giving her moral support. Last but not least, the author's parents. Without their support and their faith that they have in her, she would have been lost.

CHAPTER 1: INTRODUCTION

1.1 Background

Technologies are one of the important aspects in our daily life. It seems that almost everything we do, technology has its place and play its role in making humans life easier. With technology, more equipment are being created and developed. Therefore, with more Internet enabled equipments means the more IP addresses are needed, to support the ever growing needs for Internet access. Hence, to accommodate the growing needs for Internet access, IPv6 can help to accomplish it.

Researchers from all over the world are looking into IPv6 as the next Internet Protocol. This new protocol can provide better service than the previous Internet Protocol, IPv4. IPv4 has been used for a long time and researchers think it is time to replace it with a new protocol so that it can cater and cope with new situation, the technology era. IPv6 has been said that it can provide more IP addresses. Therefore, it is suitable with what the world has to offer, a world that is equip with many new gadgets such as mobile phones, PDAs, tablet PCs and etc. IPv6 has many more benefits to offer the new era. That is why the Malaysian government is also keen to have a research on it, as it has been stated in 9th Malaysian Plan.

For the past few years, the Malaysian government had tried to promote the importance of IPv6 research in the country. . The research program has been deployed but it is moving so slow. Other countries such as Japan and US have done and even implement IPv6 in their network. Based on one of the survey done by Malaysian Advance Network Integrated System (MANIS) shows that, 65% percent of Malaysian believes that IPv6 will be implemented in 5 years time. 50% of Malaysians gave a positive response to move to IPv6 and 40% have the competency to move to IPv6. Here it shows that Malaysians are ready to move towards IPv6.

Therefore, as to support the government and be at pace with other countries, there is no better way than to start moving into the new technology. There is no better way than to have it tested at the universities. Some universities, such as Universiti Teknologi Malaysia (UTM) and Universiti Sains Malaysia (USM), have done research and are an active member in the IPv6 organizations.

1.2 Problem Statement

In the 9th Malaysian Plan, the government has stated their concerns on making Malaysia as a leader in technology advancements. The government is promoting the main technologies such as IPv6, broadband and sensor technologies to the nation [12]. According to the government, they tend to make Malaysian IPv6-enabled nation by 2010. Hence, they are looking deeply in research and development for IPv6. They are encouraging the universities and research institutions to join and help nurture IPv6 experts in the country.

This could be the stepping stone for Universiti Teknologi PETRONAS (UTP) to be a part of the research group which is also aligned with its vision, to be a leader in technology education and centre for creativity and innovation. Therefore, to support the government, UTP can be one of the research centres for IPv6. With the research center UTP will be able to enhance their image and reputation as well as be equip with the latest technology and can compete with other universities in the country as well as abroad.

1.3 Objectives and Scope of Study

Simulation of IPv6 is the first step to help UTP to plan on how to go about to become one of the IPv6 research center in Malaysia. The objectives for the project are:

1. To conduct research on IPv6 in terms of what are the advantages that it can offer compared to IPv4, what are the new enhancements in IPv6, how is it being accepted in Malaysia and etc.
    a. The research will help to create a better understanding of what is actually Internet Protocol version 6 is and why it is important to look into it.
    b. This will also help to understand the advantages it have over the previous internet protocol, IPv4.
2. To identify the requirements needed to simulate and implement IPv6 in campus environment
    a. This project will help to identify the equipment needed in implementing IPv6 in the campus network. Therefore, this will help to predict whether the campus have the right equipment or not.
3. Able to understand on how to use a third party software for simulating IPv6
4. Construct the simulation scenario
    a. The scenario of the simulation will provide a better understanding on IPv6
5. Create a simple test bed of IPv6
    a. The test bed is done to help understand on how to configure IPv6 on Windows platform.

The scope of study for this project is minimized in order to have a better understanding on Internet Protocol version 6 (IPv6). The project is to help the members of UTP understand the importance of IPv6 and what are its advantages. Besides that, this project can also identify whether the university is ready to have an IPv6 network.

CHAPTER 2: LITERATURE REVIEW

The Malaysian government is emphasizing the research institutions and universities to help the country to have experts in IPv6. The Prime Minister, Y.A.B Dato' Seri Abdullah Ahmad Badawi, are encouraging Malaysian to boost the Information & Communication Technology (ICT) sector so that Malaysia can be one of the leader in technology. Even now, one of the issues in the 9th Malaysian Plan is to help the government to boost the adoption of the ICT in the country. The Government is also considering migrating from the current Internet Protocol version 4 (IPv4) to IPv6 in view of the latter's improved features [15].

IPv6 has been researched by other countries in the world for a very long time. In Malaysia, IPv6 has been firstly introduced by NTT from Japan. NTT then opened a branch in Malaysia which is known as NTT MSC [5]. This was more than 6 years ago. Early testing was done within NTT and also between NTT and Network Research Group (NRG), USM. Some universities are peering with Malaysian Advance Network Integrated System (MANIS) to access to IPv6. For example, Universiti Sains Malaysia, Universiti Malaya Universiti Putra Malaysia and other universities as well. It was then, considered as an excellent time to introduce the new protocol as it was inline with Multimedia Super Corridor (MSC) objectives. Therefore, NTT MSC was the pioneer of IPv6 in Malaysia.

Even though IPv6 has been introduced in Malaysia for a few years back, the progress in research and development is still slow. There are already IPv6 services provided to access and evaluate IPv6 in Malaysia but there isn't much participation from organizations.

According to survey done by MANIS, only a few Malaysian are aware of IPv6 existence. The survey was conducted by MANIS in the year 2002 [8]. In Figure 2.1 below shows the level of participants' knowledge towards IPv6. This was a part of the result received from the survey done by MANIS. The same result is also achieved by the

survey done here in Universiti Teknologi PETRONAS (UTP), 2006. The result of the survey can be obtained in Chapter 4 of this report.

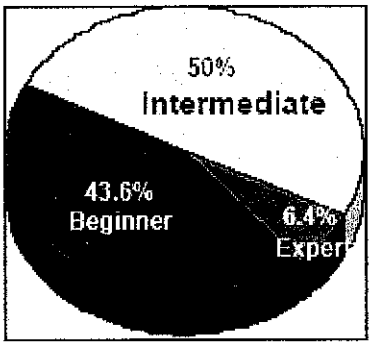


Figure 2.1: Level of IPv6 Knowledge

In the future, the need for more IP address will arise and therefore it is IPv6 role to provide more IP addresses and better security compared to the previous IPv4. The increasing needs for more IP address are mainly due to the availability of technology products that are common and cheap to obtain nowadays. IPv6 is the underlying platform for all future application technologies. It enables the use of more IP addresses and provides better security than the current IPv4, which remains widely used [12].

CHAPTER 3: METHODOLOGY

3.1 Procedure Identification

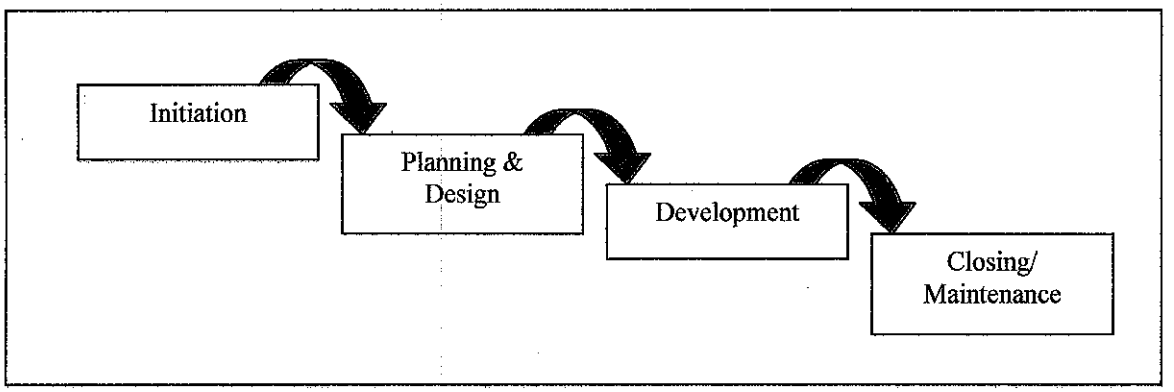


Figure 3.1: Methodology Process

Initiation Phase

This is the first phase to in making this project successful. In the initiation phase, the idea of what the project will be stated. As in this project, the title of the project was proposed by the lecturers. Therefore, the student needs to set what are his/ her focus would be for this project. During this phase, the nature and scope of the project are identified. It is also important to understand the background, which in this case is on IPv6.

Planning & Design Phase

The main activity in this phase is to conduct research on IPv6. This is essential in understanding what the main issues of IPv6 are. By conducting research, the student will be able to understand the objectives, identify the tools required, listing the tasks needed to be done and etc. a survey was also conducted in order to gain some understanding towards the perception of Universiti Teknologi PETRONAS (UTP) members towards IPv6. During this phase also, the student will design the simulation. For this project, the simulation will be based on the test bed network.

Development Phase

For this phase, the student will develop the simulation. The student will develop the simulation using third- party software. This simulation will be based on the test bed network. Besides that, the student will also create the test bed. The objective of the test bed is to help the student understand the configuration of IPv6 on a Windows platform.

Closing/ Maintenance Phase

This is the last phase for this project. For this phase, the students will gather all the information obtained from the research, survey, simulation and the test bed to summarize it and help identify whether Universiti Teknologi PETRONAS (UTP) is ready for IPv6 or not.

3.2 Tools Required

Simulation requirement:

1. Computer running on Linux platform with OMNet++ installed

Test bed requirements:

1. 1 computer running on Windows Server 2003 (SP1) for DNS Server
2. 2 computers with 2 network adapters installed in each computer, running on Windows Server 2003 (SP1) as the routers.
3. 2 computer running on Windows XP Professional (SP2) as the clients

CHAPTER 4: RESULTS & DISCUSSION

4.1 Survey Result

Information gathering is essential in doing research. Therefore, a survey was done in order to study the awareness level of UTP members towards IPv6. The survey consists of two sections which are Section A and Section B. In Section A, the questions are focused on the respondent's background and for Section B; the questions are related to the respondent's awareness level of IPv6. (Refer to Appendix 1 for the survey questions) The survey was conducted within UTP campus and it was handed out to 50 UTP members.

Below are the results obtained from the survey:

- 72% of the respondents are students, 8% lecturers, and 20% others. (Please refer to Figure 4.1)

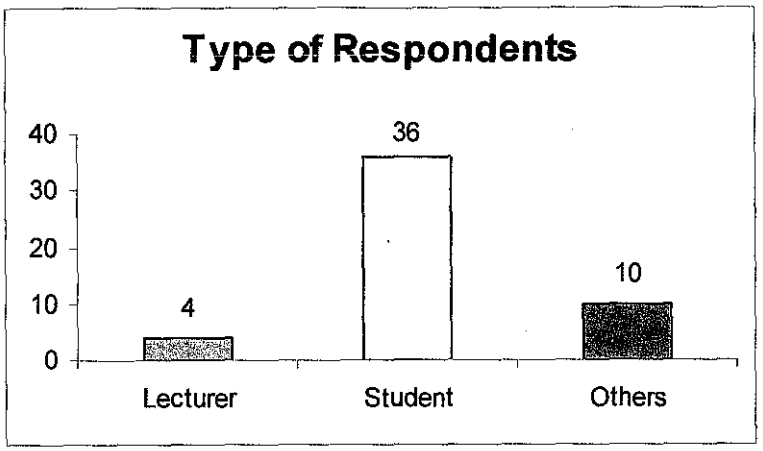


Figure 4.1: Type of Respondents

- 40% of the respondents have heard of IPv6
- 65% of the respondents thinks that UTP should migrate the network from IPv4 to IPv6

- The respondents who have heard of IPv6 have different level of knowledge on it Please refer to Figure 4.2.

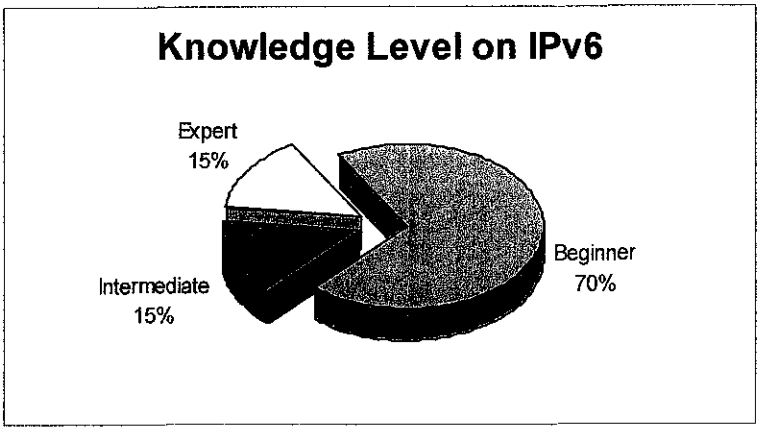


Figure 4.2: Respondents' Knowledge Level on IPv6

From the results obtained, we can assume that majority of UTP members are not aware of IPv6 existence. This may be due to the fact that, most of the respondents are the end users. Therefore, the back end story of the network does not seem to be their concern. What is important to them is the quality of the network provided by UTP. Besides that, the survey also shows that there is not enough promotion by the Malaysian government on IPv6. Why? Well, maybe one reason is that, the promotion of IPv6 was only done for certain group of people but not for the whole society because not all of the society will be interested in it. Examples of groups that might be interested in IPv6 are the Internet Service Provider (ISP), communications company and technologists.

This survey was mostly done by the students because majority of UTP members are the students. They are the primary user of UTP network. Most of the technology students are more aware of IPv6 because it was introduced to them in one of the subjects taken but for the engineering students, not so many of them are aware about it. Some of the engineering students might obtain the information about IPv6 from their friends, from reading materials and others.

From the total number of respondents who are aware of IPv6, most of their knowledge level on IPv6 is only as beginner. This shows that there is not sufficient training done to help improve their knowledge on IPv6.

Besides that, majority of the respondents think that UTP should migrate the network to IPv6. More than half of the respondents have selected 'yes' to the last question of the survey. This is such a positive feedback, it shows those UTP members are willing to take the next step and move forward. It shows that UTP are willing to be at par with others who have implemented IPv6.

4.2 General Findings

4.2.1 IPv6 Advantages over IPv4

The problem of not having enough IPv4 addresses was the main reason to have IPv6. With the on going process of developing new technology in the world, it is important to have enough IP addresses to cater for the needs of the technology devices especially all the mobile technology. IPv6 offers some benefits over IPv4.

The first and foremost important is that IPv6 provides larger address space. IPv6 can allocate about 1030 addresses per person on the planet. Its flexible network architecture allows an organization to use only one prefix for the entire network of the organization. Therefore, it helps organization to maintain their network easily.

Due to the larger address availability, the multicast addresses are also increased. This will help the network to allow IP packets such as video stream to be sent multiple destinations at the same time. Hence, it will help to save the network bandwidth.

IPv6 also apply a more simplified header format. This new header format eliminates some content from the IPv4 header format and also enhanced some content of IPv4 header format, as shown in Figure 4.3. It provides a faster processing of IPv6 header but the efficiency for routing are dependent on option headers treatment as well as the look up algorithm of the device run on. The fields in the header are all 64 bits taking advantage of the current 64- bit processor therefore faster processing. The fragmentations are done at the source device using path transmission unit discovery protocol.

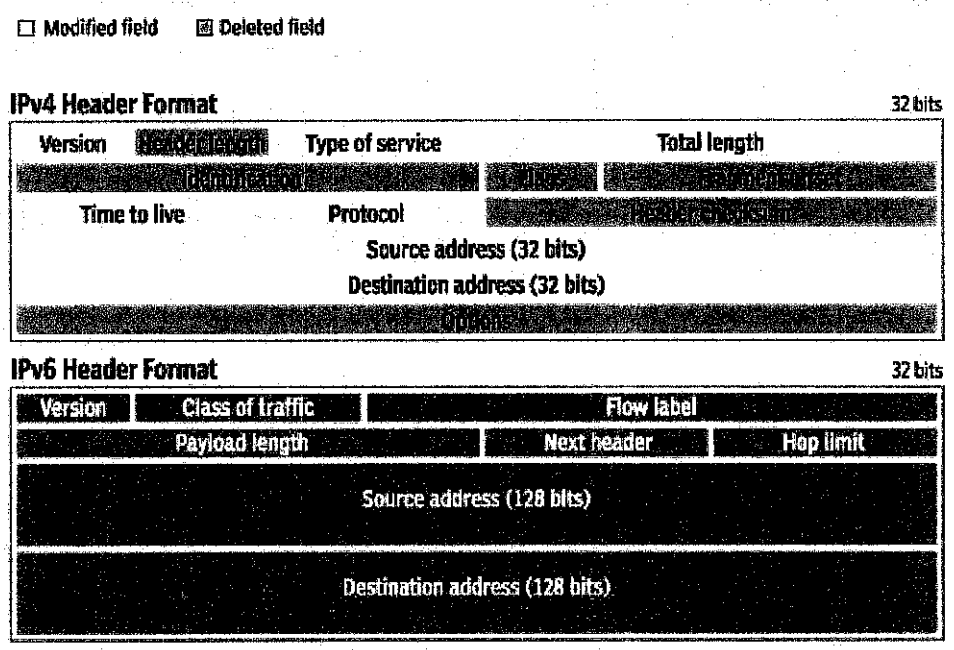


Figure 4.3: Differences in IPv4 and IPv6 Header Format

The hierarchical network architecture of the new protocol, enable the use of multiple levels of hierarchy inside address space. Each level will aggregate the traffic at that level which will helps in faster sending and receiving process. This factor will also contribute in reducing the size of the Internet routing tables.

IPv6 supports auto configuration and "Plug and Play" method. This enables large number of IP hosts to easily discover the network and get new and globally unique IPv6 address and hence will eliminates the need for DHCP server because no manual configuration is needed.

Besides that, IPv6 also have an enhanced support for mobile computing devices. IPv6 allows mobile devices that are the trend nowadays to connect to a network easily and also without having to break the existing connections. This means that user will have access on Internet wherever they go.

The security features in IPv6 are more enhanced such as having mandatory IPSec implementation and provides security extension header for easy encryption, authentication and virtual private networks.

4.2.2 Applications on IPv6

Applications should not have problems operating on IPv6. Most of the applications developed support IPv6. Mainly, all applications could operate but unfortunately not on some conditions it does not operate on IPv6. This is due to the fact that some Application Programmer Interface that applications use to interact with the network needs to be changed in order to support IPv6. Another factor is some applications use access restriction based on IP address. Sometimes the size of IPv4 address is hard coded in the communication protocol. Therefore, it needs to be changed before it can run on IPv6. Despite the problems, many applications nowadays support IPv6.

The oldest applications for the Internet are FTP and Telnet. Both of these applications support IPv6. For Windows, the ftp and telnet programs are run using the command prompt. The connectivity of IPv6 will fall back on IPv4 if the connectivity is broken. For Linux, FreeBSD and MacOS, ftp and telnet will run using command line but it does not fall back on IPv4 if the connectivity of IPv6 is broken.

For web browsing application, Internet Explorer supports IPv6 under Windows but for Mac it doesn't. Netscape has IPv6 versions for Linux but it is difficult to find. Mozilla has more IPv6 support but it is still common to find it running on IPv4 for Mac. Firefox is the only application that supports IPv6 in all distributions. For Apple's browser, Safari, it supports IPv6 but it prefers to run on IPv4 rather than IPv6. Konqueror will load web pages on IPv6 and does not fall back on IPv4. This browser application is usually for Linux.

Mail clients applications such as Internet Explorer supports IPv6 but not for Microsoft Outlook Express. For UNIX and Linux mail clients, they are all fully IPv6 enabled. Firefox and Thunderbird are IPv6 enabled only on Windows platform but not on

Mac. Meanwhile, Apple's mail application prefers the new protocol, IPv6, compared to IPv4.

Windows Media Player, Quicktime Player and Apple's iTunes are some example of media player applications that can play content that it downloads with HTTP over IPv6. On the other hand, Video LAN Client (VLC) supports IPv6 in another whole level. VLC is able to play almost every audio and video format there is, either from a file or CD/ DVD or over the network. Most of the operating system such as Windows, MacOS, Linux as well as FreeBSD can run VLC.

4.3 Introduction to OMNet ++

OMNet ++ is a C++ based discrete event simulation package developed at technical University of Budapest by Andras Varga [1, 7]. OMNet++ was chosen as the simulation framework because it is open- source and free for non- profit use, it allows the designing of modular simulation models, which have combined and reused flexibility., it supports parallel simulation and many more.

OMNet++ model consists of the following parts:

- NED language topology description –(.ned) files
    - This describe the module structure with parameters, gates, etc. this can be written using text editor or GNED graphical editor.
- Message definition – (.msg) files
    - Message types are defined here and data fields are added. OMNet++ will translate message definitions into full- fledged C++ classes.
- Simple modules sources – (.h/ .cc) suffix

The simulation is consists of the following components:

- Simulation kernel – (.a/ .lib) extension
    - Codes that manage simulation and simulation class library. It is written in C++, compiled and put together to form a library.
- User interfaces – (.a/ .lib) extension
    - The OMNet++ user interfaces are used in simulation execution, to facilitate debugging, demonstration, or both batch executions of simulations. It is written in C++, compiled, and put together into libraries.

Running the simulation and analyzing the results. OMNet++ can create a simulation executable. This is standalone program that can run without having OMNet++ or the model files installed or present. The program starts by reading the configuration file. A

file called *'omnetpp.ini'*. Then the output of the simulation will be written onto data files such as output vector files, output scalar files and even the user's own output files. To view and plot contents s of the output, a GUI tool is provided. This GUI tool is known as Plove. All the output files are in text files. Therefore, we can use other programs that can read math packages such as Mathlab or Octave. These programs can provide more functionality for statistical analysis and visualization.

The user interface acts as the display of the simulation. The user interface makes the internal model be visible to user and allows the user to make changes in the variables or objects inside the model. It lets the user to get almost like hands- on experience of the model's behavior.

4.4 IPv6 Test bed

For this project, a simple test bed was done to help understand how to configure IPv6 for a small network that consists of a DNS Server, router and clients. The IPv6 test bed is based on Microsoft's Step- by- step Guide for Setting up IPv6 Test lab. For the network diagram of the test bed, please refer to Figure 4.4 below. The configuration must be done in the following order to eliminate any problems. The order is as follows: the DNS server, Client1, Router1, Router2, and finally Client2.

The tools required for the test bed are as follows:

- 1 computer running on Windows Server 2003 (SP1) for DNS Server
- 2 computers with 2 network adapters installed in each computer, running on Windows Server 2003 (SP1) as the routers.
- 2 computers running on Windows XP Professional (SP2) as the clients

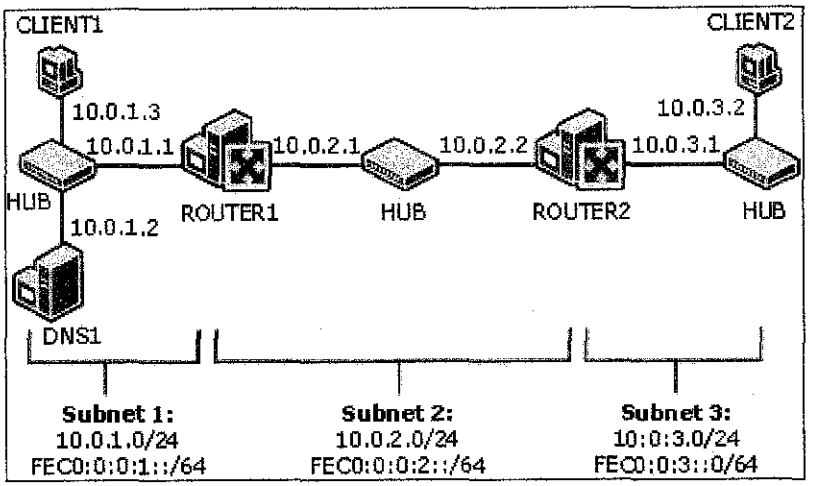


Figure 4.4: IPv6 Test Bed Diagram

Configure DNS1 to provide DNS Services

1. Install Windows Server 2003 with SP1, Standard Edition, as a stand-alone server. Set the Administrator password.
2. After restarting, log on as Administrator.
3. Configure the TCP/IP protocol with the IP address of 10.0.1.2, the subnet mask of 255.255.255.0, and the default gateway of 10.0.1.1.

Install the DNS Server service

1. Open Windows Components Wizard. To open the Windows Components Wizard, click **Start**, click Control Panel, double-click **Add or Remove Programs**, and then click **Add/Remove Windows Components**.
2. In **Components**, select the **Networking Services** check box, and then click **Details**.
3. In **Subcomponents of Networking Services**, select the **Domain Name System (DNS)** check box, click **OK**, and then click **Next**.
4. If prompted, in **Copy files from**, type the full path to the distribution files, and then click **OK**.

Define a forward lookup zone

1. Open DNS. To open DNS, click **Start**, click **Control Panel**, double-click **Administrative Tools**, and then double-click **DNS**.
2. In the console tree, right-click the DNS server **DNS1**, and then click **New Zone** to run the New Zone Wizard.
3. On the **Welcome to the New Zone Wizard** page, click **Next**.
4. On the **Zone Type** page, the option to create a primary zone is selected by default, as shown in the following Figure 4.5.

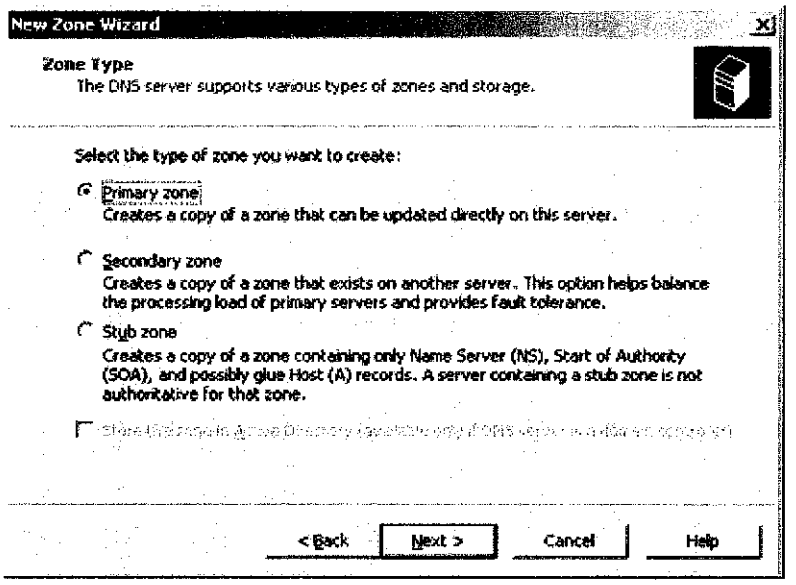


Figure 4.5: Zone Type Page

5. Click **Next**. On the **Forward or Reverse Lookup Zone** page, the option to create a forward lookup zone is selected by default, as shown in the Figure 4.6.

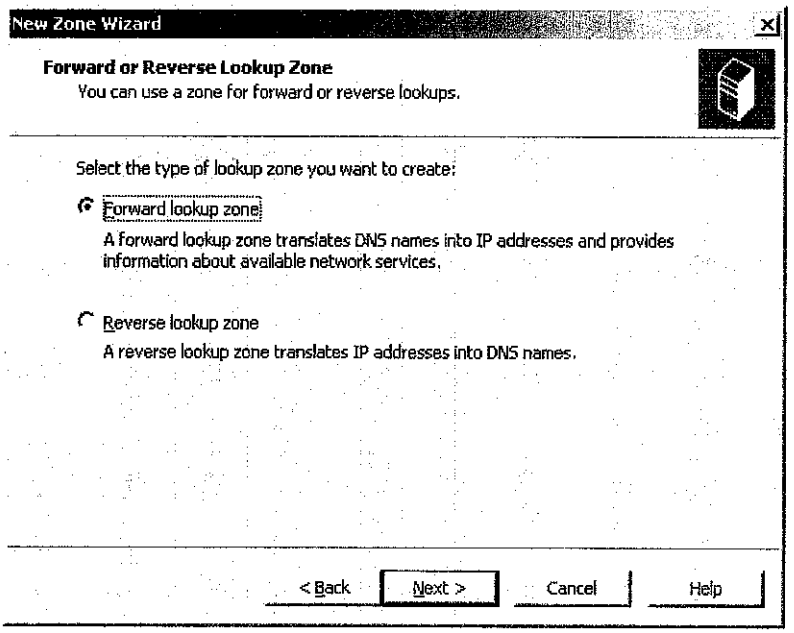


Figure 4.6: Forward or Reverse Lookup Zone Page

6. Click **Next**. On the **Zone Name** page, type **ipv6testlab** in **Zone name**, as shown in the following Figure 4.7.

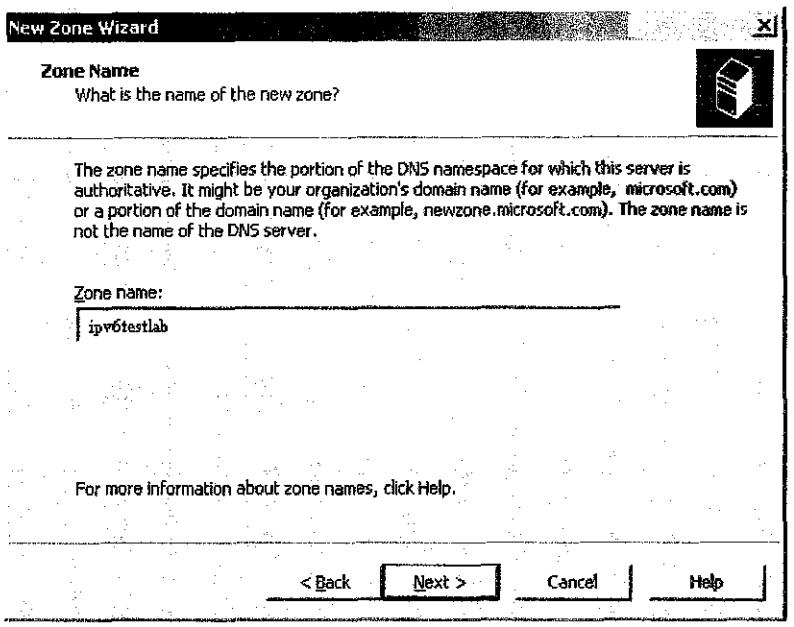


Figure 4.7: Zone Name Page

7. Click **Next**. On the **Zone File** page, the new zone file name **ipv6testlab** is automatically derived from the zone name entered on the previous page, as shown in Figure 4.8 below.

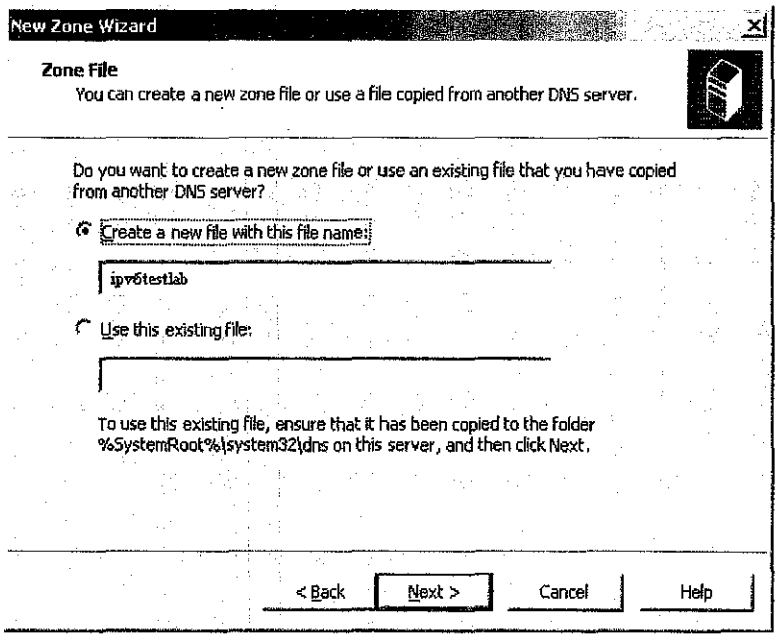


Figure 4.8: Zone File Page

8. Click **Next**. On the **Dynamic Update** page, select **Allow both nonsecure and secure dynamic updates**, as shown Figure 4.9.

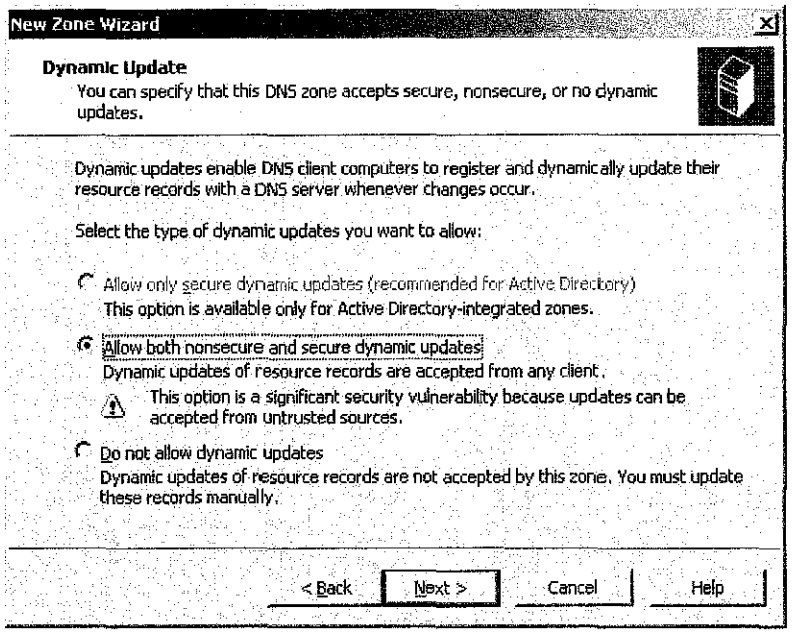


Figure 4.9: Dynamic Update Page

9. Click **Next**. On the **Completing the New Zone Wizard** page, click **Finish**, as shown in the following Figure 4.10.

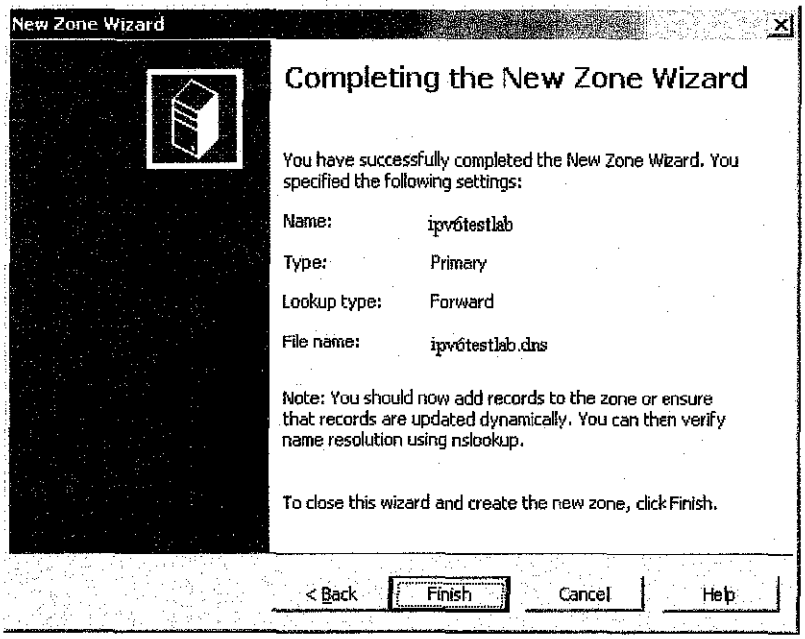


Figure 4.10: Completing the New Zone Wizard Page

Install IPv6

1. On DNS1, at the command prompt, type:

   netsh interface ipv6 install

Configure CLIENT1 as a client computer

1. Install Windows XP Professional with SP2 as a workgroup computer. Set the Administrator password.
2. After restarting, log on as Administrator.
3. At the command prompt, install the IPv6 protocol by typing:

   netsh interface ipv6 install
4. Configure the TCP/IP protocol with the IP address of 10.0.1.3, the subnet mask of 255.255.255.0, a default gateway of 10.0.1.1, and the DNS server IP address of 10.0.1.2.

Configure Windows to allow communication between client computers

1. Click **Start**, point to **Control Panel**, and then click **Security Center**.
2. Click **Windows Firewall**, and then in the **Windows Firewall** dialog box, click the **Advanced** tab.
3. Click **Settings** for **ICMP**, and then click **Allow incoming echo request**.
4. Click **OK** twice to close **Windows Firewall**.

Configure ROUTER1 as a router

1. Install Windows Server 2003 with SP1, Standard Edition, as a workgroup computer. Set the Administrator password.
2. After restarting, log on as Administrator.
3. At the command prompt, install the IPv6 protocol by typing:

   netsh interface ipv6 install
4. In **Control Panel-Network Connections**, rename the LAN connection connected to Subnet 1 to **Subnet 1 Connection** and rename the LAN connection connected to Subnet 2 to **Subnet 2 Connection**.

5. For **Subnet 1 Connection**, configure the TCP/IP protocol with the IP address of 10.0.1.1, the subnet mask of 255.255.255.0, and the DNS server IP address of 10.0.1.2.
6. For **Subnet 2 Connection**, configure the TCP/IP protocol with the IP address of 10.0.2.1, the subnet mask of 255.255.255.0, and a default gateway of 10.0.2.2.
7. Start the registry editor (Regedit.exe) and set HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\Tcpip\Parameters\IPEnableRouter to 1.
   This step enables IPv4 routing between Subnet 1 and Subnet 2.
8. Restart the computer.

Configure ROUTER2 as a router

1. Install Windows Server 2003 with SP1, Standard Edition, as a workgroup computer. Set the Administrator password.
2. After restarting, log on as Administrator.
3. At the command prompt, install the IPv6 protocol by typing:
   netsh interface ipv6 install
4. Open Network Connections, and rename the LAN connection connected to Subnet 2 to **Subnet 2 Connection**, and rename the LAN connection connected to Subnet 3 to **Subnet 3 Connection**.
5. For **Subnet 2 Connection**, configure the TCP/IP protocol with the IP address of 10.0.2.2, the subnet mask of 255.255.255.0, and a default gateway of 10.0.2.1.
6. For **Subnet 3 Connection**, configure the TCP/IP protocol with the IP address of 10.0.3.1 and the subnet mask of 255.255.255.0.
7. Start the registry editor (Regedit.exe) and set HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\Tcpip\Parameters\IPEnableRouter to 1.
   This step enables IPv4 routing between Subnet 2 and Subnet 3.
8. Restart the computer.

Configure CLIENT2 as a client computer

1. Install Windows XP Professional with SP2 as a workgroup computer. Set the Administrator password.
2. After restarting, log on as Administrator.
3. At the command prompt, install the IPv6 protocol by typing:
   netsh interface ipv6 install
4. Configure the TCP/IP protocol with the IP address of 10.0.3.2, the subnet mask of 255.255.255.0, and a default gateway of 10.0.3.1.
5. Verify the integrity of the IPv4 routing infrastructure by pinging 10.0.1.3 from the CLIENT2 computer. On CLIENT2, type the following command:
   ping 10.0.1.3

   The result:

```
C:\>ping 10.0.1.3

Pinging 10.0.1.3 with 32 bytes of data:

Reply from 10.0.1.3: bytes=32 time<1ms TTL=126
Reply from 10.0.1.3: bytes=32 time<1ms TTL=126
Reply from 10.0.1.3: bytes=32 time<1ms TTL=126
Reply from 10.0.1.3: bytes=32 time<1ms TTL=126

Ping statistics for 10.0.1.3:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum = 0ms, Average = 0ms
```

Configure Windows Firewall to allow communication between client computers

1. Click **Start**, point to **Control Panel**, and then click **Security Center**.
2. Click **Windows Firewall**, and then in the **Windows Firewall** dialog box, click the **Advanced** tab.
3. Click **Settings** for **ICMP**, and then click **Allow incoming echo request**.
4. Click **OK** twice to close Windows Firewall.

Creating a Static IPv6 Routing Infrastructure

Configure a static IPv6 routing infrastructure so that all test lab nodes are reachable by using IPv6 traffic.

Create a static IPv6 routing infrastructure

1. On ROUTER1, type the **netsh interface ipv6 show address** command to obtain the index of the interfaces connected to Subnet 1 Connection, Subnet 2 Connection, and their link-local addresses.

The result:

```
C:\Documents and Settings\Administrator>netsh interface ipv6 show address
Querying active state...

Interface 6: Teredo Tunneling Pseudo-Interface
Addr Type  DAD State  Valid Life   Pref. Life   Address
---------  ---------- ------------ ------------ ------------------------------
Link       Preferred      infinite     infinite fe80::5445:5245:444f

Interface 5: Subnet 2 Connection
Addr Type  DAD State  Valid Life   Pref. Life   Address
---------  ---------- ------------ ------------ ------------------------------
Link       Preferred      infinite     infinite fe80::290:27ff:fea6:1a42

Interface 4: Subnet 1 Connection
Addr Type  DAD State  Valid Life   Pref. Life   Address
---------  ---------- ------------ ------------ ------------------------------
Link       Preferred      infinite     infinite fe80::20b:cdff:fe63:5b2e

Interface 2: Automatic Tunneling Pseudo-Interface
Addr Type  DAD State  Valid Life   Pref. Life   Address
---------  ---------- ------------ ------------ ------------------------------
Link       Preferred      infinite     infinite fe80::5efe:10.0.2.1
Link       Preferred      infinite     infinite fe80::5efe:10.0.1.1

Interface 1: Loopback Pseudo-Interface
Addr Type  DAD State  Valid Life   Pref. Life   Address
---------  ---------- ------------ ------------ ------------------------------
Loopback   Preferred      infinite     infinite ::1
Link       Preferred      infinite     infinite fe80::1
```

2. On ROUTER2, type the **netsh interface ipv6 show address** command to obtain the index of the interfaces connected to Subnet 2 Connection, Subnet 3 Connection, and their link-local addresses.

The result:

```
C:\Documents and Settings\Administrator>netsh interface ipv6 show address
Querying active state...

Interface 6: Teredo Tunneling Pseudo-Interface
Addr Type  DAD State  Valid Life   Pref. Life   Address
---------  ---------- ------------ ------------ ------------------------------
Link       Preferred      infinite     infinite fe80::5445:5245:444f

Interface 5: Subnet 2 Connection
Addr Type  DAD State  Valid Life   Pref. Life   Address
---------  ---------- ------------ ------------ ------------------------------
Link       Preferred      infinite     infinite fe80::20b:cdff:fe63:5bf1

Interface 4: Subnet 3 Connection
Addr Type  DAD State  Valid Life   Pref. Life   Address
---------  ---------- ------------ ------------ ------------------------------
Link       Preferred      infinite     infinite fe80::20a:5eff:fe02:76ae

Interface 2: Automatic Tunneling Pseudo-Interface
Addr Type  DAD State  Valid Life   Pref. Life   Address
---------  ---------- ------------ ------------ ------------------------------
Link       Preferred      infinite     infinite fe80::5efe:10.0.2.2
Link       Preferred      infinite     infinite fe80::5efe:10.0.3.1

Interface 1: Loopback Pseudo-Interface
Addr Type  DAD State  Valid Life   Pref. Life   Address
---------  ---------- ------------ ------------ ------------------------------
Loopback   Preferred      infinite     infinite ::1
Link       Preferred      infinite     infinite fe80::1
```

3. On ROUTER1, type the following commands:

   netsh interface ipv6 set interface "Subnet 1 Connection" forwarding=enabled advertise=enabled

   netsh interface ipv6 set interface "Subnet 2 Connection" forwarding=enabled advertise=enabled

   netsh interface ipv6 add route fec0:0:0:1::/64 "Subnet 1 Connection" publish=yes

   netsh interface ipv6 add route fec0:0:0:2::/64 "Subnet 2 Connection" publish=yes

   netsh interface ipv6 add route ::/0 "Subnet 2 Connection" nexthop=*ROUTER2AddressOnSubnet2* **publish=yes**

   In the preceding command, *ROUTER2AddressOnSubnet2* represents the link-local address assigned to the Subnet 2 Connection interface on ROUTER2.

4. On ROUTER2, type the following commands:

   netsh interface ipv6 set interface "Subnet 2 Connection" forwarding=enabled advertise=enabled

   netsh interface ipv6 set interface "Subnet 3 Connection" forwarding=enabled advertise=enabled

   netsh interface ipv6 add route fec0:0:0:2::/64 "Subnet 2 Connection" publish=yes

   netsh interface ipv6 add route fec0:0:0:3::/64 "Subnet 3 Connection" publish=yes

   netsh interface ipv6 add route ::/0 "Subnet 2 Connection" nexthop=*ROUTER1AddressOnSubnet2* **publish=yes**

   In the preceding command, *ROUTER1AddressOnSubnet2* represents the link-local address assigned to the Subnet 2 Connection interface on ROUTER1.

If ROUTER2 is running Windows Server 2003 with SP1, Standard Edition, type the additional commands:

netsh interface ipv6 set interface "Subnet 2 Connection" siteid=1

netsh interface ipv6 set interface "Subnet 3 Connection" siteid=1

5. Verify the integrity of the IPv6 routing infrastructure. On CLIENT2, type the following commands:

ping *CLIENT1SiteLocalAddress*

tracert -d *CLIENT1SiteLocalAddress*

The result:

```
C:\>ping fec0::1:20b:cdff:f363:5bb3

Pinging fec0::1:20b:cdff:f363:5bb3 with 32 bytes of data:

Reply from fec0::1:20b:cdff:f363:5bb3: TTL expired in transit.
Reply from fec0::1:20b:cdff:f363:5bb3: TTL expired in transit.
Reply from fec0::1:20b:cdff:f363:5bb3: TTL expired in transit.
Reply from fec0::1:20b:cdff:f363:5bb3: TTL expired in transit.

Ping statistics for fec0::1:20b:cdff:f363:5bb3:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum = 0ms, Average = 0ms
```

```
C:\>tracert -d fec0::1:20b:cdff:f363:5bb3

Tracing route to fec0::1:20b:cdff:f363:5bb3 over a maximum of 30 hops

  1    <1 ms     *        <1 ms  fec0::3:20a:5eff:fe02:76ae
  2    <1 ms     *        <1 ms  fec0::2:290:27ff:fea6:1a42
  3    <1 ms     *        <1 ms  fec0::3:20a:5eff:fe02:76ae
  4    <1 ms     *        <1 ms  fec0::2:290:27ff:fea6:1a42
  5    <1 ms     *        <1 ms  fec0::3:20a:5eff:fe02:76ae
  6    <1 ms     *        <1 ms  fec0::2:290:27ff:fea6:1a42
  7    <1 ms     *        <1 ms  fec0::3:20a:5eff:fe02:76ae
  8    <1 ms     *        <1 ms  fec0::2:290:27ff:fea6:1a42
  9    <1 ms     *        <1 ms  fec0::3:20a:5eff:fe02:76ae
 10     1 ms     *         1 ms  fec0::2:290:27ff:fea6:1a42
 11    <1 ms     *        <1 ms  fec0::3:20a:5eff:fe02:76ae
 12     1 ms     *         1 ms  fec0::2:290:27ff:fea6:1a42
 13     1 ms     *         1 ms  fec0::3:20a:5eff:fe02:76ae
 14     1 ms     *         1 ms  fec0::2:290:27ff:fea6:1a42
 15     1 ms     *         1 ms  fec0::3:20a:5eff:fe02:76ae
 16     1 ms     *         1 ms  fec0::2:290:27ff:fea6:1a42
 17     1 ms     *         1 ms  fec0::3:20a:5eff:fe02:76ae
 18     1 ms     *         1 ms  fec0::2:290:27ff:fea6:1a42
 19     1 ms     *         1 ms  fec0::3:20a:5eff:fe02:76ae
 20     1 ms     *         1 ms  fec0::2:290:27ff:fea6:1a42
 21     1 ms     *         1 ms  fec0::3:20a:5eff:fe02:76ae
 22     2 ms     *         1 ms  fec0::2:290:27ff:fea6:1a42
 23     1 ms     *         1 ms  fec0::3:20a:5eff:fe02:76ae
 24     2 ms     *         2 ms  fec0::2:290:27ff:fea6:1a42
 25     2 ms     *         1 ms  fec0::3:20a:5eff:fe02:76ae
 26     2 ms     *         2 ms  fec0::2:290:27ff:fea6:1a42
 27     2 ms     *         2 ms  fec0::3:20a:5eff:fe02:76ae
 28     2 ms     *         2 ms  fec0::2:290:27ff:fea6:1a42
 29     2 ms     *         2 ms  fec0::3:20a:5eff:fe02:76ae
 30     2 ms     *         2 ms  fec0::2:290:27ff:fea6:1a42

Trace complete.
```

4.5 IPv6 Streaming Test

One of IPv6 advantages over IPv4 is that it can support for resource allocation. In IPv6, the type- of –service field has been removed, but a mechanism called flow label has been added to enable the source to request special handling of the packet. This means that it can be used to support traffic such as real- time audio and video.

In order to prove that IPv6 supports resource allocation, a simple streaming test was done. The streaming is stream on the SERVER using VLC media player. Where as CLIENT2 will access the streaming file using the same media player as SERVER. At the same time, CLIENT1 will send traffic by sending packets which is a text file of a certain size. On ROUTER2, NTop and PRTG software is installed to help monitor the network performance.

There are two basic tests that were conducted. The first test was done on IPv4 mode and the second test was done on IPv6 mode. There are three basic activities prepared for each test. First of all, only traffic was sent from Client1 to Client2. Followed by the second activity, only streaming is done. Lastly, both traffic and streaming are performed. These activities are done for a certain amount of time.

Results from the testing are as follows:

TEST 1: IPv4

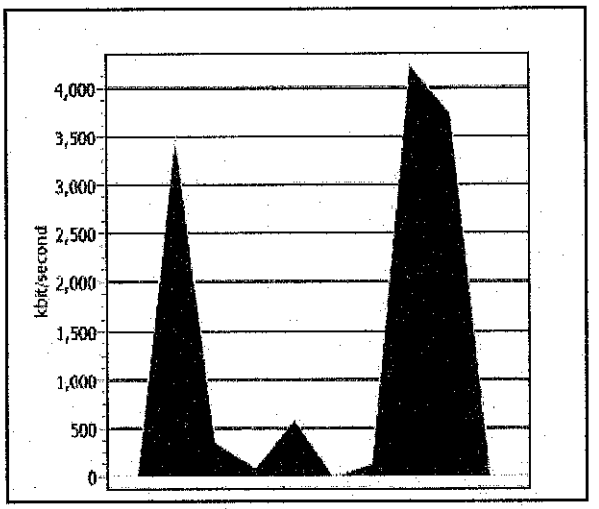


Figure 4.11: Streaming Result on IPv4 using PRTG

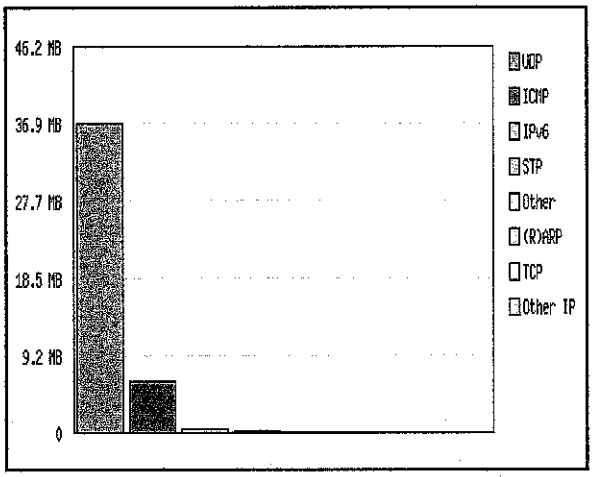


Figure 4.12: Streaming Result on IPv4 using NTop

TEST 2: IPv6

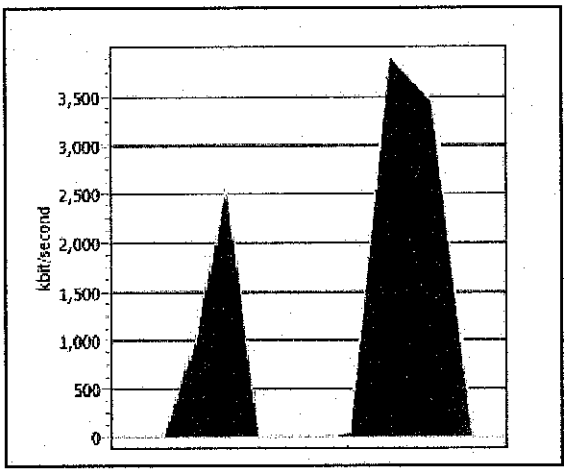


Figure 4.13: Streaming Result on IPv6 using PRTG

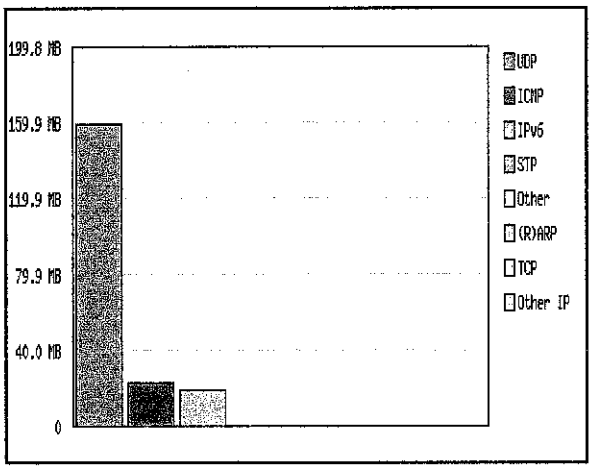


Figure 4.14: Streaming Result on IPv6 using NTop

As shown in Figures 4.11 and 4.13, there are three peaks. The first peak in Figure 4.11 and Figure 4.13 indicates the packets that are sent to Client2 from Client1. The main idea of the packets sent is to create traffic on the network. The second peak in the same figures indicates the streaming file. At this time, only streaming is run without any traffic. The third peak in the figures shows the network load when streaming and traffic occurs. But in Figure 4.13, the peak can't be display because PRTG can not detect the streaming packets due to some error. Therefore, to indicate and prove that the streaming is running

on IPv6, NTop is used. As shown in Figure 4.14, there are data running on IPv6 but there is none in Figure 4.12.

From the result obtained above, it shows that when streaming is running on IPv6, the data loaded on the network is smaller than on IPv4. Streaming on IPv4 the network load is more than 4,000 kilobit/second meanwhile on IPv6 is less than 4,000 kilobit/second. It shows that streaming can be run smoother on IPv6 than on IPv4.

The main problem of this test is that it is not really accurate. This is because, the time the activity is performed are not done in a fixed interval. Time, in this test is consider the amount of time it takes for each of the activity to run until it finished. It is hard to have the time fixed for the activities to be performed. Therefore, in the future, there should be a fixed time to run the activities for each test.

CHAPTER 5: CONCLUSION & RECOMMENDATIONS

IPv6 is the enhanced version of IPv4. The new design of Internet Protocol helps to accommodate the on going expansion of the Internet. The advantages of IPv6 to IPv4 are expanded routing and addressing capabilities, header format simplification, improve support for options, authentication and privacy capabilities, quality- of- service capabilities and lots more.

The government is looking into the migration of IPv4 to IPv6. UTP should follow the government and support them by being one of the universities to deploy IPv6 in the network. UTP should also look into providing some of the students with training on IPv6 to improve their knowledge on IPv6.

A simple simulation can be created with the use of third- party software known as OMNet ++. This software uses C++ as the language to construct the simulation. It is also an open- source software, therefore it has the advantages of providing tutorials and help from other users in the OMNet ++ community. The test bed is conducted to identify whether or not it is feasible to what UTP can offer, in terms of equipments and other things that are relevant.

In the future, this project can be enhanced to generate better result in deciding whether it is appropriate to have IPv6 in the campus network or not. This can be done by, first of all, to create a simulation based on the campus network. This will provide more information and a clearer idea for making any decision in considering implementing IPv6 in the campus. This simulation will also help to identify problems that may occur such as incompatibility with the hardware available and etc.

Another enhancement can be to really implement or execute IPv6 in the campus network. It can be done by implementing it to some part of the campus. This will help to identify whether it can work or not in the campus. By doing so, it will produce better outcome for evaluation process. Once there's no problem, then the university can deploy it to the whole campus. Hence, become one of the universities to have IPv6 in the campus network as well as support the government in research and etc.

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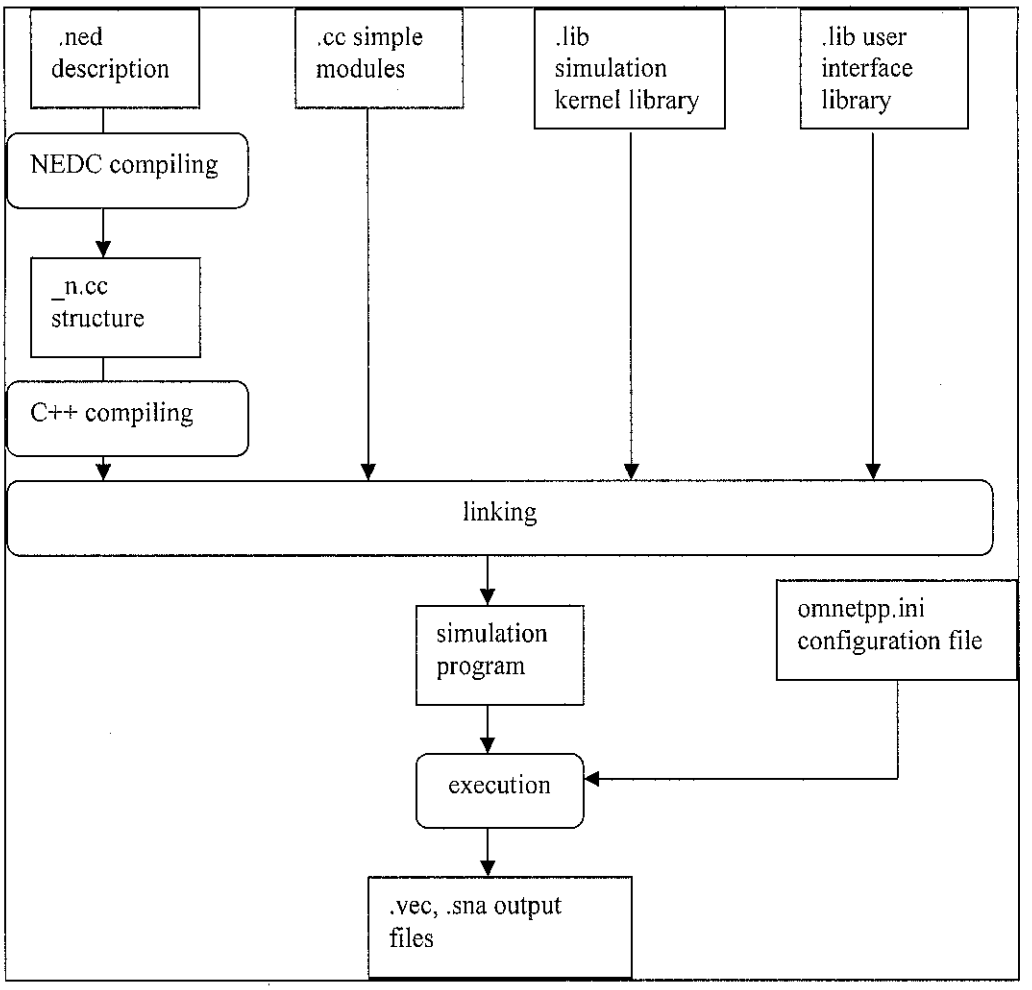
APPENDICES

Appendix 1: Building and running simulation



Appendix 2: IPv6 survey questions

Tajuk/Title : IPv6
Disediakan oleh/ Prepared by : Maisarah Mohamad Aminuddin
e-mel/e-mail : sarahaminuddin@yahoo.com

***Objektif* / Objective**

Tujuan kaji selidik ini diadakan adalah untuk mengetahui tahap pendedahan masyarakat Malaysia terhadap IPv6. Kajiselidik ini mengandungi dua seksyen, iaitu Seksyen A dan Seksyen B. Anda dikehendaki menjawab soalan pada kedua- dua seksyen tersebut.

The objective of this survey is to study the awareness level of Malaysian members towards IPv6. This survey consists of two sections, which is Section A and Section B. Respondent are required to answer all sections.

***Seksyen A: Latar Belakang* Responden**
Section A: Respondent's Background

***Arahan*/ Instruction**
Sila tandakan [x] di *kotak yang disediakan*/ Please tick [x] in the box given.

1. *Lingkungan umur*/Age range

	15 – 20 *tahun*/years		41 – 45 *tahun*/years
	21 - 25 *tahun*/years		46 – 50 *tahun*/years
	26 – 30 *tahun*/years		51 – 55 *tahun*/years
	31 – 35 *tahun*/years		56 – 60 *tahun*/years
	36 – 40 *tahun*/years		> 60 *tahun*/years

2. *Jantina*/Gender

	Lelaki / Male		*Perempuan* / Female

3. *Bangsa*/Race

	Melayu / Malay		*India* / Indian
	Cina / Chinese		*Lain-lain* / Others

4. *Adakah anda pelajar ataupun pensyarah?* /Are you a student or lecturer?

	Pelajar/ Student
	Pensyarah/ Lecturer
	Lain- lain/ Others

5. Di jabatan manakah anda berada?/ Which department are you in?

	Kejuruteraan Mekaninal / Mechanical Engineering
	Kejuruteraan Awam/ Civil Engineering
	Kejuruteraan Elektrik dan Elektronik/ Electrical and Electronic Engineering
	Kejuruteraan Kimia / Chemical Engineering
	Teknologi Maklumat & Sistem Informasi / Information Technology & Information System
	Pembelajaran Am/General Studies
	Lain- Lain/ Others

Seksyen B: Tahap Pendedahann Responden terhadap IPv6
Section B: Respondent's Awareness on IPv6

***Arahan/* Instruction**
Sila tandakan [x] di *kotak yang disediakan/* Please tick [x] in the box given.

1. *Pernahkah anda mendengar tentang Ipv6? Jika jawapan anda tidak, kaji selidik tamat di sini.*
   Have you ever heard of IPv6? If your answer is no, the survey ends here.

	Ya / Yes		*Tidak* / No

2. *Jika Ya, dari manakah anda mengetahui mengenainya?*
   If so, from where did you hear it from?

	Rakan- rakan atau Saudara- mara/ Friends or Relatives
	Internet/ Internet
	Bahan bacaan/ Reading materials
	Lain-lain (sila nyatakan) / Others (Please justify) : _____

3. *Sejauh manakah pengetahuan anda tentang IPv6?*
   How would you rate your knowledge about IPv6?

	Amatur/ Beginner
	Pertengahan/ Intermediate
	Mahir/ Expert

4. *Pada pendapat anda, perlukah rangkaian UTP bertukar dari IPv4 kepada IPv6?*
   Do you think UTP should migrate the network from IPv4 to IPv6?

	Ya / Yes		*Tidak* / No

Soalan kajiselidik tamat. Terima kasih atas kerjasama yang diberikan.
End of questionnaire. Thank you very much for your cooperation.

Appendix 3: OMNet ++ & IPv6SuitewithINET Installation

OMNet ++

1. Download the source package (omnetpp-*X.X*-src.tgz) from the omnetpp.org download area.

2. Copy the omnetpp archive to the directory where you want to install it (usually your home directory). Extract the archive using the command:

   tar zxvf omnetpp.tgz

3. A sub-directory called omnetpp will be created which will contain the simulator files. You should now add the following lines to your startup file (.bashrc or .bash_profile if you're using bash; .profile if you're using some other sh-like shell):

   export PATH=$PATH:~/omnetpp/bin
   export LD_LIBRARY_PATH=$LD_LIBRARY_PATH:~/omnetpp/lib

   For these variables to be included in the environment you will need to restart the shell before proceeding (logout and login again).

4. First you should check configure.user to make sure it contains the settings you need:

   vi configure.user

5. Then the usual GNU-like stuff:

   ./configure
   make

6. You should now test all samples and check they run correctly. As an example, the dyna example is started by entering the following commands:

   cd ~/omnetpp/samples/dyna

   ./dyna

   By default the samples will run using the Tcl/Tk environment. You should see nice GUI windows and dialogs.

IPv6SuitewithINET

1. Download the gzipped tar bundle: IPv6SuiteWithINET-20060119.tgz
2. Untar the bundle into a directory (say $HOME/oppsim), you should now have a subdirectory called IPv6SuiteWithINET under the $HOME/oppsim directory.
3. cd $HOME/oppsim/IPv6SuiteWithINET
4. Look inside the file INSTALL and follow the steps mentioned there.

Appendix 4: Snapshots of Simulation