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Research Article

IPV6 Deployment Status for Higher Education Institutions' Website of Ministry of Education Malaysia

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Abstract

The IPv6 has been recently deployed to replace the implementation of IPv4 due to the predicted exhaustion regarding the space of IPv4 addresses. However, most service providers are reluctant in enabling IPv6 by default due to the poor performance and disruption to customer traffic. Therefore, this study used a network performance evaluation technique to investigate the usage of IPv6 network among the higher institution of learning in Malaysia as effective implementation of internet services becomes a necessity in the era in which higher education is regarded as a form of commodity through which quality higher education provider can make continual improvement and benchmarking. The result found that IPv6 network has not been widely used among the institutions of higher learning in Malaysia. Thus this research stands as a starting point on which future researchers, network engineers as well as network administrators can provide an update for monitoring and planning of work in the whole institutions of higher education.

Keywords: *IPv4, IPv6, network performance evaluation technique and institute of higher education*

1. Introduction

The power of Information and Communications Technology (ICT) helps quicken continuous improvement is universally accepted by the Governments around the globe. It provides the ability for the Governments to support and reach out to its individuals even in rural and remote corners of the country. Malaysian Government through various federal ministries has put numerous ICT initiatives in place towards the development of the country and reaching his goals of National e-Governance Plan for the future (Malaysian Development Goal, 2010). In order to deliver as well as to access public services in a transparent, efficient and effective way at the doorsteps of people through easy and reliable access over the internet. The e-Governance infrastructure in Malaysia is robust, scalable which include various federal and State Government Ministries, also the departments including their Ministry of higher education. These departments are one of the largest users of information technology (IT) that provide the products and services in this country. As such, the Government organization through their important role in the ecosystem can be referred to as a big example of the sectors through which timely adoption of IPV6 can be enhanced.

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Ministry of education (MOE) in Malaysia is the most an important sector that relates to the development of IPv6 in Malaysia. This is because they responsible for the provision of most grant on IPv6 researches for the Institutes of Higher Learning on the deployment of IPV6 (Nikkhah *et al*.2011). These institutes are the center of Research and Development (R&D) in Malaysia. According to the previously conducted study over the last several years on the progress of IPV6 deployment, many of these studies were based on active of servers to network topology (Clay *et al*.2011), and the measurement based to server, routing data and DNS root server data (Andrew *et al*.2012). These studies provided good information on IPv6 capabilities of network servers which is responsible for running IPv6 operating system and configuration.

This initiative makes it important for MOE to focus on increasing the quality of human capital because innovative human capital is the main vehicle capable of accelerating the nation's transformation. The Innovative Human Capital Development Action Plan was created to drive an innovation based economy, whereby the human capital functions as the main mover. Therefore, achieving this plan will be beneficial in the creation of opportunities to the society from all aspects of life to benefit from the HEIs that is available in their community for knowledge and qualification enhancement (Sirat *et al*.2010).

The aim of Malaysian government is to become an international center of higher education by 2020. Thus,

it encourages different sectors and departments to be translated. Therefore, it effectively implements the ministry of higher education as policy implementer to deliver services to the world. This is essential, particularly in the era in which higher education is regarded as a form of commodity. Thus, Malaysian status as a quality higher education provider requires continual improvement and benchmarking (Muda *et al* 2008).

The internet protocol is used in connecting with different nodes in a network, so all the devices need IP addresses to connect with all kinds of IP application on the internet. IPv4 is the fourth version in IP development and it is determined by 32 bits address. Based on the importance of the internet connection, especially IPv6 to the ministry of higher education in Malaysia, this research covers a detailed study of DNS Resource Records and IPv6 test on the websites. It described what the information of DNS Resource Records are, the purpose and how DNS records are used. There are various types of DNS Resource Records and which are used for specific purposes. The focus of this study is based on a particular part of AAAA records IPv6 addresses which maps a host name to 128 bits in the domain of IPv6 addresses. In the end, this study explains the AAAA record in IPv6 address and described the several ways to test IPv6 on the website of universities, in particular to improve IPv6 measurement method.

2. Domain Name System

As the growth of the Internet IP addresses are increasing at a rapid rate. connection with a computer on a network requires one to know its IP address. Since IP addresses were no longer limited, humans found it difficult to remember the numerical IP addresses. To deal with the problem, computers on the network were supplied with hosts.txt. At this point, the computer at SRI International, which mapped name to numerical addresses, and the rapid growth of the internet had made it more difficult to calculate or save the handcrafted hosts. txt file. For this reason, it became essential to put into action an even more scalable system which could easily share the mapping between names along with IP addresses.

The idea of creating a structured topology when the names need to be organized into domains at the first time was presented by D.L. Mills in 1981. In the beginning of 1983, the Domain Name System was invented by Paul Mockapetris and wrote its first implementation about it, On the other hand, the first original specifications were related to DNS published in 1983 (Mockapetris *et al*.1983) Unfortunately, the original specifications had been replaced by the specifications published in 1987.

Domain Name System can be defined as a service to translate between Internet names and Internet addresses. It could also be defined as a fundamental Internet service used by every application using IP addresses or IP devices. that distribute hierarchical database that helps in storing the mappings of IP addresses to hostnames . The Internet names are names that we usually use to refer to hosts on the Internet, such as www. Websites.net. Thus, the routers are used to move traffic across the Internet which is called the Internet addresses. For example 69.64.156.229. On the other side, the DNS records or Zone files are used for mapping URLs to an IP, also there are several servers called the DNS servers which typically are the connection with our website and the outside world.

For example, type AAAA (IPv6 address record) is a RR that contains the IPv6 address of a host and type NS (Name Server record) is another RR used to identify the authoritative name server for a zone. A zone is a portion of domain space that is authorized and administered by a primary name server and one or more secondary name server. However, Since the Internet is based on IP addresses and humans find it difficult to remember long, complicated sequence of numbers, DNS was invented. That helps people to find it easy to remember the domain names.

The Domain Name Server plays a significant role in the operation of Internet by translating human friendly domain names to machine friendly IP addresses and also vice versa. DNS is usually a hierarchical distributed database which uses intensive replication and caching to achieve high scalability and resiliency to server failures. The Domain Name System performs many functions which are the following:

2.1 Domain Name Space

This is defined by DNS when its running on the networking system. It could be defined as the rules for structuring of names and their usage. It as well defines the relation between the name of one device and the names of other devices in the system, it helps system to avoid the problems, to ensure that does not give invalid names. The domain name may consist of tree domain names as follow of.

- Node, each node contains a zero or more than resource records, it holds the main information associated along with domain name.
- The tree, is subdividing into zones, it begins from root zone.
- DNS zone, include one or more than domains and sub domains.
- Administrative responsibility on a zone can be divided by creating another zone name server and administrative entity.

2.2 Domain Name Registration

A domain name is assigned to a specific IP address it registers as a first time with a domain name registrar. The domain names are installations in domain registry of a top domain level requires the assignment of a primary name server and at least one secondary name server, which name server is required in order to keep

the domain functional even if one name server becomes inoperable or inaccessible. While registering a domain name, it should be assigned to an IP address otherwise it would lead to malfunctioning of DNS.

Resource record definition and domain

It is to support the storage of Internet addresses in the (DNS) that cannot be easily supported toextend IPv6 addresses, which happen from applications. A record type is defined to store a host's IPv6 address. A host that has more than one IPv6 address must have more than one such record. However, to support the storage of IPv6 addresses in the DNS, these extensions will be defined as the following:

i. A resource record type: is will be used to map the domain name to an IPv6 address.
ii. A domain: is defined to support lookups according to IPv6 address.
iii. An Existing queries: This is used to perform the additional section processing to locate IPv4 addresses that can be redefined to execute additional processing on both addresses of IPv4 and IPv6.
iv. A Record: define to store a host's IPv6 address, that host has more than one IPv6 address like record

AAAA record type: Is a record specific to the Internet class that can be stored a single IPv6 address. The IANA allocated value of the type is 28 (decimal).

AAAA data format: A 128 bit IPv6 address is encoded in the data portion of an AAAA resource record in network byte order (high-order byte first).

AAAA query: An AAAA query is for a specified domain name in the Internet class, that's because returns all associated AAAA (RR) in the answer section of a response. Also, the type AAAA query does not allow triggering additional section processing.

Textual format of AAAA records: The textual representation of the data portion of the AAAA (RR) is used in a master database file that known as the textual representation of an IPv6 address.

IP6.ARPA Domain: A special domain can be defined to look up a record given an IPv6 address. So, the intent of this domain may be used to provide a way of mapping an IPv6 address to a host name. Although it is used for other purposes as well asThat domain is rooted at IP6.ARPA. To represent IPv6 address as a name in the IP6.ARPA domain by using a sequence of nibbles, which divided by dots with the suffix .IP6.ARPA? This sequence of nibbles is encoded in reverse order; the lower nibble must be encoded first and followed by the next low also for other things. On the other hand, the nibble can be represented by a hexadecimal digit as on this example: 4321:0:1:2:3:4:567:89ab Will become b.a.9.8.7.6.5.0.4.0.0.0.3.0.0.0.2.0.0.0.1.0.0.0.0.0.0.0.1.2.
3.4. IP6.ARPA.

2.3 Resource Record Types

The specific information in a domain name is stored in the form of resource records (RR) s. Each resource record has a certain type, which specifies the nature of the record. The number of resource record types was defined in several DNS standards. Table 1 shows the different types and description of resource record in DNS.

This study discussed about AAAA also known as IPv6 address record which can be mapped in a hostname to 128 bits AAAA record and which allow a domain name associate with a 128 bits addresses IPv6. Whereas, the regular (DNS) maps a hostname to a 32 bits IPv4. Overall, the AAAA record indicate the IPv6 address four times the size of the IPv4 address, and the value of AAAA in the DNS is 28 as shown in this example

AAAA with Syntax
LINUX AAAA:
3ffe:1900:4545:2:02d0:09ff:fef7:6d2c

3. IPv6 Testing project

The IPv6 Testing Project was launched in November 2004 and is led by the Protocol and Testing Competence Centre (PTCC) of the European Telecommunications Standards Institute (ETSI) and also promoted by the IPv6 Forum and the eEurope Standardization Project for the Development of Test Specifications for IPv6 created by the European Commission's eEurope Action Plan. The global objective of this project is to test the domain of universities on malaysia and test development. This will be achieved by providing an open and free ipv6 website testing. In our project we used three website test for IPV6 test as the following of:

3.1 IPv6-test.com

IPv6-test.com is a free service that checks IPv6 and IPv4 connectivity and speed. Diagnose connection problems, discover which addresses are currently using to browse the Internet, and what is the browser's protocol of choice when both v6 and v4 are available. The website allows checking for the website is IPV6 ready or not by looking for three parameters:

I. AAAA DNS record
II. IPv6 web server
III. IPv6 DNS server

Figure.3.1(a), 3.1(b) show the result of the website before/ after run the website of University of Malaysia, Pahang .www.ump.edu.my

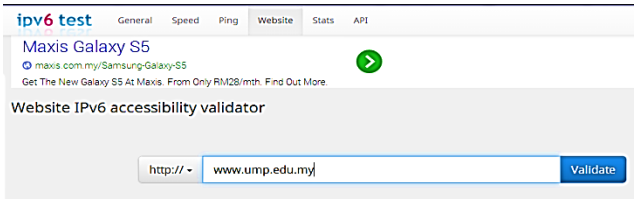

Fig.3.1 (a) Before run the website www.ump.edu.my

Table: 1 Different type of Resource Records

Recourse record type	RR Type Value	Meaning	Description
A	1	IPv4 Address Record	It returns a 32- bit IPv4 address.
AAAA	28	IPv6 Address Record	It returns a 128- bit IPv6 address.
A6	38	IPv4 Address Record (Experimental)	It return a 128- bit IPv6 address
ANY	255	All cached record	It returns all records of all types of domain name known to the name server.
CNAME	5	Canonical Name	It returns an alias of a domain name
MX	15	Mail Exchange Record	It returns the mail servers of a domain name.
NS	2	Name Server Record	It returns the authoritative name servers for a domain name.
PTR	12	Domain Name Pointer Record	It returns the pointer to the domain name. these records are used for reverse DNS lookups
SOA	6	start of Authority Record	It returns the authoritative information about a DNS zone administrator. It includes primary name server, mail address of the domain serial number and several timers relating to refreshing the zone.
SPF	99	Sender Policy Framework Record	It returns the servers which are authorized to use mail for a domain. It is primarily used to prevent identity theft by spammers.
SRV	33	Service selection	It returns the service available in the zone.
TXT	16	Text Record	It returns the textual description of a domain name.
Unknown (99)	Not defined	Unrecognized resource record	The RDATA format of such records is not known to DNS implementation.

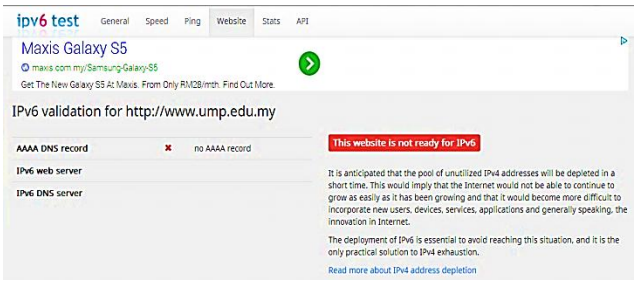

Fig. 3.1(b) After run the website www.ump.edu.my

3.2 www.IP6.NL

The website www.ip6.nl tests websites on IPv6 readiness. It also gives overviews of different types of websites for example, Ministries, municipalities, provinces, e Government services, universities, etc.

Ip6.nl is ranked 1,150,273 in the world; a low rank means that this website gets lots of visitors. The average pages load time is 0.575 seconds, it is very good. This site has a very good Pagernk (4/10), its sea score is 52.9%. IP address is 193.200.132.187, and its server is hosted at Netherlands. Last updated on Sun, 11 May 2014 14:33:41 GMT.Today it all starts with choosing the right domain-registrar. It is amazing that there are still registrars out there that are not running their name servers on IPv6. Of course you could run your own name servers, which seems considering some previous posts a good point. But in the end it is a good thing that your registrar is running them on IPv6. For testing purposes using the excellent site IP6.NL which was launched during IPv6 launch-day on 6-6-2012. There are three points that can be highlights in this websites:

1. The DNS in www.IP6.NL allows to configure AAAA-records, to translate a name into an IPv6-address.
2. Next thing is to configure the mail-servers to use IPv6. in this case it is very easy, because it run all domains on Google Apps. And Google is very far ahead of the rest when it comes to IPv6. Therefore, the DNS MX-records should point to the IPv6 addresses of its mail servers.
3. Last point is that both www-subdomain and apex, naked, domain should be configured with AAAA-records. And to reflect that, it's webserver should also be using those IPv6 addresses. When all this is done and working will get 5 stars from IP6.NL.Figure. 3.2(a), 3.2(b)show the result before/ after run the website of Cyberjaya University College of Medical Sciences. Cybermed.edu.my.

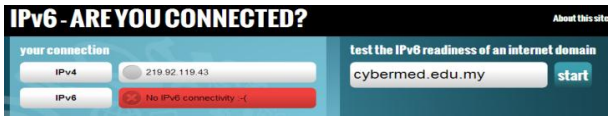

Fig.3.2 (a) Before run the website Cybermed.edu.my.

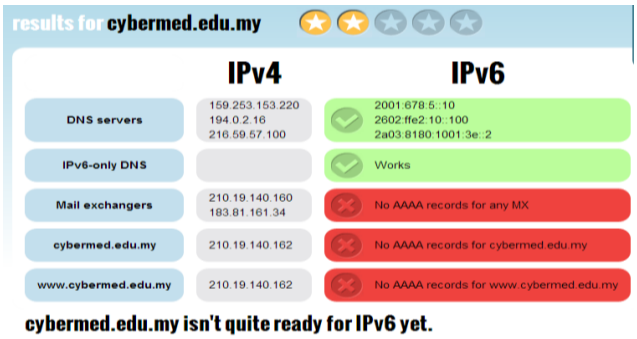

Fig.3.2(b) The result after run the website Cybermed. edu.my.

DNS Records Analysis

Table:2 10 DNS records about Ip6.nl.

Host	Type	Target / IP	TTL	Other
Ip6.nl	A	193.200.132.187	3599	class: *IN*
Ip6.nl	AAAA		3599	ipv6: *2a02:2308:10::c:19* class: *IN*
Ip6.nl	NS	ns1.tnx.nl	3599	class: *IN*
Ip6.nl	NS	ns2.tnx.nl	3599	class: *IN*
Ip6.nl	NS	ns3.tnx.nl	3599	class: *IN*

3.3 Ready.chair6.net

In recent years, the increasing market demand for more data and smart devices with pervasive connectivity has propelled the rapid new development and adoption of the Internet of Things technology. All of the sensors and machine-readable identifiers needed to make the Internet of Things a reality will have to use IPv6 to accommodate the extremely large address space required. Even if the current supply of IPv4 addresses were not to be exhausted soon, the size of IPv4 itself is not large enough to support the future requirement. Ready.chair6.net is a website test which could be test IPV6/ IPV4 on the internet. the Hostname for Ready.chair6.net an IPv4 A record is 174.136.109.18. and a hostname an IPv6 AAAA record is 2607:f2f8:a8e0::2. This website successfully connected to Ready.chair6.net on port 80 over IPv4/IPV6[22]. In. Figure. 3.3(a), 3.3(b) show the result before/ after run the website of Politeknik Sultan Haji Ahmad Shah www.studymalay.com

Fig.3.3 (a) Before run the website www. studymalay.com

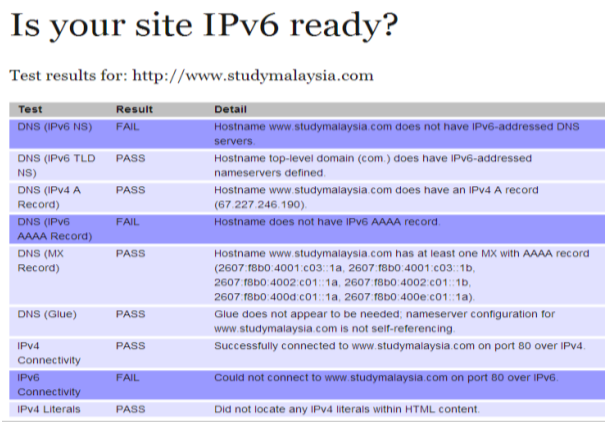

Fig.3.3 (b) After run the website www.studymalay.com

This website includes several parameters:
1. DNS (IPv6 NS): To resolve nameservers for hostname www.example.com.
2. DNS (IPv6 TLD NS): for the Hostname top-level domain (my.) show the IPv6-addressed nameservers defined.
3. DNS (IPv4 A Record): A Hostname www.example.com. to show an IPv4 A record.
4. DNS (IPv6 AAAA Record): Hostname www.example.com. for an IPv6 AAAA record.
5. DNS (MX Record): Hostname www.example.com. Discover MX records.
6. DNS (Glue): to resolve nameservers for hostname www.example.com.
7. IPv4 Connectivity: to show the connected to www.example.com. On which port over IPv4.
8. IPv6 Connectivity: to show the connected to www.example.com on which port over IPv6.IPv4 Literals: show the locate for IPv4 literals within HTML content.

4. Methodology

Network performance evaluation technique is a process that measures the performance of the model in the computer network system. Thus, the performance evaluation is one of the key features that have been taken into account during the designation, development and configuration of the computer system.

This experimental research was performed in a laboratory. In order to measure the connections with DNS AAAA request, numerous laboratory experiments was conducted by using IPv6 network. Thus, combinations of three (3) major methodologies were used to test IPv6 connection based on the following measurements of websites Application Performance Measurement (APM) and Distributed Application Performance Measurement System (DAPM). The adopted methodology was divided into five (5) phases as presented in Figure 4.0 below.

Understand the IPv6 testing

In order to evaluate the test of IPv6 connections on the website, the first step understood the IPv6

specifications. The most important thing was to identify the entire domain name required that could be affected on the IPv6 testing performances. During the evaluation of the connections, the type of domain (IPv4 or IPv6) and specifications that are suitable to measure certain quantities were identified. In this case, the need to identify the suitable websites to measure throughput to test the websites was required. Therefore, the selection of the website testing design, AAAA record specification and types of domain test are needed for identification. The result at this stage was a major platform for measuring IPv6 performance.

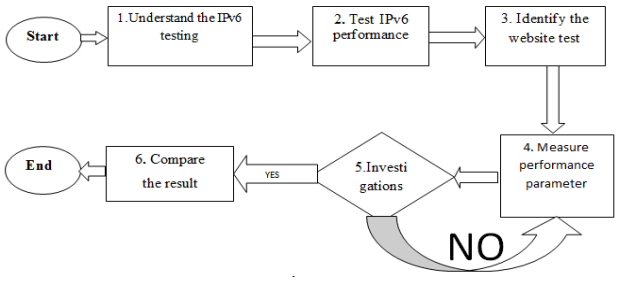

Fig.4.0 Methodology of research

Understand the IPv6 testing

In order to evaluate the test of IPv6 connections on the website, the first step understood the IPv6 specifications. The most important thing was to identify the entire domain name required that could be affected on the IPv6 testing performances. During the evaluation of the connections, the type of domain (IPv4 or IPv6) and specifications that are suitable to measure certain quantities were identified. In this case, the need to identify the suitable websites to measure throughput to test the websites was required. Therefore, the selection of the website testing design, AAAA record specification and types of domain test are needed for identification. The result at this stage was a major platform for measuring IPv6 performance.

Test IPv6 performance

Testing the performance of IPv6 website was divided into three (3) techniques. These are analytical modeling, connectivity and measurement. Prior to the commencement of the evaluation stage, the techniques of the three test was identified and which was used in this research for designing the website. However, measuring the AAAA record connection was very important. Thus, the selection of the technique almost depended on the availability of resources, environments, as well as the problem statements and objectives. After defining the AAAA (RR) performance technique. The tools used for testing the IPv6 performance evaluation was identified and divided into three (3) techniques.

Identify the website test

Upon defining the IPv6 website tests, this study proceeded with selecting three website test for evaluation. Selecting them are a key factor in performance evaluation. Normally, network performance uses the combination of three separate elements to measure the IPv6 performance. In this section all the websites were tested using the three website test that were been mentioned earlier: Testing the DNS servers (AAAA record), Connectivity of IPv6, and Checking for IPv6 website/ mail exchanger server.

5. Measure the performance parameters

After collecting data, this study needed to measure the connection AAAA record of each institution of higher learning on the domain by using Microsoft Excel.IP6 nl, ready.chair6.net and IPv6 test, which can be used to measure several different domains of performance parameters in IPv6. Those websites were running as a domain mode, which consists of websites. And that web sites are for testing IPv6 from a domain name. IP6 nl, ready.chair6.net/and ipv6-test are website program used to test IPv6 on the performance of the parameters to check and measure AAAA record, in at way to determine AAAA record on those domains. The statistic from testing websites is used by IPv6 to give the basic information regarding the status of the websites. Another website test used is ready.chair6.net website, which was used to measure DNS (IPv6 TLD NS), DNS (IPv6 AAAA Record), DNS (MX Record) and IPv6 Connectivity of the websites.

Investigation

In this research, performance parameter.IP6 nl, ready.chair6.net and IPv6 test which could be used to measure different types of performance parameters in network was measured. IP6 nl, ready.chair6.net and IPv6 test were running as a website to test the domain names, which measure IPv6 to investigate the domain after testing IPv6 to discovered the problem which impacted on the website test.

Compare the result

After analyzing all the data on IPv6 environments, comparisons were made between website, DNS and Mail Exchangers servers of universities which were used to test IPv6. These can affect the performance of ipv6 and the analysis in the following chapter can be as a guideline to researchers to do a comparison between the websites. The comparison of the performance of IPv6 is illustrated in pie graphs to support the fact.
Overall, the output of this research was a set of testing process on higher learning websites. Output was obtained by using Microsoft Excel. This study evaluated the IPv6 by analyzing the performance of three websites, and various ways to test those websites. In addition, the meaningful data in term of throughput was presented. This research provided a guideline to other researchers who are interested in testing the website. These sequences of processes also can be

implemented to measure others website. The findings of this study would helped in identifying the problems in the AAAA resource record and consequently find ways to overcome the problems and thus, provides better service quality to the IPv6 users

6. Result and Discussion

The pie charts below show the percentage of IPv6 usage for each selected institution of higher learning which provided information about the ministry of education utilization of IPv6 in Malaysia. These charts show the evaluation of Website, DNS and Mail Exchangers servers for each university. The data were collected using the ipv6-test.com, IPv6 and ready.chair6.net connection test websites. Overall, it provided the description of the implementation of IPV6 by showing the percentage of website test for website, DNS and Mail Exchangers servers in order to get an AAAA requests.

Figure 6.1 below show the result of the implementation of IPv6 in public universities. The percentage of the connections of 20 public universities on Website AAAA requests was around 5% while the percentage of the universities that do not implement IPv6 connections and has no AAAA record on website servers are more than 95%.

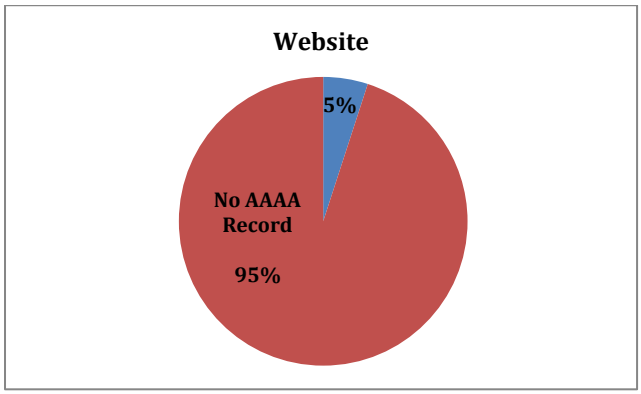

Fig.6.1 Website server connection among public universities

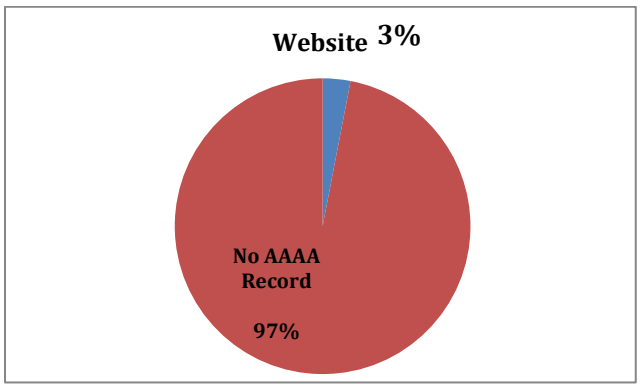

Fig.6.2 Website server connection among private universities

Figure 6.2 above presents the result of the implementation of IPv6 in Private universities. The result revealed that 3% of IPv6 connections has AAAA record are made on the websites of 33 Private universities while the percentage of universities that are not implementing IPv6 connections (Without AAAA record) is 97% which has no AAAA record. However, the result revealed that none of the 30 polytechnics investigated implements IPv6 on the website servers. As such no AAAA records were found.

The result of IPv6 connections among the public universities as show in Figure 10 shows that 20% of the public universities in Malaysia connect on DNS AAAA request while 80% do not possess AAAA record on DNS servers. Similarly, the investigation found that only 15% of the 33 private universities in Malaysia make connections via DNS AAAA request server while 85% do not. In addition to this, only 3% of the 30 polytechnics use IPv6 connections on DNS AAAA request while 97% of the polytechnics have no AAAA records on DNS servers. Figure 6.3, 6.4, and 6.5 respectively present the IPv6 connections and AAAA records of the 20 public universities, 33 private universities and 30 polytechnics.

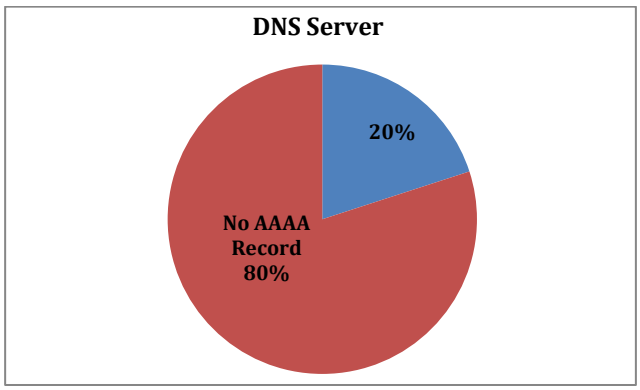

Fig.6.3 DNS servers' connection among Public universities

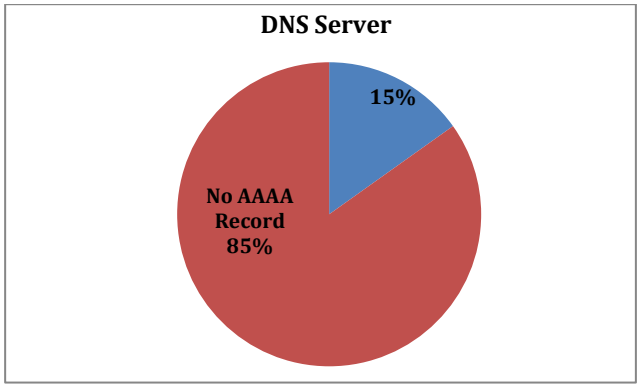

Fig.6.4DNS server connection among Private universities

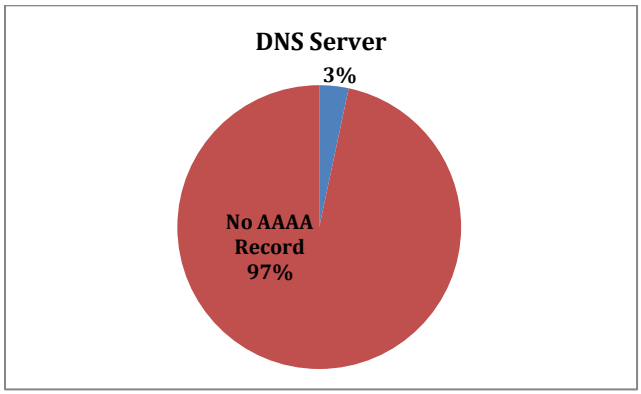

Fig.6.5 DNS server connection among polytechnics universities

Furthermore, Figure 6.6, 6.7 and 6.8 presents the result of IPv6 connection and AAAA records of the 20 public universities, 33 private universities and 30 polytechnics via the mail exchangers. The result revealed that 10 % of the public universities have AAAA record of IPv6conncetion via mail exchanger servers while AAAA record could not be found for 90 %. Among the private universities, AAAA record of IPv6 connection on mail exchanger servers could be found for 27% and no record of IPv6 connections via mail exchanger was found for 73%. In addition, the result revealed that 13% of the 30 polytechnics connect on IPv6 via mail exchanger server while 87% of the polytechnics do not have AAAA records of IPv6 connections on mail exchanger server.

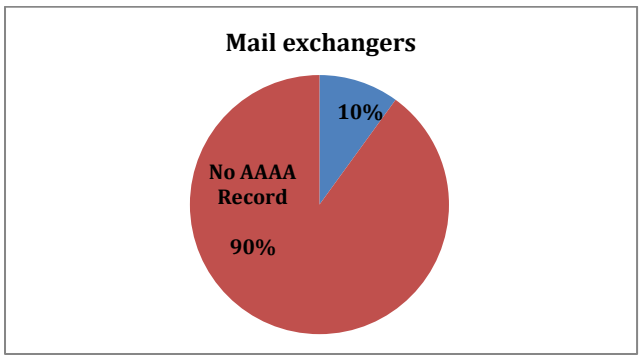

Fig.6.6 Mail exchanger server connection among Public universities

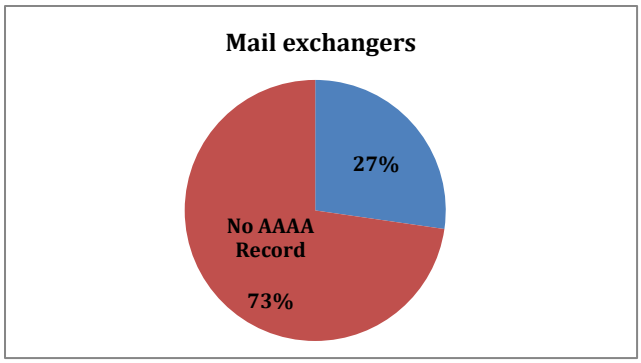

Fig.6.7 mail exchanger server connection among private universities

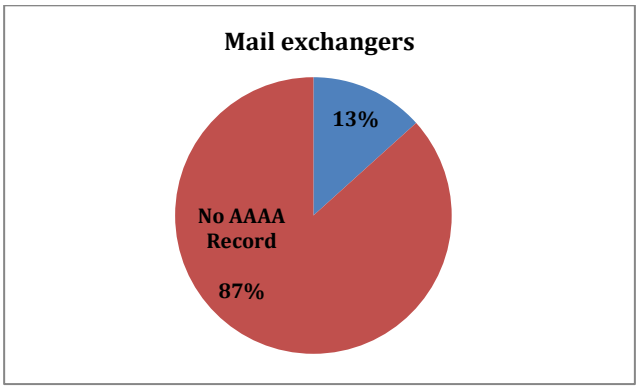

Fig.15 mail exchanger server connection among polytechnics universities

Conclusion

This study has been able to evaluate the implementation of IPv6 connection among the higher institution of learning in Malaysia. The study is significant because it has been able to Perform and configure IPv6 test in the department of higher learning websites. Most of the configuration and performance testing IPv6 network in the 20 public, 33 private and 30 polytechnics universities. Also, the current study was able to provide systematic performance testing of IPv6 guidelines for future research in the aspect of network connections. The idea of this research is basically to give an experience on how to identify the suitable website test of the IPv6 readiness on website and the study found that the usage of IPv6 is still not widely used among the institution of higher learning in Malaysia.

This study is a starting point for testing IPv6 network in higher learning due to the limited researches conducted in Malaysia. It thus opens the way for future researchers, network engineers as well as network administrators to provide an update for monitoring and planning of work in the whole institutions of higher education in Malaysia.

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