

IPv6 Migration towards Developing E-Government

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Abstract— Countries around the world including Malaysia are improving their government agencies delivery to citizens and businesses through e-Government, defined as electronic government. To provide services between government agencies and citizens (G2C), businesses (G2B), employees (G2E) and other non-governmental agencies, most governments globally are using tools and systems made possible by Information and Communication Technologies (ICTs).

Malaysia is not left behind in the global government ICT initiative as Malaysian government welcomes the advent of ICT with its opportunities and promises of a new world order and globalization towards its vision 2020.

Malaysian e-Government project's main objective is to serve the citizens and businesses with efficient, high-quality administrative online services. However, increasing demands for the online services might be affected by (Internet protocol version 4) IPv4 limitations. The need for a more advanced protocol will be more apparent especially to support government mobility, cost and security such as integrity, authorization and authentication.

IPv6 is seen as a solution to solve IPv4 limitations and a strong contributor towards providing efficient online services by government agencies through e-Government. IPv6 deployment in Malaysia is supported by the IPv6 timeline mandating IPv6 adoption by agencies under e-Government by year end 2008. In this paper, we introduce e-Government, IPv6, Migration to IPv6 as well as IPv6 migration issues and challenges, especially in Malaysia. This paper shows the importance of e-Government and IPv6 migration in Malaysia. This paper also outlines the need for IPv6 in developing e-Government as a need to move towards the next-generation ICT world, especially in developing countries.

Keywords— Information and Communication Technologies (ICTs), Internet Protocol Version 6 (IPv6) Migration, Malaysian e-Government, Next-Generation Networks, Cost Efficiency

I. INTRODUCTION

E-Government is an abbreviation of the phrase electronic government which refers to the use of government agencies with information technologies such as Wide Area Networks, the Internet, and mobile computing. Similar to e-commerce, which allows businesses to transact with each other more efficiently (B2B) and brings customers closer to businesses (B2C), e-government aims to allow the interaction between government and citizens (G2C), government and business enterprises (G2B), and inter-agency relationships (G2G) more friendly, convenient, transparent, and inexpensive. The

resulting benefits that can be derived from e-Government are less corruption, increased transparency, greater convenience, revenue growth, and/or cost reductions [1].

The primary objectives of e-Government are to offer efficient, high quality of administrative on-line services to citizens and businesses with low cost and high productivity. However it makes the government more responsive to the needs of its citizens [2]

The first part of this paper discusses about the implementation of e-Government in Malaysia, covering the status of the implementation, and the potential for growth in providing better services to the public. The next section is about the fundamental and conceptual issues of IPv6, it outlines the IPv6 roll-out around the world, status of IPv6 in Malaysia and the role of the National Advanced IPv6 centre of excellence in Malaysia for IPv6 Migration, as well as the challenges faced by the IPv4 to IPv6 migration. The dual objectives of e-Government are to reinvent the government of Malaysia in terms of service delivery through the use of ICT and to catalyze the successful development of the Multimedia Super Corridor (MSC) with ICT as one of the leading sectors of the economy. This paper provides the various initiatives taken by the government in implementing e-Government projects as well as the issues, challenges and benefits derived.

II. E-GOVERNMENT IN MALAYSIA

The transformation of government into e-Government turns out to be a global phenomenon [3][4][5][6][7]. The success of Malaysian e-Government implementation is an important factor to determine the Malaysia's progress towards achieving vision 2020 [8]. To introduce some form of e-Government to benefit citizens and business, Malaysian government has specified various policies, visions, objectives, plans and strategies like many other countries [7]. As such, implementation of electronic government started with the initiation of Multimedia Super Corridor (MSC) in 1996 [8][9][10]. MSC is a government initiative, designed to jump start Malaysia into the information and knowledge age. E-Government is one of the seven flagship applications introduced in MSC. The objectives of these flagship applications are to accelerate the growth of MSC as well as enhance national competitiveness [9]. In fact, it is to create

high value job and export growth to help reduce digital divide. Figure 1 shows the MSC Malaysia Vision from 1996 to 2020.

Table 1. Projects under the e-Government flagship (as of 28th November 2007) [7][11]

Project	Characteristics/ Progress Status
Project Monitoring System (PMS)	Provides a new mechanism for monitoring implementation of development projects, incorporating operational and managerial functions, and knowledge repository. <ul style="list-style-type: none"> SPP II has introduced web-based application. implementation of RMK-9 projects Integration of SPP II system with eSPKB has been rolled out to 3 pilot agencies and roll out to other agencies will be implemented in staggered manner commencing early 2008.
Electronic Procurement (eP)	Links the government and suppliers in an online environment. Government agencies as buyers procure goods/services by browsing catalogues advertised by suppliers. <ul style="list-style-type: none"> All 28 Ministries are using eP system Since year 2001 until 31st October 2007, a total of 1,556 PTJs have been eP enabled. In year 2007, until 31st October 2007, 5,152 suppliers are minimum eP enabled.
Generic Office Environment (GOE)	Provides a new paradigm of working in a collaborative environment where government agencies communicate, interact and share information <ul style="list-style-type: none"> New version of GOE has been introduced with a more user friendly features. GOE is to be upgraded to 22 agencies.
E-Syariah	Introduces administrative reforms that upgrade the quality of services in Syariah courts and to enhance the Islamic Affairs Department's effectiveness. <ul style="list-style-type: none"> Operation/Case Registration via MyKad at the front office counter. Public can access E-Syariah Portal by visiting to www.esyariah.gov.my to get the information such as Syariah court procedures and regulations, online case pre-registration and online Faraid calculation.
HRM Information System (HRMIS)	Provides a single interface for government employees to perform HRD functions effectively and efficiently in an integrated environment. <ul style="list-style-type: none"> As of Nov 2007, rollout activities on base data preparation completed for 600 agencies. 10 modules implemented in pilot agencies ED and PR modules implemented in all Ministries and 12 State Secretariat Offices (SUK)
ELX	A one-stop-centre for labor market information, accessible to government agencies, the business sector and the citizens. <ul style="list-style-type: none"> Fully rolled out for Kem. Sumber Manusia & all states & district offices of Manpower & Labor Department at 105 sites. As of 31 October 2007, 106,285 active job-seekers were captured and 717,405 vacancies reported by employers with 18,562 job seekers hired.
eServices	Enables direct, online transactions between the public, the government and large service providers via electronic means <ul style="list-style-type: none"> Renewal of Competency Driving License (Class D) can now be done online via JPJ portal or myEG (www.myeg.com.my). Public have a choice to make payment via credit card, or myEG prepaid. Renewal slip can be delivered to individual home/office with minimal charges. Updated of the new driving license expiry date in myKad can be done via myEG outlets or Jabatan Pendaftaran Negara.
E-Land / ETanah	To achieve an updated, effective, efficient and accurate National Land Administration System via utilization of Information Communication and Technology (ICT), the E-Tanah project of Ministry of Natural Resources and Environment encompasses 24 main areas in land administration including disposal, registration of titles, transfer approvals and distribution of property

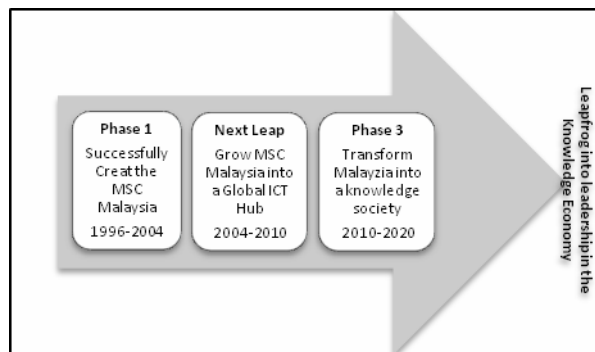


Figure 1. MSC Malaysia Vision [11]

There are eight main pilot projects identified under the e-Government flagship applications since it was started in 1997. All these projects will use ICT and multimedia technologies to transform the way the government operates, coordination and enforcement. Table 1 shows these pilot projects and their characteristics [8][10][11]. These flagship applications serves two main purposes or platform: firstly, to provide the necessary "development" mechanism, and secondly, assuring an "environment" for the growth of Malaysian multimedia and information technologies [12].

In addition of these eight main projects under e-Government flagships, several government agencies has taken initiatives to introduced online services for the public projects, aims to increase the ease and efficiency of public service to the people [8][10].

Most government agencies globally are using tools and systems made possible by ICTs. IPv6, a new version of Internet protocol, is a way forward for the enhancement of the Internet and the migration to the technology is essential for the development of a country's ICT infrastructure [13]. However most of the countries are deploying IPv6 as IPv6 is vital and an avenue towards ICT development. Migration to IPv6 is necessary in order to stay competitive and deploy the benefits of IPv6. IPv6 will lead countries around the world towards the next generation technology advancement.

III. PERSPECTIVE OF IPV6 MIGRATION WORLD-WIDE

The current IPv4 Internet protocol that have been used since 1984, provides 4.3 billion addresses, which currently only about 700 million or 16% are left for new applications. The increasing demand for internet based services, such as smart tags in shops, factories and airports, IP phones, digital camera and digital radio with 8000 channels, energy management for street lighting and intelligent buildings/smart home, IP car, there would not be enough of IP addresses left. Especially in Asia, where very few IPv4 addresses have been assigned, the pressure is expected to be very big. Figure 2 shows the global distribution of the IPv4 addresses [14].

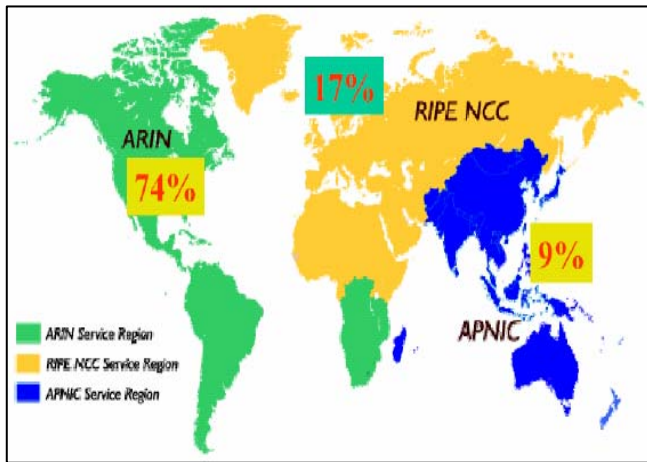


Figure 2. Global distribution of the IPv4 addresses [14]

IPv6, a new version of Internet protocol, was recommended by the IPng Area Directors of the Internet Engineering Task Force (IETF) at the Toronto IETF meeting on July 25, 1994 in Request for Comments (RFC) 1752. The recommendation was approved by the Internet Engineering Steering Group and made a Proposed Standard on November 17, 1994. The core set of IPv6 protocols were made an IETF Draft Standard on August 10, 1998 [14][15].

IPv6 is seen as a solution to solve IPv4 limitations. IPv6 provides unlimited amount of IP addresses available (3.4×10^{28} addresses). Thus, it supports innovative Internet applications using devices that are too numerous or costly for IPv4. Furthermore, home users can easily build their own private networks and connect more devices to the internet using simple IPv6 autoconfiguration without breaking the end-to-end principle. However, IPv6 has enhanced mobility, built-in security and built-in plug-and-play. In a summary, the Internet will be even more scalable, cheap and reliable with IPv6 than with IPv4 [16].

IPv4 is still widely used but many corporations and institutes have started the discussion and planning towards a transition to IPv6 [14]. Most new computers and servers being sold by major manufacturers are already IPv6 compatible, but are only reachable through their old IPv4 addresses. Encouraging internet users and providers to adopt the latest Internet Protocol (IPv6) will provide a massive increase in address space, much in the same way as telephone numbers were lengthened in the 20th century [17]. This in turn will provide an opportunity for companies to innovate still further, and produce the next generation of internet applications.

The deployment of IPv6 has started world-wide. The progress is still slow, but according to the estimates on the availability of IPv6 addresses, the rate of IPv6 deployment should increase drastically during the next two to three years in most parts of the world. Initiatives have been taken to adopt IPv6 in several parts of the world e.g. Asia, Europe and U.S. [14].

A. Asia

The IPv4 address allocations have been historically lower in the Asian countries. The roll-out of IPv6 is led by Japan. In September 2000, Japan took political leadership of the design of the IPv6 roadmap by setting a deadline in 2005 to upgrade their Internet protocol to IPv6, existing networks in every business and public sector.

The Japanese initiative seems to have been crucial to the Asia-Pacific region. Korea followed suit in February 2001 by announcing plans to roll out IPv6. Taiwan has also taken a decision concerning IPv6 and has established an IPv6 steering Committee. Bilateral consultations, at ministerial level, between China and Japan have taken place on the means to further promote IPv6 [18]. In Japan, NTT (Nippon Telecom and Telegraph) already has a global IPv6 backbone called "NTT/VERIO" which covers Asia, USA, Europe and Australia. China implemented networks that are both IPv4 and IPv6 compatible for the Beijing Olympics [14][17].

B. USA

As U.S. was first in the "land rush" for IPv4 address space, they are not yet in such a critical position as the Asia-Pacific region and Europe. However, an industrial initiative which is the establishment of a North American IPv6 Task Force was launched on December 2001, reflects the growing pressure for an upgrade of the Internet.

In February 2003 the U.S. reported that its national strategy will form a taskforce to examine the issues related to IPv6, including the appropriate role of government, international interoperability, security in transition and benefits [19]. Even if the IPv6 progress is slower in the U.S. compared to Asia and Europe, U.S. seems to look at IPv6 as the next step for the Internet advancement [15]. U.S. government sees IPv6 as a requirement for public procurement, but on the ground that their internet technology remains similar to that of the European Union (EU) [14][17].

C. Europe

As for the EU the commercial IPv6 roll-out has been marginal compared to the Asian-Pacific, but the efforts is bigger than in the U.S. In 2002, the European Commission launched an action plan to prepare for the migration to IPv6, by supporting the IPv6 enabling in public sectors, including educational sectors. As a result, Europe's backbone Internet network for research "GEANT" are IPv6-ready and has led to Europe having the highest take-up of IPv6 addresses of any region in the world. However, this improvement has not yet established through the public Internet. More than 30 European R&D projects directly related to IPv6 have been financed through the EU's research frameworks. The European Commission has target Europe to get 25% of EU industry, public authorities and households to use IPv6 by 2010. This also called for

Member States to put the European public sector at the forefront of deployment by migrating their own internet networks, public sector websites and e-Government services to IPv6. To encourage the European IT industry to move forward, Member States should make use of IPv6 as a condition for a public procurement, (as the European Commission and the US Government have already done), raise awareness of businesses and organisations and help them with the transition [14][16][17].

D. Status of IPv6 in Malaysia

Countries around the world are deploying IPv6 as IPv6 is vital and an avenue towards ICT development. In Malaysia, the shortage of IP addresses is due to 3 main factors:

- i. Growing Population & Small No of Allocated Addresses (Figure 3)
- ii. Rising Internet Penetration Rate (Figure 4)
- iii. Increasing Broadband Subscribers (Figure 5)

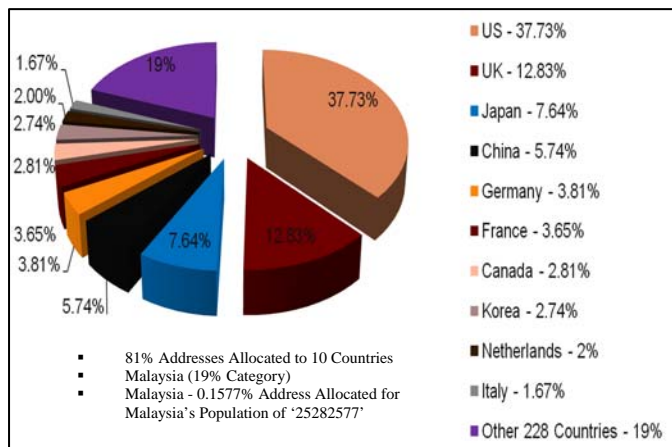


Figure 3. Global IP Address Allocation [20]

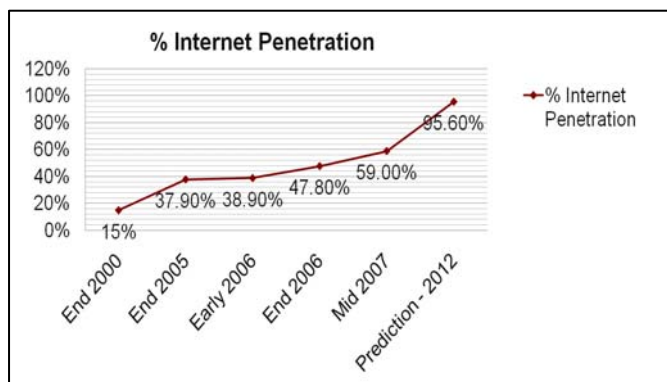


Figure 4. Internet Penetration Rate in Malaysia [21]

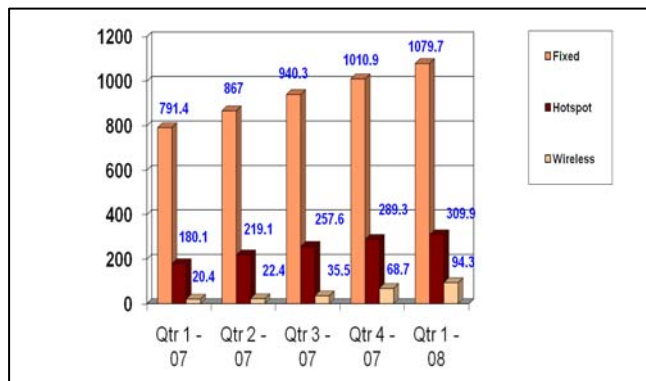


Figure 5. Broadband Subscribers in Malaysia [22]

Migration to IPv6 in Malaysia is necessary in order to stay competitive and deploy the benefits of IPv6. IPv6 will lead Malaysia towards the next generation technology advancement. Ministry of Energy, Water and Communications (MEWC) setup the National IPv6 Council and had its first meeting in December 2005. The IPv6 Council consists of several ministries and telecommunication companies (Telcos). The council's main role is to plan and implement IPv6 in Malaysia. IPv6 timeline was also mandated whereby Internet Service Providers (ISPs) must provide IPv6 infrastructure by 2006, e-Government to migrate to IPv6 by 2008 and entire nation to be IPv6 enabled by 2010 [23]. National Advanced IPv6 (NAv6) Centre was established by MEWC to coordinate IPv6 deployment and activities in Malaysia. Efforts have been made to ensure IPv6 deployment is prioritized in Malaysia. IPv6 has been identified as one of the eight key infrastructures under MyICMS886 blueprint which is Malaysia's ICT strategy [24].

IPv6 is also highlighted as one of the three main technologies focused by MEWC, apart from sensor technology and broadband in the 9th Malaysian Plan [25].

Malaysia's national research education network has IPv6 dual-stack deployed linking 12 Universities and Research Centres [26]. NAv6, being the main centre in-charge of the IPv6 deployment in Malaysia, serves as the national centre for IPv6 research, human resource development and monitoring of IPv6 deployment in Malaysia. NAv6 plays an important role in planning and implementing programs to ensure Malaysia meets its 2010 IPv6 timeline. NAv6 centre was entrusted to develop the National IPv6 Roadmap, a blueprint to guide Malaysia IPv6 implementation which outlines IPv6 implementation strategy to migrate from the current IPv4 infrastructure to IPv6. Another effort carried out towards meeting the IPv6 timeline is the IPv6 pilot project of two government agencies (MEWC and Malaysian Administrative Modernization and Planning Unit (MAMPU)). The IPv6 pilot project consists of four phases which are the preparation of dedicated networks using dual-stack mechanism and IPv6 tunnelling, overall improvement in MEWC and MAMPU networks and the preparation of national guidelines. Through the pilot project completion, a comprehensive guideline to deploy IPv6 will be produced for the other government

agencies. In terms of the human resource development aspect of IPv6, training courses were developed by NAV6 Centre. Since IPv6 is an essential technology for Malaysia, it is important for Malaysia to produce IPv6 engineers, programmers and experts in the country. IPv6 awareness are continuously conducted to create awareness to the public (local industries, government and private sectors and internationally) on the importance of IPv6. To be able to monitor IPv6 implementation among the ISPs in Malaysia, auditing of IPv6 implementation is required. ISP IPv6 audit was conducted in March 2007 reported that major ISPs in Malaysia are providing phase 1- IPv6 connectivity [27].

One of Malaysia's main IPv6 focus right now is the federal government agencies IPv6 migration by 2008. The federal government agencies in Malaysia are also known as electronic Government (e-Government) agencies. There are a total of 87 e-Government agencies in Malaysia. 2 agencies are involved in the IPv6 Pilot Project while the other 85 agencies have not started migrating to IPv6. Currently e-Government agencies' network is running on IPv4 networks. However, the limitations of IPv4 such as address depletion cause the need for a next generation internet protocol. To ensure e-Government project achieves its goal to provide good services to the public, IPv6 implementation is necessary. Realizing the importance of IPv6 in accelerating e-Government project, the National IPv6 Council mandated all government agencies involved in e-Government project to migrate to IPv6 by 2008. The migration to IPv6 process in e-Government agencies' network will be in a gradual adoption manner while adopting several IPv6 migration techniques such as dual-stack, tunneling and/or translation. However, these techniques require not only the latest model of equipments compatible with IPv6 and also skilled manpower to ensure a smooth migration process [13].

IV. IPv6 MIGRATION ISSUES AND CHALLENGES

When the IETF finalized the IPv6 standard, experts thought the transition from IPv4 to IPv6 would be relatively smooth; similar to an operating system upgrade; but that is not the way it turned out since it is completely a new protocol [28]. The IPv6 migration process presents various problems.

One of the major problems is the complexity of the migration process from IPv4 to IPv6. It is expected that the migration process will be long and there will be a necessity for IPv4 and IPv6 nodes to coexist with each other [29].

Among the challenges faced by organizations in IPv6 migration are:

- Lack of IPv6 technology awareness;
- Refusal to migrate to the next generation Internet Protocol (IPv6) due to the large investment in the current IPv4 infrastructure;
- Still have adequate IPv4 addresses and do not see the need for IPv6;

- Uncertainty of the migration cost;
- Security issues;
- Unsure of the migration steps that are involved in the migration process.

The three biggest IPv6 migration challenges identified are uncertainty of cost, security concerns and ambiguity of the migration steps.

Cost: Cost is one of the major concerns of the IPv6 migration as organizations are afraid the migration will cost too much [30]. The migration costs could be categorized as hardware costs, software costs, and cost of staffs and services [28]. Additional cost can be imposed if outside expertise is used because certain organizations require speedy deployment, due to the lack of staff experienced in IPv6 migration. Also, the cost of porting applications to IPv6 needs to be considered [31].

Security: Security maintenance during IPv6 migration is another main concern of organizations. There is concerns on creating vulnerabilities in the existing IPv4 networks when IPv6 is deployed [32].

Migration steps and process: The third main concern of IPv6 migration is the being uncertain of the migration steps. Organizations planning to deploy IPv6 are not sure which areas of the network need attention, which network equipments support IPv6 and those that require upgrading or replacing, which is the initial step of the migration process. Organizations are also uncertain of their roles in the migration process [33].

The migration from IPv4 to IPv6 will be a long process and there are many details of the migration that must be looked at [35]. IPv6 deployment concerns such as migration steps, security considerations and cost are the main issues that should be researched.

V. RESEARCH FINDINGS – IPv6 MIGRATION CHALLENGES IN MALAYSIA

Since IPv6 migration is essential in the success of e-Government project, the migration process should be prioritized. However, as the same around the world, IPv6 Migration in Malaysia presents issues and challenges. In order to obtain the information on the issues and challenges, the questionnaire method has been used. The findings identified the migration to IPv6 challenges in Government Agencies according to the government agencies' staff in Malaysia. The challenges of IPv6 deployment in government agencies from the most challenging factor until the least challenging factor are the lack of staff with IPv6 knowledge and experience, followed by inadequate funding or budget, configuration considerations, porting applications consideration, lack of time, security consideration; and then the least challenging factor is the lack of vendor support.

Since cost is one of the major concerns of the migration to IPv6 process, the results from the government agencies feedback on the cost concern as shown in figure 6 states that 35% felt that network cost is the biggest cost concern while 22% felt the major cost was the security. 18% thought it is human resource training cost, 14% felt its major cost concern is the contents management cost and only 11% felt it was the administrative cost.

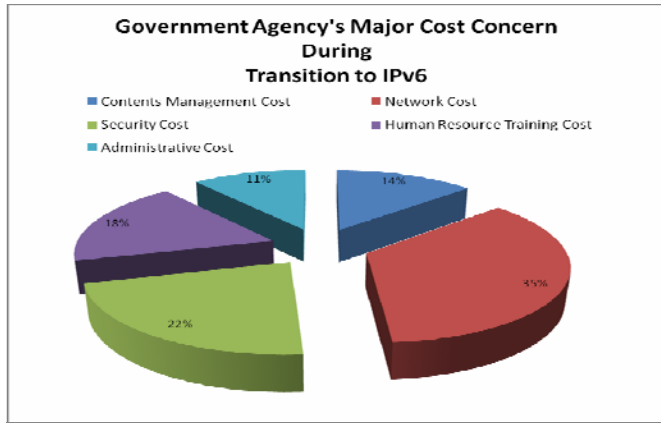


Figure 6. Government Agency's Major Cost Concern during Transition to IPv6

On the issue of required assistance during the migration to IPv6 process in Government Agencies, 29% wanted training assistance, 25% needed guidelines assistance, 24% required transition assistance and 22% wanted costing assistance as shown in figure 7.

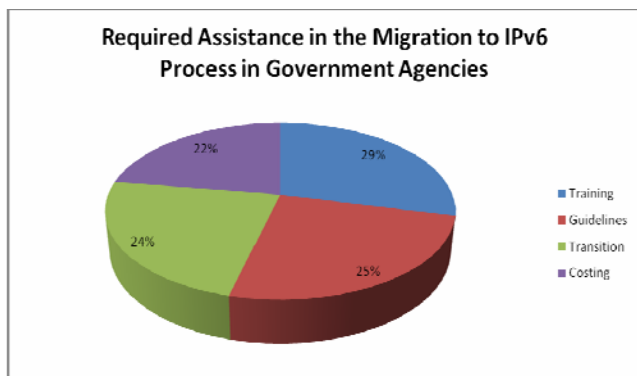


Figure 7. Required Assistance in the Migration to IPv6 Process in Government Agencies

Also, a few other concerns were listed by the government agencies staff on the migration to IPv6 in the recommendation section. Security is a big concern as it is essential that the migration to IPv6 should maintain the security of the network. Agencies are not sure of the migration cost and thus find difficulty migrating to the next generation protocol as budgets need to be prepared much earlier. Agencies do not have any

specific approach towards the migration as they are uncertain of what should be done. Through the IPv6 migration challenges identified and addressed, the migration to IPv6 in Government agencies in Malaysia can be done smoothly. Through the IPv6 migration, the goal to ensure e-Government project delivers good services to the end users [13].

VI. CONCLUSION

The first most important step to undertake in the process of integrating IPv6 with e-Government project to achieve the success of the e-Government project is the identification and addressing of the challenges of IPv6 migration. Agencies should budget their migration to IPv6 much earlier. Assessment and planning should be done to figure the rough estimation of the migration cost. Agencies should design an overall vision of how IPv6 will be employed in their architectures [35]. Planning guideline listing the migration steps should be created with deliverables and milestones for the important steps [36]. Research institutes should not only focus on IPv6 Research and Development (R&D) but also the planning aspect of the migration. More research on the impact of IPv6, transition cost, security and others should be carried out which will in return address the migration concerns.

IPv6 migration challenges must be addressed during the necessary migration to IPv6 process. The three major concerns of the migration process are the cost uncertainty, security considerations and ambiguity of the migration steps. Through case studies and pilot projects carried out as well as literature available on the migration process, a transition guide can be created which will address the agencies concerns. This will then accelerate the IPv6 adoption in e-government agencies and thus, meet the IPv6 timeline. The effectiveness of e-Government project involves rethinking organizations and processes while changing the behaviour of the public services to ensure public services are delivered efficiently to the people who utilized them. Once the IPv6 migration in Government agencies runs smoothly, it will be one step closer towards achieving the promise of providing good services through e-Government project. The benefits and advantages of IPv6 should be integrated into the e-Government agencies services. With the integration of IPv6 into e-Government project, all citizens, enterprises and organizations are able to carry out their businesses with the Government agencies more effectively.

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