Faculty of Information and Communication Technology

THE EXTENSION OF ORGANISATIONAL READINESS MODEL TOWARDS TECHNOLOGY MIGRATION: A CASE OF IPV6 MIGRATION

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THE EXTENSION OF ORGANISATIONAL READINESS MODEL TOWARDS TECHNOLOGY MIGRATION: A CASE OF IPV6 MIGRATION

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DECLARATION

I declare that this thesis entitled *"The Extension of Organisational Readiness Model towards Technology Migration: A Case of IPv6 Migration"* is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Date : ……..

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Doctor of Philosophy.

Signature : …….....

Supervisor Name : DR. NURUL AZMA BINTI ZAKARIA

Date : …….....

DEDICATION

In honor of,

My beloved mother, Hajah Saadiah Hj Atong

In memory of,

My late father Hj Main bin Ahmad,

Who taught me to trust in Allah, believe in hard work and give his blessing in what ever I do

My siblings,

For always cheering me up during hard times

My supervisors,

Who have constantly been the source of my knowledge and inspiration

My beloved friends,

Without them, I never would have been able to succeed

ABSTRACT

Internet Protocol, often referred to as IP, is the Internet addressing protocol that allows devices to connect to each other. At present, the existing Internet Protocol Version 4 (IPv4) is being gradually replaced by a new version of the protocol, Internet Protocol Version 6 (IPv6), to provide a larger scale of addresses and to facilitate various improvements to the protocol. Migration from IPv4 to IPv6 is seen as a lengthy and difficult process for any organisation as it comprises many aspects such as talent management especially the IT personnel and technology competence in terms of the current infrastructure capability to facilitate IPv6 environment and the process which include testing and implementation. The highlighted issue in this study is that in most places, the IPv6 deployment process is quite slow, despite the crucial changes to the new protocol. This concern is contributed by the fact that many organisations are still not prepared for the migration to the IPv6 even though they are aware of the serious needs to apply it in their network. Factors that influence the readiness of an organisations towards IPv6 have been studied from different aspects and perspectives by previous studies, therefore, the objectives of this study were to analyze the physical and human factors that can define the readiness of an organisation to migrate to the IPv6; to develop the IPv6 organisation readiness model based on categorized factors and to validate the IPv6 organisation readiness model. A mix-method research strategy was applied in this research which consisted of two phases; determine the factors (qualitative) for the early phase and model development and reliability and validity (quantitative) for the second phase of the study. For the qualitative approach, document analysis and structured interviews were chosen as the research instrument for the data collection involving five experts to explore the factors. Manual approach to transcribe the findings or coding was used for the data analysis of the interview. For the next phase, data were collected from 107 IT personnel who were managing the computer networks in polytechnics and community colleges throughout Malaysia, and a 5-point Likert Scale questionnaire was employed as the data instrument. Rasch measurement model was applied as a direction for data analysis and the data were analysed using the statistical analysis software, Winstep version 3.69.1.11, to determine the most important factor towards IPv6 migration and to validate the model as well. The results revealed that equipment, cost, deployment, motivation, skill and knowledge were the factors required for migration to the IPv6 and the most important factor in physical category was deployment (mean measure=-0.20, mean score=4.4) and the most important factor in human category was skill (mean measure=-0.62, mean score=4.52). For the model validity, the unidimensionality test revealed that each factor was proven based on the independent items and model fit. In conclusion, the results significantly proved that the factors had high potentials to measure the readiness of an organisation for IPv6 migration.

ABSTRAK

Protokol Internet atau IP, adalah protokol pengalamatan yang membolehkan peranti untuk berhubung antara satu sama lain dalam Internet. Pada masa ini, Internet Protokol Versi 4 (IPv4) sedang beransur-ansur bertukar ke Internet Protokol Versi 6 (IPv6) yang menawarkan pengalamatan lebih besar serta penambahbaikan kepada beberapa aspek. Penghijrahan daripada IPv4 kepada IPv6 dilihat sebagai satu proses yang panjang dan sukar bagi sesebuah organisasi kerana ia terdiri daripada banyak aspek seperti keupayaan staf IT dan infrastruktur semasa yang menyokong persekitaran IPv6 serta proses termasuk ujian dan pelaksanaan. Isu dalam kajian ini menekankan bahawa di kebanyakan tempat, proses perlaksanaan IPv6 adalah agak perlahan, walaupun perubahan kepada protokol baru ini dilihat sangat penting. Kebimbangan ini disumbangkan oleh beberapa organisasi masih tidak bersedia untuk proses peralihan kepada IPv6, walaupun mereka sedar keperluan yang serius untuk mengimplementasi IPv6 dalam rangkaian mereka. Oleh kerana faktor yang mempengaruhi organisasi untuk bersedia ke arah migrasi IPv6 telah dikaji berdasarkan aspek dan ciri-ciri yang berbeza-beza sebelum ini, dengan itu, objektif kajian ini adalah untuk meninjau faktor fizikal dan manusia yang boleh menentukan kesediaan organisasi untuk berhijrah ke IPv6; untuk membangunkan model organisasi kesediaan IPv6 berdasarkan faktor yang telah dikategorikan dan untuk mengesahkan model organisasi kesediaan IPv6. Strategi kajian berbentuk campuran telah diaplikasikan yang terdiri daripada dua fasa iaitu menentukan faktor (kualitatif) untuk fasa awal dan pembangunan model, kebolehpercayaan dan kesahan (kuantitatif) bagi fasa kedua kajian. Dalam pendekatan kualitatif, analisis dokumen dan temu bual berstruktur telah dipilih sebagai instrumen kajian untuk pengumpulan data yang melibatkan lima pakar bagi meneroka faktor tersebut. Pendekatan manual untuk mentranskrip dapatan iaitu pengekodan telah digunakan untuk menganalisis data temuduga. Bagi kedua, data telah diperolehi daripada 107 kakitangan IT yang menguruskan rangkaian komputer di politeknik dan kolej komuniti di seluruh Malaysia, dan 5-titik skala Likert soal selidik telah digunakan sebagai kaedah pengumpulan data. Model pengukuran Rasch telah digunakan sebagai rujukan analisis data dan data dianalisis menggunakan perisian statistik, Winstep versi 3.69.1.11, untuk menentukan faktor yang paling penting ke arah migrasi IPv6 dan untuk mengesahkan model. Keputusan kajian mendedahkan bahawa peralatan, kos, perlaksanaan, motivasi, kemahiran dan pengetahuan adalah faktor-faktor yang diperlukan untuk berhijrah ke IPv6 dan faktor yang paling penting dalam kategori fizikal ialah perlaksanaan (min pengukuran = -0.20, skor min = 4.4) dan yang paling penting dalam kategori manusia adalah kemahiran (min pengukuran = -0.62, skor min = 4.52). Untuk kesahan model, hasilnya ditunjukkan dari ujian keunidimensian bahawa setiap faktor dibuktikan berdasarkan faktor bebas (independent) dan kesesuaian model. Kesimpulannya, keputusan membuktikan bahawa faktor yang telah diuji mempunyai potensi yang tinggi untuk digunakan bagi mengukur kesediaan organisasi migrasi ke IPv6.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The Internet is currently one of the most important technologies because it has influenced people's lifestyles. It can provide numerous benefits, such as facilitating business communications, and most users use the Internet as an electronic medium for data transmission and sharing information (Poon, 1996) apart from the highly growth of electronic commerce nowadays (Grandon and Pearson, 2004). The communications protocol that allows the conductance of packets in a network is known as Internet Protocol (IP). IP is the primary protocol that sets up the Internet and IP addresses, and can be considered as the permission to make a connection to the Internet (Dell, 2012a). An IP address is made up of a row of binary numbers of between 32 bits and 128 bits, which is used as an identification address for each host (computer) in a network. At present, the IP version 4 (IPv4) is employed, which has been in operation since the 1980s (Dobrijevic *et al.*, 2012). However, according to Gold (2011) this current Internet Protocol (IP) address (IPv4) has been experiencing a run-out caused by the rapid growth of internet and mobile applications. In fact, Asia is the first continent where shortage of IPv4 was faced (Dawadi and Khanal, 2015).

Therefore, the IP version 6 (IPv6) was created as the next generation of network layer protocol to overcome the limitations of the IPv4 (Wu *et al.*, 2013) and to overcome the lack of addresses in the IPv4 (Dai, 2011). The IPv6 can be seen as the only effective strategy for a long-term protocol as it can ensure the continued growth of the Internet and is an innovation

that comes with an end-to-end connectivity (Babiker *et al.*, 2011). Besides providing a larger space, the IPv6 also facilitates the development of other features that do not exist in the IPv4 (Van Der Pal, 2013), such as different types of address configurations: global addresses, global unicast addresses, multicast addresses and link-local addresses (Dai, 2011). In addition, IPv6 not only will provide more number of devices but IPv6 also play an important role in Internet of Things (IoT) application (Kumar *et al.*, 2016).

Other than the critical issue of the address limitation of the IPv4, organisations need to deploy the IPv6 to allow for the continued growth of the Internet as it can provide more than a trillion address spaces (Omae and Adeya, 2011). It seems that this extension can support more devices and users on the Internet, as well as make traffic routing more efficient. On the other hand, the deployment of the IPv6 is not only concerned with providing a large number of IP addresses to the network, but also with upgrading the network to take advantage of many aspects such as applications, services and technologies. It enables organisations that mostly depend on the Internet for their daily activities to compete with other organisations. At the same time, it is essential that organisations do not lag behind those that have deployed earlier.

There are generally three techniques for the transition of the IPv4 to the IPv6, namely dual stack, tunnelling, and translation, before full deployment to the IPv6 is complete (Nguyen *et al.*, 2012). Hence, critical issues with regard to these different transition techniques, such as address mapping, routing and forwarding, should be studied before any of these techniques are implemented (Wu *et al.*, 2013). It is impossible to implement the IPv6 fully into networks and to replace the previous protocols while the IPv4 is still in existence, so the IPv4 will coexist with the IPv6 until full migration to the IPv6 is completed. This migration is seen as a lengthy and difficult process for an organisation because it comprises many aspects such as stakeholder engagement, infrastructure design (George *et*

al., 2012), procedures and methodologies (Arkko and Baker, 2011), costs (Dai, 2011) as well as proper planning (Che and Lewis, 2010). Therefore, the migration from IPv4 to IPv6 involve the people referring to the compatibility with what people can do (Karahanna *et al.*, 1999), technology which is the infrastructure that focus on the ability of the current technology to facilitate IPv6 environment (Van Der Pal, 2013) and the process include the testing and implementation (Babiker *et al.*, 2011) in an organization to implement the changes.

Accordingly, organisations intending to implement the IPv6 should be ready with proper planning for the deployment, as appropriate preparations, efforts, accurate resources and expertise are required to ensure a smooth migration. Correct planning includes developing the awareness of the staff, ensuring that all the networking hardware is compatible with the new protocol, and that high technical skills among the network administrators are in place. This is because the new standards in the network will require changes to be made, not only in the IT infrastructure, but also among the management personnel operating at different levels (Kapetanovic and Ribi, 2012). Thus, the involvement of all parties, including the top management, technical staff and end users is needed to maintain the IPv6 readiness (Nguyen *et al.*, 2012).

Therefore, it is important for IT staff to plan the management of both protocols in their job schedule and to understand how the transition is to be completed rather than to plan solely for the implementation of the IPv6. In fact, the organisation needs to be aware of the significance of a quick response by starting their transition planning early (Gold, 2011). It would be useful to ensure that there is a standard method for making plans and checking the readiness within an organisation. In this way, both the technical infrastructure and business activity of the organisation will be outlined to facilitate any action that needs to be taken to commence the transition to the IPv6. A high level of organisational readiness with the

appropriate preparation, procedures, and implementation tools can control the costs and uncertainties involved concerning the project (Limkar *et al.*, 2010).

Therefore, this study was carried out to produce a model on the IPv6 organisation readiness as a guide for preparing the organisation to migrate to the IPv6, as this is important for the successful adoption of the new technology.

1.2 Background of the Study

Considering how important the deployment of the IPv6 is, every organisation should start taking steps to move towards this migration and include the IPv6 in their roadmap even if the organisation is not directly involved with the Internet industry. In view of the fact that the IPv6 is a new technology that will be replacing the current IPv4, the transition is viewed as a prolonged and difficult process. Therefore, the Malaysian government has set up the National IPv6 Council to provide leadership and planning for the implementation of the IPv6 in Malaysia. The IPv6 is recognized as a major infrastructure project under the Malaysian Information, Communications and Multimedia Services 886 (MyICMS 886) strategy to be implemented under the Ninth Malaysia Plan. Based on the National Strategic IPv6 Roadmap, the IPv6 should have been implemented in Malaysia by the end of 2010 (Ministry of Energy, 2008).

However, in facing the problem of diminishing IPv4 addresses, the migration rate of the IPv4 to IPv6 appears to be slow (Ahmad and Yaacob, 2012). Many studies have shown that in most places, the IPv6 deployment process is quite slow, despite the crucial changes to the new protocol. The migration to the IPv6 protocol seems to be slower than expected despite the many reasons that have been identified as to why this is necessary, especially with the depletion of the IPv4 address spaces (Nowicki *et al.*, 2011). Until April 2012, only about 5.5% of the world's Internet users were using the IPv6 environment (Svedek *et al.*,

2011), even though 184 countries around the world had been allocated their IPv6 address (Tseng *et al.*, 2012). Meanwhile, it has been reported that the diffusion of the IPv6 traffic worldwide was approximately only 3.5% as of April 2014 (Paltridge, 2014).

Meanwhile, in Malaysia, it was reported that in 2012, only 1.4% of the domain names with IPv6 were enabled (Sinniah, 2012). In fact, an IPv6 test reported that until January 2015, almost 100% of hosts were still supporting the IPv4, with a slow growth for the IPv6. In addition, a study by Fiaz *et al.*, (2015) indicated that only 3% out of 30 polytechnics and 20% of public universities in Malaysia are using IPv6 connections on their DNS. This is in contrast with the success indictors of the MyICMS 886 that are relevant to the IPv6, which are:

i. Malaysian ISPs to migrate to the IPv6 by the end of 2006

ii. Government agencies to commence migration to the IPv6 by 2008

iii. The IPv6 is expected to be proliferated nationwide by 2010 and with national network support (Ministry of Energy, 2008)

Based on the previous research, the factor that contributed to the above issue was the low level of readiness towards the deployment of the IPv6 into organisations because the transition from the IPv4 to the IPv6 cannot be easily achieved within a short time, but requires a lot of preparation and careful planning (Nguyen *et al.*, 2012). Therefore, a question that needs to be answered is how ready is the entire world to face this process, even more so for developing countries (Kapetanovic and Ribi, 2012). As mentioned before, the transition from the IPv4 to the IPv6 requires support in all aspects such as costs, stakeholders, methods, infrastructure and planning. For this reason, every aspect should be noted seriously so that the level of preparation and readiness in terms of the technological education, infrastructure, procedures and business returns on investments can be measured (Che and Lewis, 2010). In

fact, it can be used for assessing the readiness of the IPv6 transition planning in the technical, organisational and marketing aspects (Svedek *et al.*, 2011).

Previous findings have shown that low levels of readiness and preparation influence the progress of the IPv6 deployment, especially when the network environment is still not available for the IPv6 (Tseng *et al.*, 2012). Firstly, in terms of the transition strategy, network administrators have problems in choosing the best method for implementing the IPv6 transition (Nguyen *et al.*, 2012) because few of the options for the transition mechanism are understood by IT personnel (Khan and Sindi, 2012), and network managers tend to be confused, especially those who lack experience (Arkko and Baker, 2011a). Furthermore, network administrators with limited knowledge can be a major factor contributing to a delay in the migration progress (Nowicki *et al.*, 2011). Other than that, the facilities can also affect the migration progress, where the percentage of network equipment supporting the IPv6 is still low at less than 50% (Tseng *et al.*, 2012). In addition, according to Gold (2011), any organisation that starts planning towards the IPv6 must first take a step to assess its readiness because organisations that are not quite ready for the IPv6 and have a low level of readiness can contribute significantly to problems in the ICT industry (Dell, 2012b). Besides that, according to Tseng *et al.*, (2016), IPv6 service measurement becomes a critical topic for the IPv6 migration process. Figure 1.1 shows the migration issue and the factors involved in the process.

In view of the above scenario, it is believed that there is a need to conduct a study on IPv6 readiness to help organisations to take the appropriate action to migrate towards the IPv6.

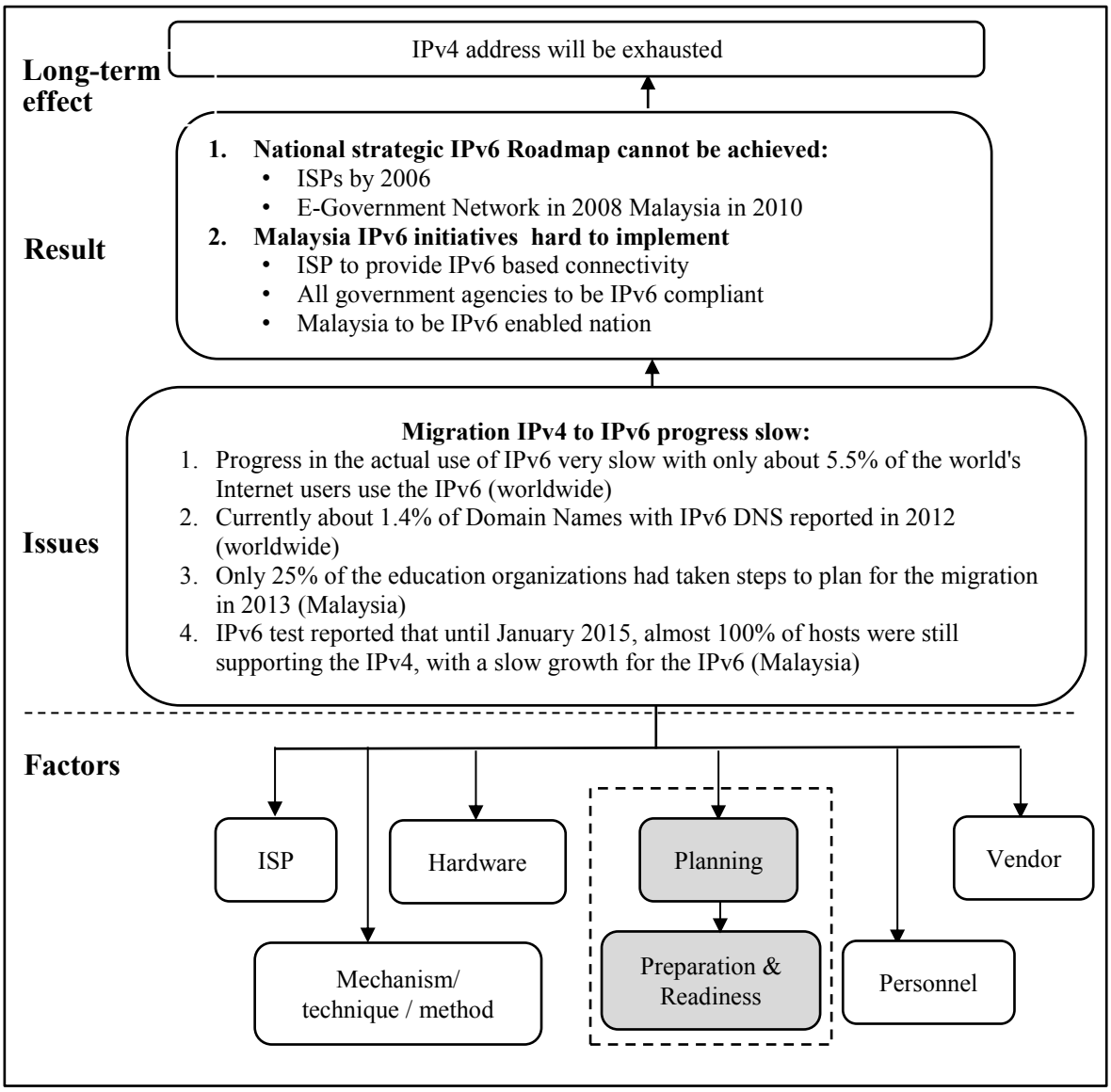

Figure 1.1: Migration issue and factors involved

1.3 Problem Statement

Many studies have drawn attention to the failure of change implementation which is contributed by the problem of organisation's management (Keen, 1981). Leavitt and J, (1965) classified the organisation as a diamond in which task (process), technology (physical infrastructure), people (human), and structure are interrelated and mutually adjusting. When any component is changed, the other components often adjust to gain the impact of the changes. It is claimed that everything in the organisation affects everything else as indicated