Curtin Business School
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Understanding IPv6 Resistance: A Model of Resistance among Indonesian Organizations

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Declaration

To the best of my knowledge and belief, this thesis contains no material previously published by any other person except where due acknowledgment has been made. This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

The research presented and reported in this thesis was conducted in accordance with the National Health and Medical Research Council National Statement on Ethical Conduct in Human Research (2007) – updated March 2014. The proposed research study received human research ethics approval from the Curtin University Human Research Ethics Committee (EC00262), Approval Number IS_13_01 (29 January 2013) and IS_14_10 (3 April 2014)

Signature :

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Abstract

This research examines the resistance to technology within the context of Internet Protocol version 6 (IPv6). A research model, the IPv6 Resistance Model, was developed and empirically tested and validated in the context of Indonesian organizations.

IP address plays an essential part in the Internet's architecture by providing a unique address to identify every connected device. The current version, IP version 4 (IPv4) was standardised in 1981 and since then has been incredibly successful: it remains the protocol in use by practically all Internet-connected devices worldwide. However, the massive growth of the Internet that has occurred since then was not anticipated by the designers of IPv4 and in early 2011 the last five unused IPv4 address blocks were distributed to the five Regional Internet Registries (RIRs). This effectively signalled the end of IPv4's capacity to continue expanding.

Various strategies have been applied to extend the effective lifespan of IPv4 but these were intended only to be short term solutions, and IPv6 was designed and developed as a long-term replacement for IPv4. However, despite being able to support an Internet many orders of magnitude larger than IPv4, and also having a number of other technological improvements, the adoption of IPv6 is still very rare.

This project investigated resistance to IPv6 and was completed in three phases. In the first, preliminary phase a survey of Indonesian organizations was conducted to gain a high-level empirical overview of the research domain. This phase revealed that although most Indonesian organizations believe that IPv6 is important, they do not consider it to be urgent. The findings also indicated that Indonesian organizations have generally not made any significant preparations for IPv6 in terms of five readiness criteria, including training, planning, developing policy, assessing the IT environment and actual deployment. This finding suggests that Indonesian organizations are resistant to change to IPv6.

After this preliminary phase, the main research was conducted in two phases following a mixed method approach. The first of these phases was conducted using a qualitative methodology and employed semi-structured interviews with 17 organizations to explore the salient reasons that they resisted changing to IPv6. The data were analysed using a Domain Analysis technique, leading to the identification of four domains that each have an important role in leading organizations to resist IPv6. A theoretical model and research hypotheses were developed based on the qualitative findings.

The model and hypotheses were then tested and validated in the final, quantitative phase. This involved the deployment of an online survey to collect data about Indonesian organizations' attitudes towards IPv6. These data were analysed using SEM-PLS in two steps: assessing the measurement model, and validating the structural model. The findings from this phase indicate that Lack of Felt Need, Perceived Threat and Lack of Environmental Influence all have a significant relationship with organizational resistance to IPv6. Satisfaction with the Current System was not, however, found to have a significant impact on resistance. The findings also revealed that Switching Cost has no effect on organizations' resistance to IPv6.

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Chapter 1. Introduction

1.1 Background to the Research

The Internet has grown dramatically and become an integral part of modern society (Wellman & Haythornthwaite, 2008). It has affected, in a variety of ways, many areas of human endeavour (Castells, 2011) including the economy (Haag & Cummings, 2009), politics (Bakker & de Vreese, 2011; Howard & Parks, 2012; Sundar *et al.*, 2003), social life (Ellison *et al.*, 2007; Tow *et al.*, 2010) and technology development (Bughin *et al.*, 2010; Gubbi *et al.*, 2013). The Internet has contributed significantly to economic development as it enables people to conduct flexible and real-time transactions (Baltzan & Phillips, 2010). The Internet provides political tools allowing people to obtain up-to-date information and to participate in the political process (Sundar *et al.*, 2003; Vergeer *et al.*, 2013). Furthermore, the Internet plays a significant role in social interactions, enabling people to communicate with others all around the globe (Block, 2004) without being limited by boundaries (Kozierok, 2005). Moreover, the Internet can be used to enhance technological development in order to provide better services for communities (Haag & Cummings, 2009).

The recent data (www.InternetWorldStats.com, 2015) indicates that the number of Internet users reached 3,079 million at the end of 2014, and this represents 42.4% of the world total population. The data reveals that Internet users have increased in number almost ten times during the last fifteen years. This relatively recent increase is not only due to the increased use of traditional computers (such as desktop and laptop), but many new devices and applications have become available, such as always-on technology, machine-to-machine communication, network sensors and smart devices required connection to the Internet to enable their system. This initiative is called the Internet of things which allow more objects to connect to the Internet and have the ability to communicate without requiring human-to-human or human-to-computer interaction (Gubbi *et al.*, 2013).

To be able to connect to the Internet, every device is identified by a unique virtual address which is called an IP (Internet Protocol) address. IPv4 (IP version 4) is the common Internet protocol standard that has been used since the Internet was first introduced to the public in the early 1980s. It has served the Internet for more than 30 years. The original IP specification is documented on RFC 760 and contains 32-bits address spaces or 4,294,967,269 unique addresses. However, in the early 1990s the Internet standard communities identified a potential limitation of the IPv4. Wang and Crowcroft (1992) issued a warning in the very early days of the Internet when it was not as widespread as it is today. Several other authors (Bohlin & Lindmark, 2002; Colitti *et al.*, 2010; Dell, 2010; Huston, 2012; Karpilovsky *et al.*, 2009; Mueller, 2008) have also shown their concern over the address limitation.

On 3rd February 2011, ICANN[1] as the IP regulatory body joined with the NRO (Number Resources Organization), the Internet Architecture Board (IAB) and the Internet Society in announcing that they had allocated the last IPv4 blocks to five the RIRs (Regional Internet Registry)[2] as organizations which provide technical coordination for the Internet infrastructure. Apparently, it indicates that the dearth of addresses has become a real problem where entire available IPv4 addresses have been allocated (Dell, 2011). The only addresses left were at the regional or provider level, but this was only for short periods. For example, Huston (2015) reports that APNIC became the first RIR to announce that all address space had been exhausted in April 2011, followed by RIPE in September 2012, LACNIC in May 2014 and ARIN in June 2015. AFRINIC still holds about 40 million available addresses which could survive to accommodate the address demand in this region for the next 3.5 years based on its current levels (Huston, 2015). This figure also suggests that different rates of address consumption in different regions indicate that the Internet is not ubiquitous in every part of the world. Hence, scholars need to consider the Internet in the context of the whole world, not just certain parts of it.

[1] ICANN (Internet Corporation for Assigned Names and Numbers) is the non-government body that coordinates the Domain Name System (DNS), Internet Protocol (IP) addresses, space allocation, protocol identifier assignment, generic (gTLD) and country code (ccTLD) Top-Level Domain name system management, and root server system management functions

[2] http://www.enterprisenetworkingplanet.com/news/article.php/3923391/IPv4-Officially-Depleted-Eyes-on-IPv6.htm, accessed on 05/01/2012

IPv6 (IP version 6) or next generation IP was introduced as a de facto standard to replace IPv4 (DeNardis, 2009). Standardized in 1998 (Deering & Hinden, 1998), IPv6 is necessary not only to extend the address space number, but also to solve other inherent IPv4 problems (Durdagi & Buldu, 2010; Mueller, 2010a) such as routing, security, mobility and services issues. In short, IPv6 offered more enhanced features than did its predecessor and is believed to be able to deal with the needs of the current and future Internet. For example, the address space was increased from 32-bits to 128-bits or 340,232,366,920,938,463,463,374,607,431,768,211,456 unique addresses, which is said to be equivalent to every grain of sand on Earth (Wiljakka, 2002).

On the other hand, the technological adoption of IPv6 is still a controversial issue and its adoption remains minimal (Che & Lewis, 2010; Limoncelli, 2011). Although IPv6 has been available for several years and offers many advantages, it has not yet become widely implemented. IPv6 is not directly compatible with IPv4 because of the technical differences of both standards. Elmore *et al*. (2008) predicts that it will take about 8 to 22 years or even more to achieve full adoption based on the current trends (Dell, 2010). Recently, OECD (2014) reported that according to various measurements, the transition to IPv6 is still in in its very early stage. The BGP analysis reports indicates that IPv6 represents only 3.8 % of the total global BGP prefix (www.potaroo.net, 2014).

Given the aforementioned facts, this research project aims to empirically investigate why organizations resist switching to IPv6 in the context of Indonesian organizations. While the majority of prior studies related to IPv6 were conducted in the context of developed countries (Dell, 2011; Gallaher & Rowe, 2006; Hovav *et al.*, 2011; Martey, 2014; Pickard, 2014), the issue of IPv6 resistance in developing economies has been relatively unexplored. Indonesia is classified as a developing country which currently is the fourth most populous country in the world. Although Che and Lewis (2010) point out that the Internet has spread rapidly in developing countries, the problem has not been comprehensively investigated from the perspective of the developing country.

1.2 Research Objectives

The IPv6 was standardized almost two decades ago and introduced as a de facto standard to replace the IPv4 (Shen. *et al.*, 2009). However, the adoption of IPv6 has been very limited (Colitti *et al.*, 2010; Mueller, 2010a). A few studies have been conducted related to IPv6 adoption, although the factors of organization adoption are still not well understood. Even though organizations have already had IPv6-capable equipment, many have not yet integrated IPv6 into their networks (Dell, 2011). The main aim of the current study is to investigate why organizations have not adopted the standard, since IPv6 has superior features and has accommodated future Internet growth. Hence, understanding the enablers of and barriers to IPv6 adoption becomes increasingly valuable (Dell, 2010) since it is a common belief (Grossetete *et al.*, 2008; Mueller, 2008) that the IPv4 addresses have run out, and organizations need to anticipate the IP problem (OECD, 2010). Moreover, delaying the adoption could introduce more problems to the Internet (Dell, 2010; Tassey *et al.*, 2009). Mueller (2008) argued that the impact of the address scarcity would be similar to the impact of the oil crisis in the 1970s. Naturally, where the Internet has become a critical and widely-used resource (Wellman & Haythornthwaite, 2008), this scarcity will significantly affect many aspects of modern human life (OECD, 2014).

Therefore, it is critical to better understand those determinants which can assist the Internet communities, policy makers or change agents to recognise the barriers to IPv6 technology adoption and use. The objectives of the current study are:

- OB1. To investigate Indonesia's IPv6 readiness;
- OB2. To explore, review and synthesise relevant literature related to the adoption of and resistance to technology;
- OB3. To identify factors that might influence IPv6 resistance among organizations in Indonesia;
- OB4. To develop a conceptual model based on findings from objective 3
- OB5. To validate the model in an effort to generalize the findings.

1.3 Research Questions

IPv6 has been introduced as a de facto successor of IPv4 which currently dominates the Internet. Although, IPv6 provides better features than IPv4 (Wu *et al.*, 2013) and can also accommodate today's Internet requirements and many aspects of the future Internet, (Cannon, 2010; Dul, 2011; Hagen, 2006), it has not been widely adopted.. Therefore, in relation to the research objectives, the research questions addressed by the current study are as follows:

R1. What is the current status of IPv6 readiness among organizations in Indonesia?
R2. Why do organizations resist changing to IPv6?
R3. What factors lead organizations to resist changing to IPv6?
R4. What is the relationship between these factors?
R5. To what extent do these factors contribute to making organization resistant to change?

It is expected that, in answering these questions, we will be able to significantly enhance fundamental knowledge and provide valuable insight into the underlying reasons why Internet users are adhering to the status quo. Such understanding and insights may enable competent parties to deal with the problem.

1.4 Significance and Contribution of the Study

The contributions of this study can be viewed from two perspectives: the practical and the theoretical.

1.4.1 Practical contribution

In the practical sense, this study will enhance the knowledge of the Internet community by providing empirical evidence about the readiness of organizations in Indonesia to adopt IPv6. Also, this study can assist competent parties to plan future strategies, particularly in Indonesia, in order to encourage more people to use it. Additionally, the investigation of the factors that are mainly responsible for organizations' resistance to IPv6 can provide an insight into the planning of better strategies for a development, deployment and promotional campaign.

1.4.2 Theoretical Contribution

The contributions of this study to theory can be seen from various perspectives. First, while resistance to and adoption of technology factors are not a mirror (Gatignon & Robertson, 1989), two body of literature are integrated into a single study in order to extend the current understanding of why organizations maintain the status quo regarding the IP addressing standard. Bhattacherjee and Hikmet (2007) argue that combining both adoption and resistance factors can yield important insights into the phenomenon. Second, it identifies the key factors that cause an organization to resist changing to a particular technology, in this case IPv6. Third, it proposes a theoretical IPv6 Resistance Model. Finally, it provides empirical support for the proposed model.

1.5 Research Methodology

In order to achieve the research objectives, this research project consists of a literature review, a preliminary study and the main study. Firstly, a literature review is conducted to obtain current knowledge about the Internet and IP addressing issue. In addition, the effort continues to review the prior studies on the adoption of and resistance to new technology in order to increase the researcher's understanding of the technological resistance phenomenon. The review also serves to identify the existing gaps in the research on resistance to IPv6 among Internet communities. Secondly, a preliminary survey is conducted to obtain the readiness status of Indonesian organizations to IPv6 and also increase confidence in extrapolating the findings from previous IPv6 studies. Finally, the main study deploys an exploratory sequential mixed-method design which consists of two phases. The first phase involves a qualitative study in order to fully understand why organizations prefer to maintain the status quo and resist switching their IP technology to IPv6. The findings from the first phase provide the foundation for developing the research model to be tested and validated in the second phase which is the quantitative study.

1.6 Structure of the Thesis

The remainder of the thesis is organized into nine chapters as follows.

Chapter 2, **Review of Internet, Internet Protocol and IPv6**, provides an overview of the development of the Internet, the problem with IP addresses and the current effort to deal with shortcomings. Furthermore, the organizations/bodies which have contributed to ensure the smooth interconnection of the Internet will be discussed. This chapter also reviews the recent development of the Internet in Indonesia.

Chapter 3, **Review of Resistance and Adoption Theories**, reviews the relevant literatures and theoretical backgrounds which support the current study. The main objective of the review is to identify the relevant concepts related to understanding resistance to change to an alternative technology. This chapter also identifies the theoretical concept related to the technological resistance phenomenon. The initial section presents an overview of relevant studies on the issue of adoption. This is followed by a discussion of resistance theories. This chapter concludes with an examination of the existing studies on IPv6 adoption and resistance.

Chapter 4, **Research Methodology**, describes the research methodology used in this study. Firstly, the chapter discusses several research paradigms and the various research approaches available in the social research domain. This is followed by a discussion and justification of the researcher's choice of research approach, research design, sample design, data collection technique and analysis procedure. Ethical considerations pertaining to the collection of data are also presented.

Chapter 5, **Readiness Survey Report,** is dedicated to describing and reporting the readiness survey as a preliminary study in order to become familiar with the IPv6 readiness status of organizations in Indonesia. This includes a discussion of research methodology and research findings. This chapter also briefly discusses the relevance of the findings to the main study.

Chapter 6, **Qualitative phase**, describes the phase one mixed-method approach including the data collection process and data analysis. The analysis process follows domain analysis including identifying the domains, taxonomy analysis, specifying the components of domains and identifying the relationship among domains.

Chapter 7, **Quantitative phase**, reports the phase two mixed-method. It begins by developing a conceptual model based on the relationship of domains from the previous phase, and hypotheses development. This is followed by instrument development, sample design, data preparation and data analysis.

Chapter 8, **Research findings and discussion**, discusses the key findings of the thesis. Also, it summarizes the results of the entire research and the contributions of the research, along with research limitations and suggestion for future research directions.

Chapter 2. Review of the Internet and Internet Protocol

2.1 Introduction

This chapter aims to provide a theoretical foundation for the current study regarding the Internet and IP addressing issue. The first section of this chapter presents an overview of the Internet, including its historical development and several organizations which contributed to its development. This section also presents a discussion of political and technical challenges and the debate related to who should govern the Internet. The Internet has been deployed all around the world and therefore it has become of international interest. This section will conclude with a discussion of the need for a new layer of the Internet in anticipation of current and future developments of the Internet. The second section of the literature review explores and synthesises the relevant literature on IP addressing technology. IP is the most important protocol in the Internet layer (Tanenbaum & Wetherall, 2011) and is effectively the only permit enabling connection to the Internet (Dell, 2010). IPv4 has served Internet users for many years and recently has shown its limitation when an entire addresses space has been allocated (Hovav *et al.*, 2011). After endless discussion, debate and consideration (DeNardis, 2009), IPv6 was accepted as the next generation protocol, designed to replace IPv4. Both of the protocols will be discussed in this section including the issues related to them. The chapter will be summarised in the last section.

2.2 The Internet

The Internet is described as a global set of interconnected networks that support communication among devices all over the world (Bradner, 1996). The Internet is a massive independent network connecting millions of devices globally. It is reported that the Internet has penetrated to about 42% world population (www.InternetWorldStats.com, 2015). It appears in many aspect of human life (Urry, 2007) and has become the most phenomenal technology ever introduced (Cleveland & Cleveland, 2013; Leiner *et al.*, 2009b). The Internet has dramatically changed people's lives in the last two decades (Wellman & Haythornthwaite, 2008). Initially, the Internet was used only for simple purposes such as mail or ftp (file transfer protocol) but now it has facilitated a wide range of services (DeNardis, 2009). Only twenty-two countries were connected to the Internet in the early of 1990s; by the late 1990s, this had grown enormously to more than 200 countries. The first part of this section presents the historical background of the Internet and its development. Historically, the United States (U.S.) contributed significantly to the development of the Internet and currently the U.S. are trying to retain their domination over the Internet (Mueller & Kuerbis, 2014). However, since the Internet has become an international interest, it is expected to become less dependent on the U.S. (DeNardis, 2009). The second part highlights several important organizations and their roles in determining the Internet standard. It is intended to provide an understanding of how these organizations contribute to determining the policies and standards for the Internet. This is followed by a review of the political and technical challenges to its governance. Finally, we discuss the need for a new Internet layer protocol.

2.2.1 Historical development of the Internet

The Internet has grown to become a globally distributed network (James, 2010) which consists of many voluntarily interconnected networks (Mueller, 2010b). Initially, the Internet was developed by the Advanced Research Project Agency (ARPA) to provide a reliable communication technology. It is important to note that the ARPA conducted the research to implement a network based on packet-switching technology (Naughton, 2000) for military purposes. Since the ARPA did not have enough resources to develop the ideas, they provided grants and invited many other competent parties (mainly from academia) to become involved in the project.

In 1966, Robert Taylor put forward the idea of a network-testing experiment by connecting a few nodes which later become known as the ARPANET (Tanenbaum & Wetherall, 2011). By the end of 1969, the network had connected four nodes at University of California Los Angeles (UCLA), SRI (Stanford Research Institute), UCSB (University of California at Santa Barbara) and the University of Utah. With later developments, several other institutions joined the community network. At this time, the ARPANET was relatively closed, homogeneous, and controlled by a small elite group (Naughton, 2000).

Hence, the network spanned only a limited community and this led to the idea of expanding the network. In the early developmental stages, it relied on the NCP (Network Control Protocol) as the primary protocol which combined addressing and transport into a single protocol (Handley, 2006). The NCP was developed to accommodate host-to-host communication (Leiner *et al.*, 2009b). However, one of the drawbacks of the protocol was that it could not handle end-to-end host error control (Naughton, 2000), which was an important aspect to prevent any packet loss during transmission and increase network reliability. The experiment showed that the ARPANET protocol was not suitable across different networks (Tanenbaum & Wetherall, 2011) and to connect various networks (Naughton, 2000).

This led to the introduction of the TCP/IP model and protocol, developed by Kahn and Cerf, which suited the open-architecture network environment (Naughton, 2000). Basically, the TCP/IP model- focused on end-to-end reliability and consisted of two protocols. Firstly, the Transport Control Protocol (TCP) was responsible for providing a reliable connection-oriented protocol, such as flow control and recovery of lost packets. Secondly, the Internet Protocol (IP) was responsible for addressing and forwarding individual packets to any destination within any network. Another important protocol in the TCP/IP suite is the Users Datagram Protocol (UDP) as a simple connection-less means of transmission. Naughton (2000) stated that it took six months to ensure the protocol's readiness which is currently recognized as IPv4.

Almost six years later, after intensive development and experimentation involving many parties, TCP/IP officially replaced the NCP on January 1, 1983 as a "flag-day" transition (James, 2010; Leiner *et al.*, 2009b). The full transition occurred after being "*carefully planned within the community over several years before it took place…*" (Leiner *et al.*, 2009a, p. 7). It is important to note that the Internet then was not as big as today's Internet – it comprised about four hundred nodes (Handley, 2006) and the transition still needed several years to be completed. Also, since the development was funded by the ARPA, they had authority to do so.

In later developments, although the Internet was initially funded by the government for military purposes, it changed in the early 1990s (James, 2010). The former closed network gradually shifted to become an open network (Wellman & Haythornthwaite, 2008) when it started to be used not only by research, educational and governmental users, but also business and personal users. Furthermore, some businesses began to operate their own network, thereby allowing more people to connect to the network.

However, while the Internet gained enormous popularity beyond the prediction of the founder of the Internet itself[3], it suffers from the limited number of addresses available and the features necessary to accommodate the development of technology (see Section 2.4 for more details). Therefore, IPv6 was introduced as a new standard to replace the IPv4. IPv6 promises several enhanced features which are believed to offer a comprehensive solution for the Internet today and in future. On the other hand, the transition was not as smooth as expected. The transition began almost two decades ago, but to date, the adoption of IPv6 is still very rare. Regardless of the method used to measure the uptake of IPv6, OECD (2014) reported that the implementation of IPv6 is still in its early phase. While the initial development of the Internet was funded and regulated by the ARPA, which are the organizations nowadays that contribute significantly to the development of technical standards, and to determining appropriate policy and controlling the internet resources. The next section discusses these organizations and how they contribute to the development of the Internet.

2.2.2 How the Internet and Internet Protocol govern

Why should the transition from IPv4 to IPv6 take such a long time? Even the complete transition tends to be unclear. As previously discussed, the transition of the NCP to IPv4 should have been accomplished smoothly because of the enactment of the flag-day. This raises a question: is there any institution/body able to force the Internet's users to move to IPv6? Furthermore, who is governing the Internet?

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[3] Vint Cerf blamed himself for deciding to use the 32bit. In his opinion, the protocol was intended for research purposes only. However, the research did not end until recently, retrieved on 17/07/2014 from http://www.networkworld.com/article/2227543/software/why-ipv6--vint-cerf-keeps-blaming-himself.html

The Internet was not born by accident, but through a series of processes as described previously. In the early days of the Internet, the U.S. government via the ARPA took the primary control of the Internet, since they funded the project (Braman, 2011). Consequently, the ARPA were fully authorised to switch off the NCP and urge users to move to the TCP/IP model at the time (Leiner *et al.*, 2009b). However, the Internet has been growing not only in terms of network infrastructure; the interests of most nations now depend on it.

The Internet eventually became a deregulated (Huston, 2013) and self-regulated industry (DeNardis, 2009). As noted by Shinder (2001), no-one owns the current Internet. It has changed since TCP/IP was introduced, giving many parties the opportunity to connect their network to a global network. Millions of different private networks are connected to today's Internet. Each of them can develop its own policies and determine the technology to be used in response to technological forces and practical needs (Domanski, 2013). As Huston (2013) stated, the Internet operates without a central coordinating body. It has become a self-governing or self-regulated industry which means that rules which govern behaviour in the industry are developed, administered and enforced by the people, entities within its industry (Mueller, 2002). Hence, there is no single institution that can force users of the Internet to move from one standard to another standard (Huston, 2013). Handley (2006) maintains that "*changing a large network is very difficult"* (p. 199).

However, to ensure smooth interoperability, several organizations/bodies are involved in developing technical standardization, determining policy, and maintaining the development of IP-based networks and Internet resources. Regarding Internet protocol, DeNardis (2009) discusses the Internet governance from both technical and political perspectives. The current study starts by describing ICANN as the regulatory body for Internet Addressing and Domain Name System along with other related institutions that manage and distribute the addressing resource. Also, according to Domanski (2013), there are three primary working groups which play an important role in governing the Internet standard or protocol: the ISOC (Internet Society), the IETF (Internet Engineering Task Force) and the W3C (World Wide Web Consortium). These organizations will be briefly discussed in order to better understand the importance of their role in making decisions about the Internet and the Internet Protocol. Several other institutions which play an important part in the protocol standard will be discussed. Furthermore, the discussion of governments' role will be presented to understand their contribution to supporting the implementation of IPv6.

2.2.2.1 Internet Corporation for Assigned Names and Numbers (ICANN) & (Internet Assigned Numbers Authority (IANA)

ICANN has a significant role in ensuring that the Internet runs smoothly and is accessible to all. It was established under a U.S. Government contract to coordinate the distribution of addresses as unique identifiers in the Internet and to define the policy regarding how the name and number of the Internet should be determined. With the Internet being adopted globally, the status of ICANN as a private corporation under the U.S. Government's contract drew criticism from other governments (Mueller, 2002). The position of the U.S. Government as the controller of the Internet gradually sparked controversy from those demanding that the control should be more internationally distributed (DeNardis, 2009). Although ICANN comprises a wide range of entities, organizations and vendors, it is not the representative of the entire body of Internet users in controlling the Internet governance function such as the assignment of IP addresses and the development of core Internet protocols. Therefore, it should be governed by an international organization (Mueller & Kuerbis, 2014). One might question the reliability of ICANN as a contractor of the U.S. government to make a fair decision which benefits the Internet community, and not only benefits for, for example, the U.S. government or American companies[4] (discussed in more detail in 2.2.3)

ICANN was founded in 1998 and officially established as a central body to manage Internet protocol number and DNS root (Bygrave & Bing, 2009) to replace IANA (Internet Assigned Number Authority) which was initially in charge of assigning IP addresses to Internet users. Instead of replacing it, ICANN kept IANA as its

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[4] The hot discussion and recent information related to how the Internet has to be governed is available online on www.internetgovernance.org. Since the Internet is a public network, Milton Mueller as the author provokes 'high politic' debates over the global balance of power to govern the Internet.

department for managing the allocation of global unique names and numbers to Internet users (Kozierok, 2005). IANA was founded by the U.S. government in 1988 and was administered by Jon Postel who made a big contribution to the early development of the Internet (Mueller, 1999). Kozierok (2005) argues that this often leads to confusion about both organizations in terms of who is responsible for IP addresses and parameters.

IANA is responsible for three activities: managing the DNS root, coordination of the global pool of IP and AS numbers, and delegating the IP addresses to Regional Internet Registries (RIRs). RIRs become sub-agencies of IANA which are administratively responsible for distributing IP address and AS numbers to their customers, including Local Internet Registries (LIRs), Internet Service Providers (ISPs) or end-user organizations on their region. RIRs is described in RFC7020, replacing RFC2050, as the component of Internet Number Registry System. Huston *et al.* (2013) state that there are five RIRs which operate in five different regions, including:

- American Registry for Internet Number (ARIN) for America, Canada
- Reseaux IP Europeans – Network Coordination Centre (RIPE – NCC), For Europe, Middle East and Central Asia Asia Pacific Network Information Centre (APNIC) for Asia Pacific Countries Latin American and Caribbean Internet Addresses Registry (LACNIC) for Latin America
- Africa Network Information Centre (AfriNIC) for Africa

Together, the RIRs form the NRO (Number Resource Organisation), the primary goals of which are to: (1) protect the unallocated IP number resource pool; (2) promote and protect the bottom-up development process of the Internet; (3) act as the focal point for the Internet community input into the RIR system.

2.2.2.2 International Communication Union (ITU)

The ITU, established in 1865, is part of the United Nations and is a specialized agency which is formally responsible for information and communication technologies (ICTs) issues and standards. As the oldest intergovernmental organisation responsible for telecommunication services, this body currently has 193 members of states and also over 700 members from private-sector entities and academic institutions[5]. This organization has become a bridging body among nations in terms of coordinating the shared use of the radio spectrum, promoting international cooperation, and assisting the development and coordination of worldwide telecommunication technical standards. Another important role of the ITU is to assist developing countries to obtain access to information and to help narrow the digital divide. Because its role is quite similar to that of the ICANN and ISOC (discussed on the next section), a conflict of interest has emerged in terms of determining who should regulate the Internet. This will be discussed in more detail in 2.2.3.

2.2.2.3 Internet Society (ISOC)

The ISOC, established in 1992, is a high level governing body and has become the top organization involved with providing and promoting policy, technology and standards of the Internet. The ISOC is a large, open, non-profit organisation which comprises more than 65,000 members and supporters[6]. Since the decline in U.S. government funding for Internet standard activities, ISOC provides source funding for the development of an Internet standard (DeNardis, 2009). The organisation actively supports the Internet as an open and decentralized platform for the benefit of everyone. It collaborates with other entities – government and national or international organizations in activities such as research, education, public policy development and standardization (Kozierok, 2005). Furthermore, the ISOC has become the organizational home for the management and development of Internet standards through task forces such as the IAB (Internet Architecture Board), IETF (Internet Engineering Task Force) and other task forces which are responsible for developing and providing standards for the Internet.

The IAB acts as the ISOC's advisor in matters relating to technical, architectural and policy matters which may affect the Internet and its enabling technology. It collaborates with the IETF and the IRTF (Internet Research Task Force) (Cerf, 1995) to develop and determine the standards used in the Internet. The IAB is described in

[5] ITU Membership, accessed on 03/03/2015 from http://www.itu.int/en/membership/

[6] ISOC official website retrieved on 20/07/2014 from <http://www.internetsociety.org/who-we-are>

the RFC 2850 and has significant responsibility for technical developments or engineering supervision of Internet standards. The IAB serves as a technical architecture's assessor and final editor of Internet standards. This organization has the authority to manage the RFC (Request for Comments) publication process. In addition, the IAB performs as an appeal board for complaints regarding inappropriate use of a standard as well as resolving any disputes which cannot be handled by the IETF (DeNardis, 2009).

The IETF is a working group which is responsible for developing Internet architecture standards and ensuring the smooth operation of the Internet. Unlike the ISOC, there is no formal membership or membership requirement. Any people having relevant competence can voluntarily participate in the organization's activities. Its main mission is to make the Internet work better by providing relevant technical documentation that can be used as guidelines for the design, use and management of the Internet.[7]

The IETF develops communication standards to ensure the interoperability between applications and devices connected to the Internet. The Internet Protocol is an open standard developed and introduced by the IETF. The standard is established by a rough consensus and running code which means that the decisions are determined based on the engineering judgement of the participants.[8] Rough consensus was proven to be effective to determine Internet standards while formal standard organizations failed to precisely formalize these (Domanski, 2013). The IESG (Internet Engineering Steering Group) is responsible for the day-to-day management of the IETF and provides the final technical review activities and makes decisions regarding the status of the Internet standard process.

2.2.2.4 World Wide Web Consortium (W3C)

While the aforementioned organizations govern the Internet standards for the hardware at the infrastructure level, the primary activity of the W3C is to develop standards and

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[7] For further discussion, this information can be found on the IETF official website on http://www.ietf.org

[8] IETF official website

guidelines for the Web, more for software rather than hardware. The Web contains a remarkable information space of interrelated resources, growing across languages, cultures and media.[9] To enable communication between people, a standard is needed that allows developers to build an application that is accessible from any platform and devices. The W3C actively provides an open web platform for application development, so all the standards are available to the public at no cost.

2.2.2.5 Government

Although many argue that the Internet has to be free from government control, every country still has a powerful control over the Internet usage. Domanski (2013) emphasizes the important role of government concerning the Internet, especially at the physical layer. Also, since the Internet is important for political purposes, some governments play a significant role in determining policy, especially in restricting or allowing certain traffic that can be accessed by their citizens. The growth of Internet-based technologies, such as electronic commerce and social media, also requires governments to regulate it (Perset, 2007). Different governments might have differing views about the benefits of the Internet (DeNardis, 2009). The growth of the Internet not only affects businesses; it has become increasingly important in the social lives of citizens. Clearly, it is crucial for any country to protect its national interest since the Internet renders the boundaries of a country less meaningful.[10] Previous IT implementation studies emphasize the importance of government in supporting the implementation of a particular technology as highlighted in Chapter 3.

2.2.3 Political and technical challenge related to the Internet Governance

The Internet has been adopted globally, raising international concerns about how the Internet should be governed for the benefit of all nations. As the result, Internet

[9] Architecture of the World Wide Web, Volume One (2004) retrieved on 21/07/2014 from http://www.w3.org/TR/webarch/

[10] For further information, there are many studies on the role of government in the Internet. For example, the Dutch government used analysis Mason's framework to organize government roles on determining the Internet governances.[11] Minutes of IAB Meeting on Teleconference 26th April 1990, accessed on 22nd March 2015 from http://www.iab.org/documents/minutes/minutes-1990/iab-minutes-1990-04-26/

governance has become a highly complex (DeNardis, 2009) and controversial issue (Mueller, 2010b) among Internet communities. The controversy began when many countries questioned the U.S.-centric role in controlling the Internet via ICANN. As described at section 2.2.2.1, ICANN is the U.S. government's contractor which is responsible for managing the Internet domain and IP addresses. Therefore, the ICANN process cannot avoid either government regulation or government control (Mueller, 1999).

DeNardis (2009) reports the heightened concern evident at the IAB meeting[11] in 1990 that in future the Internet should be governed by a more international, non-military and non-profit organisation. MacLean (2004) reports that while some governments, mainly the U.S. and the European Union, support the role of ICANN, other countries, led by China and members of G20, want to place all Internet management systems under an intergovernmental organization of the United Nations (Zhao, 2004). In this instance, ICANN's supporters argued that Internet governance tends to be a technical issue and therefore it would be better handled by a private institution (Kleinw, 2004). On the other hand, ITU supporters believe that the Internet is about political issues and closely related to the sovereignty of the government of UN members. The controversy over control of Internet addresses continued whereby the IETF and IAB recommended that the IANA control the addresses on one side via ICANN, and the United Nations recommended that an international body replace the U.S. agency on the other hand. Since there was such great controversy over who should control the Internet, the decision of the WSIS (World Summit in Information Society) meeting was to retain the status quo (Zhao, 2004). This means that the IETF and IAB still control internet standards and policies. The ICANN via the IANA is still responsible for the allocation of addresses. However, DeNardis (2009) maintains that the international debate regarding Internet governance remains open and unresolved.

Internet governance could influence a wide range of social, economic and political activities. The role of ICANN continues to become a dilemma and is still the subject of lengthy debate among many nations which demand an international regulation to

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[11] Minutes of IAB Meeting on Teleconference 26th April 1990, accessed on 22nd March 2015 from http://www.iab.org/documents/minutes/minutes-1990/iab-minutes-1990-04-26/

replace the U.S. centric role. Mueller (1999) described that theoretically ICANN operates under principle of self-regulation and self-governance. However, since ICANN is a U.S. contractor (explained previously in Section 2.2.2.1), Mueller and Kuerbis (2014, p. 3) argue that

> *"The IANA functions contract does far more than empower the U.S. Commerce Department to authorize changes to the root zone. It regulates very detailed aspects of ICANN's behavior and requires ICANN to be incorporated in, maintain a physical address in, and perform the IANA functions in the U.S. This makes IANA subject to U.S. law and provides America with greater political influence over ICANN. Because the contract must be renewed every three years, the U.S. can modify the contract to shape ICANN's behavior, or threaten to award it to someone else. This tie to one government undermines the global and multi-stakeholder nature of Internet governance."*

Recently, at the 2014 ITU conference in Busan - Republic of Korea, the discussion on Internet issues become heated.[12] For example, Russia recommended that the ITU begin allocating IP addresses and that this activity not be performed by other non-intergovernmental organizations; the Arab States and Brazil proposed to give a mandate to the ITU to develop legal and policy to prevent illegal online surveillance; and India suggested increasing the government's role in controlling the Internet. However, the U.S. opposed many proposals and conducted off-the-table negotiations. Subsequently, some states withdrew their support for proposals about online privacy, cybersecurity and other Internet proposals.

There are many interesting discussions about Internet governance which have caused international conflict among internet communities. This topic is beyond the scope of this study - for those who are interested in obtaining more details, see DeNardis (2009), Jørgensen (2006), Deibert *et al.* (2010) or Internet Governance Project (IGP) by visiting http://www.internetgovernance.org. The next section will highlight the IP address standard which prevails in the current Internet.

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[12] The Guardian (2014), 'How will internet governance change after the ITU conference?', accessed on 25 April 2015 from http://www.theguardian.com/technology/2014/nov/07/how-will-internet-governance-change-after-the-itu-conference

2.3 Internet Protocol (IP) version 4

Like humans, computers or devices need to use the same language to 'talk' with others. Therefore, a protocol which defines the rules and procedures for communicating (Tomsho *et al.*, 2003) is used as the medium to allow communication between various devices or applications. The most important protocol in the Internet layer is the IP address to allow the Internet to operate globally. For smooth communication, an IP address has two important functions (Pan *et al.*, 2011), an addressing function and a routing function. An IP address serves as a unique identifier of every device connected to the Internet to be recognized in the network. In other words, no device can connect to the Internet without an IP address. Another function is to allow network routers to determine the best route of packet data travelling from its source to its destination.

IPv4 was designed by classifying each 32-bit address into a two-level address hierarchy – network portion and host portion, hereinafter referred to as a prefix (Tanenbaum & Wetherall, 2011). Figure 2.1 shows the header structure of IPv4.

<table>
<tr><td>Version
4 bits</td><td>IHL
4 bits</td><td>Service Types
8 bits</td><td colspan="2">Total Length
16 Bits</td></tr>
<tr><td colspan="3">Identificatioin
16 bits</td><td>Flags
3 bits</td><td>Fragmentation Offset
13 bits</td></tr>
<tr><td colspan="2">Time to live
8 bits</td><td>Protocol
8 bits</td><td colspan="2">Header Checksum
16 bits</td></tr>
<tr><td colspan="5">Source address
32 bits</td></tr>
<tr><td colspan="5">Destination address
32 bits</td></tr>
<tr><td colspan="3">Option</td><td colspan="2">Padding</td></tr>
</table>

Figure 2.1. IPv4 Header Structure

The first eight bits represent the network portion and 24-bit relates to the host address. IPv4 address uses a unique 32-bit integer value as the network address. When IPv4 was initially introduced, it was divided into five classes which were identified by the first octet of the address (see Table 2.1) but only three classes (A, B, C) are available to the public.

Table 2.1. IPv4 classful

Class	Bits	Start	End	Total host each network
A	0	0.0.0.0	127.255.255.255	2^{24} = 16,777,216
B	10	127.0.0.0	191.255.255.255	2^{16}=65,536
C	110	192.0.0.0	223.255.255.255	2^{8} = 256
D	1110	224.0.0.0	239.255.255.255	Not defined
E	1111	240.0.0.0	255.255.255.255	Not defined

Theoretically, a 32-bit number represents approximately 4.3 billion unique addresses. However, in the actual implementation, the numbers decrease significantly due to several reasons. Firstly, some addresses are not available to the public since they are reserved only for private addresses and loopback. A private address can be used by anyone without the need to obtain permission from the Internet Registry. Secondly, ICANN allocates several addresses for particular purposes, such as for testing, multicast (class D) and future use. The combination of the two previous reasons contributes to nearly 600 million addresses being unavailable to the public (Cotton & Vegoda, 2010) as presented in Table 2.2 below.

Table 2.2. Special Use IPv4 address

Address Block	Present Use	Reference
0.0.0.0/8	This Network	RFC 1122
10.0.0.0/8	Private Networks	RFC 1918
127.0.0.0/8	Loopback	RFC 1122
169.254.0.0/16	Link Local	RFC 3927
172.16.0.0/12	Private Networks	RFC 1918
192.0.0.0/24	IETF Protocol Assignments	RFC 5736
192.0.2.0/24	TEST-NET-1	RFC 5737
192.88.99.0/24	6to4 Relay Any cast	RFC 3068
192.168.0.0/16	Private Networks	RFC 1918
198.18.0.0/15	Network Interconnect Device Benchmark Testing	RFC 2544
198.51.100.0/24	TEST-NET-2	RFC 5737
203.0.113.0/24	TEST-NET-3	RFC 5737
224.0.0.0/4	Multicast	RFC 3171
240.0.0.0/4	Reserved for Future use	RFC 1112
255.255.255.255/32	Limited Broadcast	RFC 919 & RFC 922

Source: Cotton and Vegoda (2010) in RFC 5735

Finally, many addresses allocated to the user are not actually used due to the inefficiency of the classful concept on IPv4. Some organizations are allocated more or less addresses than what they actually need. This led to the introduction of the classless concept which allows a single block of address can be aggregated into smaller multiple blocks (described more detail on Section 2.5.1.2). Furthermore, it is important to note that IANA has distributed 34 large address blocks, A class addresses (about 570 million addresses) were allocated to several companies or organizations (such as IBM, GE, Xerox, AT&T, etc.) during the early of development of the standard in the early 1990s. This means that more than a quarter of the total number of IPv4 addresses are actually not available for allocation.

As discussed in section 2.2.1, IPv4 formally replaced NCP in 1983 and became the common IP address used for the current Internet. It works extremely well to support the exponential of the Internet growth (Tanenbaum & Wetherall, 2011). However, the massive development of Information Technology has revealed the true limitations of IPv4 (Hovav *et al.*, 2004), with addressing space becoming the main problem. Moreover, several authors (Clark *et al.*, 1991; Wang & Crowcroft, 1992) issued warnings about IPv4 address spaces in the very early stage of the Internet when the network was not as big as it is today. Other authors (Bohlin & Lindmark, 2002; Colitti *et al.*, 2010) emphasized that the high demand for Internet connection has driven to the migration to a much larger address space and this migration has become a high priority to overcome a serious Internet problem in the future (Mueller, 2006). The principal limitation of the Internet is the size of the 32-bit address space used by IPv4 which will not be able to accommodate the future development of the Internet. During 2008, the numbers of devices connected to the Internet surpassed the number of people on Earth (Evans, 2011).

DeNardis (2009) argue that the Internet has been approaching a critical point. Several authors have also shared their concern over the IPv4 address shortage (Bohlin & Lindmark, 2002; Dell, 2010; DeNardis, 2009; Mueller, 2008) along with other limitations to accommodate today's Internet. Therefore, since IPv4 is believed to be inadequate to meet the performance and functional requirements of today's and the future's Internet, the Internet needs a new IP standard. The next section explains in more detail the problem with IPv4 and the features expected of the next generation protocol.

2.4 The Need for a New Internet Layer Protocol

The significant growth of the Internet occurred in the 1990s with the emergence of World Wide Web (WWW) (Tanenbaum & Wetherall, 2011) and businesses began to take advantage of the network. Currently, the Internet plays a role in almost every aspect of human life and it has changed the world.[13] The Internet has made people comfortable with obtaining or sharing information without the constraints of geographical boundaries (Kozierok, 2005). Hence, IPv4 has had to accommodate more connections to the Internet. The protocol has shown its age and needs a new promising protocol to replace it (Dul, 2011).

An IP address serves as a foundation to connect to the Internet (Cannon, 2010). It is a unique identity that allows devices to communicate over the Internet (Dell, 2011). The initial design of IPv4, defined in RFC791, did not anticipate the explosion of Internet (Gallaher & Rowe, 2006). The 32-bit space which provided 4.3 billion unique addresses was not able to accommodate the ubiquitous adoption of the Internet (OECD, 2014). Apart from resolving the problem of space, the fundamental IP-related issues, such as security, quality of service, mobility, multicasting and network management, have to be addressed comprehensively.

Hence, in the early 1990s, IETF began to develop a new protocol to accommodate the demand for modern features, to resolve the current IP problems, and to accommodate the future Internet. In this case, numerous authors (DeNardis, 2009; Hagen, 2006; Tanenbaum & Wetherall, 2011) emphasize some salient features of the future Internet protocol.

Firstly, the future Internet protocol has to accommodate a huge address space which will be enough despite inefficient distribution (Tanenbaum & Wetherall, 2011). The address shortages (Bohlin & Lindmark, 2002) has become the most important and central issue facing the IPv4. On 3 February 2011, the announcement regarding the allocation of the last remaining IP blocks to five RIRs clearly revealed the real condition of the address limitation. The number of Internet users reached 3,079 million by the end of 2014 or 42.4% of the world total population. At the same time, the growth of the Internet tends to continue exponentially (Figure 2.2). This is because of the many new technologies (e.g. mobile, flexible and always-on communication systems) requiring the Internet connection to enable their system (Hovav & Schuff, 2005;

[13] ICANN (2014), ‘Global Internet Report 2014’ from www.icann.org

Tassey *et al.*, 2009), and the fast growth of the Internet in developing countries (Che & Lewis, 2010).

Currently, the development of technology tends to adopt IP-based systems to allow them to connect to the Internet. For example, the Internet of Things (IoT) initiative[14] is designed to allow more physical objects or things to connect to the Internet. These kinds of initiatives aim to improve the quality of human live by utilizing the existing Internet infrastructure.

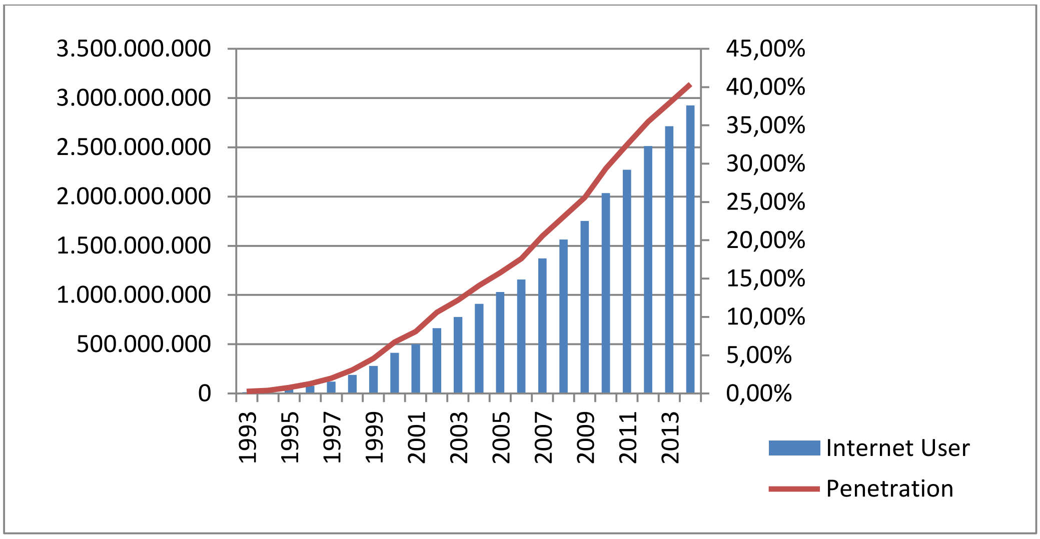

Figure 2.2. Internet Growth and Penetration
(source : www.Internetlivestats.com)

Nowadays, there are more and more IP-based technology in the market with the added word 'smart' to indicate that the technology is an Internet-enabled device. For example, the new platform TV is not only available on ultrahigh-definition, but also has started to enable the connection of the Internet to the system, allowing movies to be rented and watched via the Internet. Many car companies have begun to introduce the Internet to their products, making the human as driver less important. Furthermore, the smartphones, tablets, game controllers and other devices contribute a great deal to the growth of the Internet. Evans (2011) reported that the number of devices which were connected to the Internet, were almost double that of the world population in

[14] Basically the Internet of Things (IoT) is a simple concept which links devices to the Internet, so they require an IP address. Also, this technology relies on a massive number of sensors for data collection.

2010. Following Moore's law, Evans therefore predicts that the connected devices will significantly increase to 25 billion by the end of 2015 and reach 50 billion by 2020. This number is far above 4.3 billion addresses which is the number that, in theory, can be accommodated by the 32-bit address space protocol. It is believed that IPv4, which currently dominates the Internet, will not be able to accommodate the growing demand for connection. Since an IP address is the only way to connect to the Internet (Dell, 2010), the address problem will significantly affect the future development of the Internet.

Secondly, the future protocol also has to address and accommodate the ongoing growth of Internet routing table. Routers within the Internet are connected together and exchange routing information using the Border Gateway Protocol (BGP). In order to send a packet, the routers determine the most efficient route to the destination. The router obtains the data from its neighbours and updates its table, called a routing table. In this case, the routing table plays a critical role since it supplies data to the router to predict the next hops and send the packet to its neighbour. Mueller (2010a) notes that the combination of the rapid changes in routing announcements and the rapid increase of routing tables potentially require more processing power. Hence, the size of the routing table will substantially influence the routers' speed, accuracy and cost when routing the packet from the source to the destination (Meyer et al., 2007). The Internet routing table has steadily grown, reaching 256k routes in 2008. These prompted Internet communities to anticipate the growth as a matter of urgency. The problem was that some types of routers could only handle not more than 512k entries by default or required some adjustment to increase the storage capacity (Mueller, 2010b). Most routers rely on a special high speed memory called TCAM (Ternary Content Addressable Memory) to store routing data. For this reason, ISPs might have to upgrade their routers to deal with the demand of high processing and larger storage capability (Huston, 2001). When routers do not have enough room to store the data, they may reboot themselves and fail to route some traffic (Tanenbaum & Wetherall, 2011). Recently, the growth of the BGP table indicates the size of the global routing table which has reached 512k entries as shown in Figure 2.3.

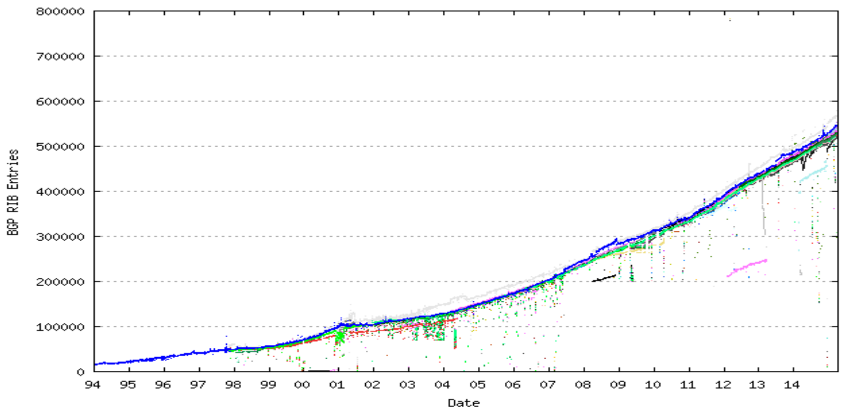

Figure 2.3. The Growth of the BGP Table - 1994 to Present
(source http://bgp.potaroo.net/)

Thirdly, another important feature of the next protocol is to the capability to support multicasting by allowing scopes to be specified (Tanenbaum & Wetherall, 2011). IPv4 currently supports some types of package delivery such as Unicast, Broadcast and Multicast. Unicast sends a one-to-one, which means it has a single sender and a single recipient. Broadcast supports the delivery of one-to-many communications in which one sender sends data to many receivers in the same network. The main difference is that multicast communications can be received prior to the recipient subscribing and becoming part of the network, while with the broadcast, the recipient receives the packet without registering in advance. In IPv4, a class D with the range of 224.0.0.0 to 239.255.255.255 is provided to accommodate the multicast features. However, these addresses are not routable on the Internet. In another words, there are not useable on the Internet. As described by Tanenbaum and Wetherall (2011), the next protocol has to provide another communication feature, namely Anycast. This feature basically combines the capabilities of unicast and multicast. Where unicast is a one-to-one communication and multicast sends data to every member of the group, Anycast allows the sending of data to any one member of the group. In another words, data is sent only to a selected member. With Anycast, network traffic will dramatically be reduced because the feature provides flexibility of communication to choose the nearest member of the group (Tanenbaum & Wetherall, 2011).

Fourthly, IPv4 was designed for a friendly and safe environment (Oppliger, 2001). Hence, security features are not inherent features of the protocol (Pan *et al.*, 2011).

However, in today's and the future's Internet, security is increasingly important (Tanenbaum & Wetherall, 2011) to ensure secure transmissions or transactions over the Internet. Therefore, the new protocol has to enhance and improve security features (DeNardis, 2009). IP security or IPsec provides security and authentication at the network layer (IP layer) by transmitting encrypted data. IPsec is a supplementary technology in IPv4, but it has to be an integral part of the next protocol (Rowe & Gallaher, 2005a).

Fifthly, the mobility feature is another important aspect of today's Internet (Tanenbaum & Wetherall, 2011) and this feature is not fully supported by IPv4 (Bhagwat *et al.*, 1996). The Internet has recently been experiencing a significant move from desktop computing to mobile computing. Mobile devices which are wirelessly connected to the Internet have begun to dominate the Internet (OECD, 2014). Mobility refers to the ability of a device to move from one server to another server while maintaining the original IP address and mac address throughout the process (Khasnabish *et al.*, 2012). In the process, it involves two network agents which are the home agent (HA) and the visited network (FA – foreign agent). Therefore, the convergence of heterogeneous networks (i.e. cellular mobile and data communication) becomes an inevitable and challenging issue (Pan *et al.*, 2011) since they have different standards and business models. For example, unlike 3G technology which is based on two parallel infrastructures consisting of circuit switched and packet switched networks, the 4G network, which is the recent standard applied in the communication industry, is completely an IP-based heterogeneous network (Hui & Yeung, 2003) meaning that it relies on the Internet as the core network (Khan *et al.*, 2009). 4G systems offer a wide range of services including data and multimedia services in addition to communication services. Consequently, the more this technology is adopted, the greater is the number of IP addresses needed. However, numerous authors have raised several concerns related to the issues surrounding the mobility feature, including: (1) the Internet is still dominated by the IPv4 and therefore it needs a mechanism to allow reliable communication between IPv4 and IPv6 and at the same time guarantee the quality of the connection services (Wu *et al.*, 2005); (2) IP management has to be resolved in order to maintain the connection as the device continues to change its location (Al-Surmi *et al.*, 2012) and; (3) charging and accounting for mobile services will be problematic since multiple providers are involved in providing the services (Chan *et al.*, 2000).

Finally, as the heart of the Internet, IP is designed to provide a single common language which can join a widely different range of network technologies to interconnect and communicate with one another (Cerf & Kahn, 1974). Therefore, IP has to be designed to contain only the minimum needed to allow the network to run properly (Leiner *et al.*, 1997). Therefore, the next protocol has to simplify the protocol header and pay more attention to the type of service. This feature allows for faster processes and better Quality of Services (QoS). QoS is an important feature of the future Internet. QoS is about prioritization of network traffic to guarantee the quality of network services, such as availability, bandwidth, latency and error rate. This feature plays an important role especially in business type applications and real-time multimedia applications which are very sensitive to delay, such as IP-TV, voice-over IP, online games and so on. IPv4, however, does not support it and relies on other protocols with uncertain results (Bouras et al., 2003).

In summary, clearly the Internet has significant issues and these have to be resolved. In the next section, several other technologies and strategies which are considered as short-term solutions are highlighted. This is followed by a description of IPv6 which is believed to be the long-term solution.

2.5 Technical Solutions and Supportive Policy to Deal with IP Issues

Since the main issue of the current IP is related to address space, there are two options for addressing the scarcity on the Internet (Levin & Schmidt, 2014; Nikkhah & Guérin, 2014). The first option is to keep using IPv4 and combine it with supplementary technology or supportive policy. Despite being only a short-term solution, this option could be a reasonable choice due to the compatibility and familiarity of the technology, as well as the possible cost involved (Levin & Schmidt, 2014). Meanwhile, the Internet communities have prepared a totally new technology as the second option. This technology is called IPv6 as the next generation protocol to replace the IPv4 and is believed to be the long-term solution to the problem of IP scarcity.

2.5.1 Keep IPv4 alive

IPv4 has served Internet communities for several years and has been proven to be a robust technology. However, the address limitation along with other shortcomings has forced Internet communities to develop a more accommodating protocol. In response to these shortcomings, several supplementary technologies have mitigated the technical problem of IPv4, namely Class Inter Domain Routing (CIDR), and Network Address Translation (NAT), as medium solutions before a more accommodative technology is widely deployed (Dell *et al.*, 2007; DeNardis, 2009). However, several authors emphasize that it is these supplementary technologies that have made people resistant to change (Bohlin & Lindmark, 2002; DeNardis, 2009; Wellman & Haythornthwaite, 2008). Another strategy is to introduce a market transfer policy to allow IPv4 holders to trade their unused or unutilized addresses.

2.5.1.1 Network Address Translation (NAT)

NAT was standardized in 1994 by RFC1631 and introduced to reduce the need to assign a public address to every interior end device. Currently, most of the Internet devices are located behind the NAT. Basically, a NAT unit operates as a gateway which allows multiple interior devices to share a single exterior public address to connect to the Internet. As a result, the need for public IP address significantly decreases because of the incremental deployment of a single public address. This method also provides some flexibility for local administrators to manage their internal network by assigning a private address instead of public address. Furthermore, it gives administrators more flexibility to apply a local network policy. Since the actual local IP address was not visible to the Internet, some people believe that NAT can serve as a security interior device within the local network (OECD, 2014). This is because of the connectivity model whereby NAT can hide private addresses within the internal network from the outside world as well as prevent an inbound connection initiated by external devices. For ISPs, NAT is a very common mechanism for connecting their customers and to save connection cost (Handley, 2006). As OECD (2014) illustrated that ISPs provide single public IPv4 address within user's equipment and this address is shared among multiple devices in the user's network

NAT has been very successful in slowing the IPv4 shortages (Hain, 2000), although it was never intended as a long-term solution (Chown *et al.*, 2004). Most developing countries, such as Indonesia and China, depend heavily on this model. However, Levin and Schmidt (2014) argue that the deployment of NAT has several limitations. NAT damages a key benefit of the Internet (OECD, 2014) as it prevents end-to-end communication (Hain, 2000) which is the basic idea of communication. Cannon (2010) emphasizes that it is difficult for NAT to facilitate such peer-to-peer communication since multiple users share a single public IP. Another drawback is that NAT inhibits the implementation network security at the IP level (Donley *et al.*, 2013) and even introduces more complexities to the network (Tassey *et al.*, 2009) for maintaining an extensive range of protocol and services (Dell, 2010). For example, the network administrator must ensure that NAT is compatible with the technology needed to run it.

Moreover, the availability of private address (RFC 1918) space could also trigger a dilemma for large ISPs or big organizations. For example, the rapid growth of the internal network of Comcast has revealed the limitation of the addresses (Hovav & Popoviciu, 2009). Comcast is a leading high speed cable provider that was serving 44% of the market of US customers in 2006. In addition, Comcast became the largest provider which received a /9 IPv4 addresses (about 8 M) from ARIN (Claffy, 2011). The basic cable services need a Cable Modem (CM) and two or three Set-Top Boxes (STBs), each of which requires 2 IP addresses. Hovav & Popoviciu described that for this purpose, Comcast required about 116.5 billion unique addresses to accommodate more than 23.3 million subscribers. By 2005, Comcast faced a real problem when the entire pool of private addresses had been fully allocated. After considering several options, Comcast became an early adopter of IPv6 (Hovav & Popoviciu, 2009).

Inspired by the success of NAT, Carrier Grade NAT (CGN) or multi layered-NAT or Large Scale NAT (LSN) was introduced to enable even more nodes to share a single public IP address. While conventional NAT is located at the border of the Internet user's network, with the CGN model (RFC 6598), NAT is moved to the Internet provider side. With this method, administrators at the Internet edge still have authorisation to manage their networks. IANA allocated 100.64.0.0/10 address block to specifically facilitate the implementation of CGN. However, this model also received much criticism. More specific to CGN, Donley *et al.* (2013) observed the CGN impacts on the network. They found that (1) CGN could drop some services; (2) CGN potentially decreases services performance; (3) CGN could produce several challenges including loss of geolocation information, lawful intercept and anti-spoofing; and (4), CGN has become attractive target for DoS attacks since a CGN device shares a single address. Clearly, CGN is not a comprehensive solution for future Internet issues, and delays in moving to a new protocol will generate even more problems for the Internet (Mueller, 2008).

2.5.1.2 Class Inter Domain Routing (CIDR)

CIDR was introduced as an answer to the classful issue of IPv4 (Meyer *et al.*, 2007). Although it is intended to make address allocation more efficient, it also produces another problem – routing table explosion. The routing table size significantly affects the cost of routing and decreases the router's performance (Mueller, 2010a).

The Internet authority proposed CIDR in 1993 by RFC1518 and RFC1519 as a supplementary technology to deal with the inefficient class concept of IPv4 (Handley, 2006). The dilemma of the classful concept left numerous unused addresses. For example, class A networks theoretically support up to 16 million hosts; it is extremely rare that users have such a high number of hosts. Conversely, 256 addresses of class C subnet were too small compared to what most organizations need. In this case, CIDR abandons the class concept and summarizes the network based on what the user needs. By doing so, the technology can improve the address utilization efficiency by minimising the number of wasted addresses.

However, while CIDR can minimize the inefficiency, more routing entries have to be created to deliver a packet from one source to the destination at the main router. The size of the routing table will significantly increase and impact on the routing process itself in addition to increasing the routing cost (Lehr *et al.*, 2008). While the Internet continues to increase exponentially and the IP addresses are completely exhausted in some regions, the current situation forces users to slice the available IPv4 block into even smaller segments. Additionally, CIDR also becomes a reason for the Internet user to just rent the public IP address from providers instead of directly obtaining it from the regulators.

2.5.1.3 Market transfer policy

Because of the limited supply of IPv4 addresses, Internet communities quickly realised that IPv4 address could potentially become a valuable thing (Edelman, 2009). This became an option to maximize the use of an existing IP address by allowing the IP address holder to trade it (Mueller, 2008). This option then inspired RIRs to approve the transfer market business models to allow IPv4 address holders to trade their addresses. Each of the RIRs provides guidelines for transfer policies (e.g. APNIC-127, ARIN Version 2015-1, LACNIC Policy Manual v1.8, RIPE-632). As a result, there are many IPv4 address marketplaces such as Hilco Streambank[15], IPTrading.com or The Kalorama Group where people can either sell or buy the addresses. As an illustration, in 2009 Microsoft took over IPv4 blocks that were previously held by bankrupt Nortel for $ 7.5 million for 666.624 addresses[16] in a bidding process. Although the initial idea of IP addresses was not for its tradable properties, the transaction also provides a clear picture of how unreal things in the name of the virtual addresses can be worthy.

Mueller and Kuerbis (2013) reported that 9.2 million IPv4 addresses were traded between 2009 to the first quarter of 2013. The policy itself has triggered a heated debate among Internet communities (Dell, 2010; Dul, 2011; Edelman, 2009; Lehr *et al.*, 2008; Mueller, 2008). Those who support the policy claimed that market transfers would produce two benefits. Firstly, it would provide incentives for holders to transfer their addresses to others who need them. Secondly, it means that the unused address could be utilised more efficiently. When the price increases as the addresses become exhausted, this would encourage to gradually and economically move to IPv6 (Mueller & Kuerbis, 2013). However, Edelman (2009) believes that the IPv4 transfer market

[15] Hilco streambank is the global IPv4 address brokerage which has successfully facilitated some either complex or simple IPv4 transaction between buyers and sellers. For more information, visit www.hilcostreambank.com

[16] Microsoft pays Nortel $7.5 million for IPv4 addresses, from http://www.networkworld.com/article/2228854/microsoft-subnet/microsoft-pays-nortel--7-5-million-for-ipv4-addresses.html

acts as a mechanism that prevents the immediate deployment of IPv6. Similarly, Dell (2010) applied an economics analysis of exhaustible resources and economics of the permit market to discuss the policy and come up with a conclusions that the prevailing policy would not encourage a significant IPv6 diffusion.

2.5.2 IPv6 (Internet Protocol version 6)

Internet communities started to discuss and proposed a new protocol as a successor of IPv4 at the early 1990. After serial selection, controversial revision and decision (Tanenbaum & Wetherall, 2011), complex technical choices, competition among technologies company (Mueller, 2010b) and resistance from large company from the US (DeNardis, 2009), Simple Internet Protocol Plus (SIPP) proposal by Deering and Francis was finally selected as the next generation Internet Protocol and officially called IPv6. IPv6 was formally standarized on 1998 and specifically documented in RFC2460.

2.5.2.1 IPv6 specification

IPv6 was designed to interoperate with IPv4, since it would likely take many years to complete transition from version 4 to version 6. Thus, IPv6 should retain the most basic services provided by IPv4. On the other hand, IPv6 should change the IPv4 functions that do not work well and support new emerging applications. Deering and Hinden (1998) decribe several important improvements from IPv4 to IPv6 including:

Expanded addressing capabilities: The most important improvement on IPv6 is that it provides a very huge address space 128-bit – approximately 3.4 x 10^{38}. As an analogy, Wiljakka (2002) argued that IPv6 may provide enough unique addresses for every grain of sand on Earth. IPv6 is believed to be able to provide enough addresses for the future of the Internet (Hagen, 2011). Moreover, the protocol also improves the scalability of multicasting addresses, and adds the Anycast feature allowing a packet to be sent to any one of a group of nodes.

Header format simplification: IPv6 not only enlarges the space address; it also simplifies the header. Hence, the routing management becomes less complicated and this can enable routers to process packets more quickly (Tanenbaum & Wetherall, 2011). From the 13 fields in IPv4, 7 fields are removed that are considered obsolete (including: IHL, identification, flags, fragment offset, checksum and option) and 4 fields are retained with different positions and names (Hagen, 2006) (including: Type of services – Differentiated Services, Total Length – Payload length, Time to Live – Hop Limit, and Protocol – Next header). One new field was added, namely flow label.

Version	Diff. Services	Flow Label
Payload Length	Next Header	Hop Limit
Source Address (128 bits)		
Destination Address (128 bits)		

Figure 2.4. IPv6 Header diagram

Improve support for extensions and options: While in IPv4 the option is part of the header, IPv6 moves the optional Internet-layer information to separate extension headers.

Flow labelling capability: Flow Label is added to tell routers to provide special treatment for a specific packet. For example, IPv6 improves the QoS by asking the router to prioritize certain traffic, so that more important traffic can pass first. QoS is an important feature in today’s Internet with the growth of multimedia on the Internet.

Authentication and privacy capabilities: IPv6 includes IPsec as a built-in feature. IPSec provides interoperable, high quality and cryptographically-based security services at the IP layer. This feature can enhance the original IP protocol by providing authentication, confidentiality and data integrity.

Support for mobility: Both protocols support the mobility feature which provides flexibility to mobility services (OECD, 2015). IPv4 is supplemented by a Mobile IPv4 (MIPv4) protocol as a mechanism to redirect traffic to its Home Network when accessed from a Foreign Network. Mobile IPv6 enhances the capability of MIPv4 and therefore provides more scalability, optimal data part between client and server, faster data transfer at the same time reducing handover latency and loss data (Mueller & Kuerbis, 2013; Van Audenhove *et al.*, 2013).

Security enhancement: While IPSec is an optional feature of IPv4, it is an integral part of IPv6. Apart from that, there is no significant difference between them. Marsan (2004) believed that IPv6 promises a dramatically larger addressing scheme as well as enhanced security and easier administration. However, OECD (2014, p. 10) argues that "*while the level of use of IPv6 in the Internet remains low, the inherent value of the IPv6 Internet is also low*". Currently, IPv4 considerably dominates the Internet. This situation forces various transition technologies to be deployed to allow both protocols to serve the Internet connection and communicate with each other. Therefore, these technologies could potentially have implications for security (Chasser, 2010) if not properly handled (Caicedo *et al.*, 2009).

Another change is the way that IP addresses are written. In IPv4, a 32-bit is divided to become four 8-bits separated by "." (dotted-decimal notation) and is written using decimals, for example 150.7.7.250. Hence, in IPv6, the 128-bit is divided to become separate 16 bits each of which is separated by a colon using and is written down by using hexadecimal. For example, 1080:0:0:0:8:800:200C:417A can be represented as 1080::::8:800:200C:417A. The technical differences between IPv4 and IPv6 are summarised in Table 2.3.

IPv6 clearly provides some benefits over IPv4 and is designed to be able to interoperate with IPv4. The most important benefit is that IPv6 has sufficient address space which, it is believed, it can accommodate the growth of the Internet (Hovav *et al.*, 2004). It allows end-to-end communication which is the basic purpose of communication where any individual can directly interact with another. While IPsec is a supplement technology for IPv4, IPsec becomes an integral part of IPv6 (Durdagi & Buldu, 2010). Another benefit of IPv6 is the improvement to the routing process which incurs less overhead in resources needed to process the routing information (Mueller, 2010a).

However, Jin *et al.* (2008) note that this technical superiority does not guarantee the success of IPv6. IPv6 is not directly compatible with IPv4 (Dell *et al.*, 2007). In fact, they are rivals. Therefore, those who want to migrate to IPv6 have to face compatibility issues. Although several transition methods have been introduced to reduce the compatibility issue, the uptake remains very low (OECD, 2014).

Table 2.3. Main different between IPv4 and IPv6

Features	IPv4	IPv6
Address	32 bits	128 bits
Checksum in header	Included	Moved to IPv6 extension headers
Option in header	Included	Move to IPv6 extension header
Quality of Services (QoS)	Differentiated Services	Use traffic classes & flow labels
Fragmentation	Done by router and source code	Only by the source node
IP configuration	Manually and DHCP	Auto-configuration or DHCP
IPSec	Optional	Built in
Communication	Unicast, multicast and broadcast	Unicast, multicast and Anycast
Address Resolution Protocol (ARP)	Used to resolve an IPv4 address	Replaced by Neighbour Discovery
Internet Group Management Protocol (IGMP)	Used to manage local subnet group	Replaced with Multicast Listener Discovery (MLD)
Domain Name System (DNS)	Uses host address (A) resource address	Use host address (AAAA) resource address
Mobility	Mobile IPv4 (MIPv4) protocol	Mobile IPv6 (MIPv6) protocol

Source: (Forum, 2014)

2.5.2.2 IPv6 still not diffused

The transition of the IP standard from IPv4 to IPv6 is crucial to supporting the massive growth of the Internet. As noted by Claffy (2011), there are many studies that measure the adoption from a variety of perspective, but Internet communities still do not have a comprehensive picture of IPv6 deployment. Czyz *et al.* (2013) believe that measuring the deployment level of IPv6 can provide valuable insight into the overall evolution of the network. Therefore, numerous authors have attempted to measure the adoption of IPv6 by quantifying the progress of its deployment (Colitti *et al.*, 2010; Czyz *et al.*, 2013; Dhamdhere *et al.*, 2012; Grégr *et al.*, 2014; Karpilovsky *et al.*, 2009). Nikkhah and Guérin (2014) suggest measuring the deployment from the three core Internet stakeholders because of their role in the Internet; these are: Internet Service Providers (ISPs), Internet Content Provider (ICPs), and Internet Consumer (Users).

Firstly, the global Internet is made up of a complex hierarchy of interconnected networks maintained by independent providers (Winther, 2006). Since their role is to carry and exchange Internet traffic, to manage routing policy, and to minimize the number of routing hops, they are well-positioned to determine the technology that is required in order to make IPv6 work. Nikkhah and Guérin (2014) measured the deployment by quantifying the number of AS announcing the IPv6 prefix. The information can be used to evaluate the readiness of ISPs to provide IPv6 services to their customers. Although the IPv6 prefix has been registered on the global BGP table, it does not directly correlate to the actual implementation of IPv6 on the user side. However, the increasing number of IPv6 prefixes can be interpreted as the progress of deployment (Grégr et al., 2014). The recent data indicated that only 22.485 IPv6 prefixes are advertised on the Internet, compared to 545.996 IPv4 BGP prefixes[17] – indicating a lack of IPv6 deployment. Nikkhah and Guérin (2014) note that while IPv4 is still dominant, users have to allocate more resources and costs to run an IPv6-based network.

Secondly, the deployment progress could be measured from the side of the Content Providers (ICPs). ICPs are an important part of the Internet as they have the power to make their web accessible via IPv6 (Guerin & Hosanagar, 2010). While ISPs provide the highway to the Internet, ICPs provide the content of the Internet itself. Thus, it is crucial to identify their position to see the importance of adopting IPv6 technology. ICPs generally have owned public IPv4 addresses and whether or not they are accessible via IPv6 depends on them (Nikkhah & Guérin, 2014). Dhamdhere *et al.* (2012) believe that the IPv6 network has matured by pointing out the exponentially

[17] Potaroo.net (2015), IPv6: IPv6 / IPv4 Comparative Statistics, accessed on 2 April 2015, from http://bgp.potaroo.net/v6/v6rpt.html

increasing number of ASs and IPv6 prefixes. However, Nikkhah *et al.* (2011) believes that IPv6 adoption "remains nascent". They quantify IPv6 adoption using access to web content and compare the quality of connection of IPv4 and IPv6. The measurement is based on the top 1 million web sites list maintained by Alexa that monitors the sites using JavaScript. Similarly, Czyz *et al.* (2013) measured the ICP deployment level from (1) transition technology, (2) name servers, (3) server readiness, and (4) client readiness. All indicators show that the deployment level is still in its very early phase. For instance, only 3.5% of the top 1M Alexa sites had IPv6-enabled servers as of early April 2013.

The third model is used to measure the deployment from Internet Users' side.[18] Google consistently measures the client adoption of IPv6 (Figure 2.5). The data indicates that 6.33% of users accessed the Google website over IPv6 in mid-2015, an increase of over twice that of the previous year, 2014. Czyz *et al.* (2013) believe that the data reveal the real deployment from the users' side, since Google has established private peering into many ISPs which allows users to reach Google by IPv6 instead of IPv4 when they are IPv6-enabled. Clearly, measurements of the deployment progress indicate that the Internet is still dominated by IPv4 and there is no significant amount of adoption of IPv6 as the next generation addressing protocol in the Internet since it was standardized in 1998. The discussion above also confirms that the majority of Internet users still resist changing to IPv6.

[18] Google are constantly measuring the IPv6 deployment of their users. It can be accessed at http://www.google.com/intl/en/ipv6/statistics.html. Although it was not represent entire Internet users, the data can be used to see the growth of IPv6 at the end user side. There are two mechanisms for users to reach the Google sites, native IPv6 and via tunnelling 6to4.

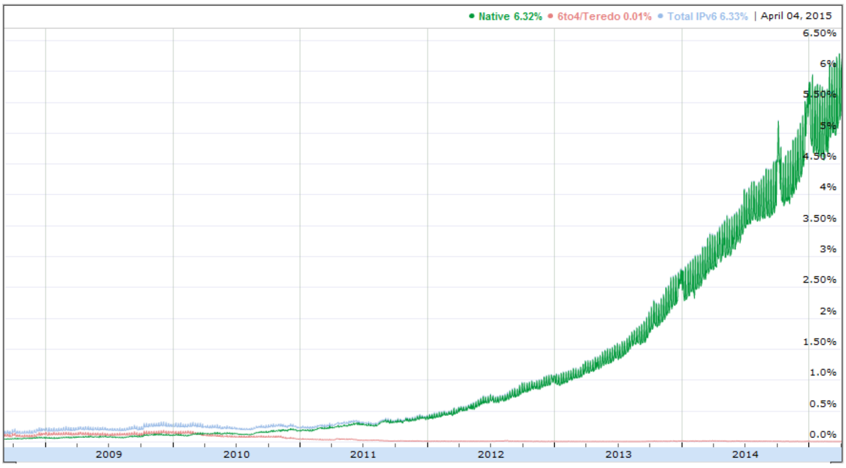

Figure 2.5. IPv6 connectivity among Google users

2.5.2.3 Variations of IPv6 deployment

As it is an undeniable fact that IPv4 addresses are running out, internet communities have been forced to make further efforts to maintain Internet growth. These efforts include a middleware solution before IPv6 as the long-term solution is completely established. However, OECD (2014) reported with various measurements, the deployment of IPv6 is still in its early phase. Previous discussion indicates that IPv6 represents only a small proportion of the Internet.

Recently, the deployment of IPv6 varies among countries while some economies have been very active, some have not. Levin and Schmidt (2014) argue that "*national government still have important role to play in the transition to IPv6"* (p.1065). Some countries, such as Japan, China, Korea and the European Union, consider it as a national priority to deal with address shortage and economy benefits. These countries have become the frontrunners of early implementation of IPv6 (DeNardis, 2009). For example, China has been actively promoting IPv6 since 2003 and introduced the China Next Generation Internet (CNGI) project to build the world's largest IPv6 network (Nielsen, 2011). South Korea mandated a policy to require the mandatory update to IPv6 in the public sector by 2010 (stated in the South Korea IT839 policy).

With the first development of IPv6, the U.S. States tended to be reluctant since the IP shortage was not an issue in the U.S. (White, 2005). The U.S. firstly mandated governmental organization to start working on IPv6 on their network on 2008 after considering that ignoring the standard could even risk their supremacy over the development of the Internet. Recently, the U.S. is becoming the largest country deploying the protocol (OECD, 2010). The major telecommunication carriers in the U.S., such as Comcast, ATT, Verizon Wireless and T-Mobile USA,[19] are vigorously deploying IPv6 and offer IPv6 on a commercial basis to end users.

This research helps to address a significant gap in the literature. While many discussions focus mainly on developed countries, this study targets Indonesian organizations since Indonesia is a developing country. The World Economy Forum - WEF (2014) classified Indonesia as a developing or emerging economy country, attaining 64th position on the Network Readiness Index (NRI). The next section traces the development of the Internet in the country and discusses the researcher's motivation for choosing Indonesia as the research subject.

2.6 Overview of the Internet and IPv6 in Indonesia

In Indonesia, the first Internet connection was established in May 1994 as a result of the collaborative efforts of the academic and research communities. Table 2.4 indicates that the penetration of the Internet in Indonesia is relatively low. Also as a nation with 17.500 islands and challenging geographical features, the connection quality varies among areas. The disparity in the telecommunication infrastructure between eastern and western Indonesia, as well as between rural and urban areas, is high, particularly since most of the eastern areas rely on satellite (Kominfo, 2010). This led to the idea of establishing the *Palapa ring* project to connect all Indonesian provinces as well as 460 districts using a optic fibre backbone. The backbone consists of 35.280 km of undersea optic fibre and 21.708 km of subterranean optic fibre. Upon completion of the project, the government expects that the number of broadband connections will rapidly grow, and the connection quality will improve (Indonesia-Government, 2010; Kominfo, 2010), leading to increased demand for IP addresses.

[21]ISOC regularly measures network operators all over the world in terms of the deployment of IPv6. It is reported that Comcast has become the largest operator to deploy native IPv6.

Table 2.4. IPv4 Allocation and population by country

Country Name	Number of IP addresses	Internet Users (000s)	Population (000s)	Addresses per Internet User	Addresses per Capita	Internet Penetration
Australia	49,256	20,200	22,751	2.44	2.17	88.8%
Brunei	205	277	430	0.74	0.48	64.5%
China	335,773	626,600	1,367,485	0.54	0.25	45.8%
India	38,117	237,300	1,251,696	0.16	0.03	19.0%
Indonesia	19,103	42,400	255,994	0.45	0.07	16.6%
Japan	204,524	109,300	126,920	1.87	1.61	86.1%
Malaysia	6,608	12,100	30,514	0.55	0.22	39.7%
Philippines	5,511	39,200	100,998	0.14	0.05	38.8%
Singapore	7,277	4,500	5,674	1.62	1.28	79.3%
South Korea	112,408	44,900	49,115	2.50	2.29	91.4%
Thailand	8,998	19,500	67,976	0.46	0.13	28.7%
Vietnam	15,758	40,100	94,349	0.39	0.17	42.5%
United States	1,597,152	276,600	321,369	5.77	4.97	86.1%

Source: www.MaxMind.com (2014) and CIA (2015)

The World Economic Forum (2013) reported that the mobile broadband technology in Indonesia increased more than ten times between 2010 to 2011 and continues to increase significantly. This figure indicates a promising development of the Internet usage in this country. APJII (2015) reported that of the Internet users in Indonesia, about 85% use a cellular telephone to access the Internet. Internet users in Indonesia actively use social media such as Facebook, Twitter and LinkedIn. In 2014, the number of users in Indonesia was in 4th position of Facebook users globally (www.InternetWorldStats.com, 2015) with a total of 51 million active users.

However, the allocation of IPv4 addresses to Indonesia is about 19.1 million addresses (www.MaxMind.com, 2014). This number is extremely small in proportion to the total population of 256 million and to the numbers in other leading countries in Asia (e.g. Japan, Taiwan, South Korea and China). The data also indicate that NAT is massively deployed in Indonesia where one address is shared among 13 people on average.

Further, IPv4 address space has been fully allocated so there is little possibility of more IPv4 addresses being allocated to Indonesia, in spite of the introduction of the transfer market policy. Clearly, the deployment of IPv6 (Levin & Schmidt, 2014) is a rational choice to ensure the growth of their network without any problems. However, while awareness of IPv6 is relatively high in Indonesia (Syamsuar & Dell, 2008), these efforts to translate awareness to adoption have not been successful.

2.7 Chapter Summary

Clearly, the adoption of IPv6 is still far from what was expected. OECD (2014) describes that the transition of Internet protocol from IPv4 to IPv6 is still in the early phase, regardless of the methodology being used. Huston (2012) believes that the current penetration of IPv6 in the Internet will not able to prevent the major problem associated with encountering IPv4 exhaustion. The slow adoption may be also because there are no shared values that can join together the needs and expectations of everyone. IPv6 is better than IPv4, but internet stakeholders have not deployed it yet. Czyz *et al.* (2013) suggest that more studies need to be conducted from the user perspective in order to provide useful insights and explain the attitude about the need for adopting, as well as uncovering the reason behind user resistance to IPv6. Furthermore, the demand side of IPv6 among end-user organizations is also necessary in deploying the technology and has not yet been explored adequately. The demand side of the IPv6 needs to be studied in order to obtain a realistic picture of the problem by investigating its deployment in both private sectors and government (OECD, 2008a) sectors. Moreover, there is a lack of empirical evidence about the adoption of IPv6 in developing economies. Therefore, the current study addresses this gap by investigating why organizations in Indonesia resist changing to IPv6.

The next chapter describes and discusses the available adoption and resistance theories in order to provide a thorough understanding of the factors underlying the resistance and adoption of a certain technology that can be applied to this case. This is followed by a specific discussion of adoption or resistance studies relating to of IPv6.

Chapter 3. Review of Adoption and Resistance Theories

3.1 Introduction

The previous chapter provided a review of the Internet, and various discussions about IP addresses and the related issues. In conjunction with the previous chapter, this chapter seeks to explore and discuss both adoption and resistance theories in order to understand the phenomenon of resistance to innovation. Roger (1995) defines innovation as *an idea, practice or object perceived as new by an individual or other unit of adoption"*. Damanpour and Gopalakrishnan (1998) state that an innovation can be a product or a service, an organizational process or an administrative program, a technology, a policy or a system related to organizational members. Therefore, IPv6 technology could be classified as an innovation.

This chapter is organized into three sections. First, we review the current knowledge regarding adoption theories. Secondly, the resistance literature is explored. Then, the specific literature on the adoption of and resistance to IPv6 technology is examined. Finally, this chapter will be summarized in the last section.

3.2 Overview of Adoption Theories

Previous research on technological innovations show some challenges in terms of providing empirical evidence to better understand factors which determine the adoption of innovation (Lam *et al.*, 2008). Many authors (Ajzen, 1985; Davis, 1989; Roger, 1995; Straub, 2009; Venkatesh & Bala, 2008; Venkatesh & Davis, 2000; Venkatesh *et al.*, 2003) have provided useful theories, frameworks or models to extensively investigate, evaluate, explain or predict the user intention using a particular technology. These theories have attracted much attention in adoption technology research (Chau & Tam, 1997). However, Fichman (2000) believes that no single theory can be applied to precisely explain the adoption factors for all technologies and measured units. Some theories focus on assessing an individual level of adoption (Davis, 1989; Venkatesh *et al.*, 2003), and others measure the adoption at the organizational level (Roger, 1995; Tornatzky & Fleischer, 1990). The following section presents further discussion on both of these levels of adoption.

3.2.1 Individual level adoption theory

Numerous theories examine the adoption technology from individual perspectives. The current study highlight several of the most popular theories in IS as suggested by Hameed *et al.* (2012), including Theory of Planned Behaviour (TPB) (Ajzen, 1985), Technology Acceptance Model (TAM) (Davis, 1989) and Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh *et al.*, 2003).

TPB, introduced by Ajzen (1985), extends the Theory Reasoned Action (TRA) which focuses on the study of attitude and behaviour. According to TPB, the best predictor of behaviour is intentions (Ajzen, 1991). Intentions themselves are determined by three motivational factors, namely attitude, subjective norm, and perceived behaviour control. The first factor is attitude toward the behaviour which represents the degree to which a person has a favourable or unfavourable evaluation of the behaviour (Ajzen, 1985). The existence of social pressure to perform or not perform also contributes to the behaviour. Finally, perceived behaviour control can either directly predict the behaviour or is moderated by intentions. The factor is related to people's perception of their ability (such as opportunities and resources availability) to perform a given behaviour.

TAM, developed by Davis (1989), has been widely used as a theoretical framework in explaining and predicting individual intention and behaviour toward a new technology (Venkatesh *et al.*, 2003; Wang *et al.*, 2003). While TPB was originating from psychology area, TAM was originally introduced to explain human computer acceptance behaviour in IS implementation. Two key variables explain why people accept or reject information technology, namely perceived usefulness (PU) and perceived ease of use (PEoU). PU is defined as "*the degree to which a person believes that using a particular system would enhance his or her job performance*" (Davis, 1989, p. 320). Meanwhile PEoU refers to "*the degree to which a person believes that using particular system would be free of effort*" (p.320). Numerous studies have utilized, replicated and tested intensively the theory (Dishaw & Strong, 1999; Gefen

& Straub, 1997; Legris *et al.*, 2003; Venkatesh & Bala, 2008; Venkatesh & Davis, 2000) to provide empirical evidence in order to better understand individual behaviour of a new technology.

However, TAM has been superseded by UTAUT (Venkatesh *et al.*, 2003), which is now the most popular theory. UTAUT unifies eight previous theories commonly used in adoption studies to investigate individual intention toward certain technology. They are TAM, TRA, MM (Motivation Theory), TPB, Combined TAM and TPB, Innovation Diffusion Technology (IDT) and SCT (Social Cognitive Theory). Based on the significant factors from the theories, the authors introduced four factors to predict a user's intention, namely performance expectancy (PE), effort expectancy (EE), social influence (SI) and facilitating conditions (FC). PE refer to "*the degree to which an individual believes that using the system will help him or her to attain gains in job performance*" (p. 447). The authors defined EE as "*the degree of ease associated with the use of the system*" (p. 450). SI is related to how surrounding people believe he or she should use the new system. Finally, FC refers to "*the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system*" (p. 453). Venkatesh *et al.* (2012) extended the UTAUT by introducing UTAUT2 which adds three more predictors to explain behavioural intention to use technology, namely hedonic motivation, price value and habit.

TPB, TAM and UTAUT are useful theories for explaining how individuals (Hameed *et al.*, 2012; Oliveira & Martins, 2011) accept a particular technology, either as a single theory or combined with another theory. Several studies have validated these theories to understand why end user adopts technology at the individual level. However, these theories are not suitable for investigating IPv6 adoption, since the adoption has to be decided on an organizational level, and is also a complex process (DeNardis, 2009; Tassey *et al.*, 2009). The adoption of an Internet protocol must be coordinated by the competent parties within the organization and is not an individual decision. Therefore, in the next section, several common organizational level adoption theories are reviewed to assess the current knowledge of organisational level adoption theories.

3.2.2 Organizational level adoption theory

For many years, numerous researchers have studied and identified the dominant factors which can motivate and inhibit the adoption a new technology at the organizational level (Lin & Lee, 2005; Swanson, 1994; Zhu & Kraemer, 2005; Zhu *et al.*, 2006). An organization has to face a wide range of considerations in order to remain competitive and, meanwhile, the process of adoption is more complicated (Furneaux & Wade, 2011) than at the individual level. At the organizational level, the adoption decision can be made by either individuals or a group of individuals who have the authority to make the decision. Damanpour and Gopalakrishnan (1998) state that innovations come to an organization in two ways: they are either generated or adopted. An organization generates an innovation usually for its own purposes or for sale to other parties. In many cases, most organizations adopt an innovation to increase profit or to improve operational processes.

Regarding organizational level adoption, Oliveira and Martins (2011) state that there are two theories commonly deployed in IS adoption studies, namely Innovation Diffusion Theory (IDT) (Roger, 1995) and Technology Organization Environment (TOE) framework (Tornatzky & Fleischer, 1990). Although both of them are considered to be classic theories, most studies on IT adoption at the organizational level refer to these two theories (Chong *et al.*, 2009).

3.2.2.1 Innovation Diffusion Theory (IDT)

IDT has become very popular among a wide variety of academic disciplines, public agencies and private firms (Hovav *et al.*, 2004) to explain and predict a technology adoption either as a single theory or combined with another theory (Attewell, 1992; Bajwa *et al.*, 2008; Cooper & Zmud, 1990; Venkatesh *et al.*, 2003). Moreover, the theory serves as a foundation for most social, economic and technological change programs (Nakicenovic & Grübler, 1991), since it is relevant to many disciplines and issues (Dooley, 1999). As noted by Pervan *et al.* (2005), IDT has become the most widely applied theoretical basis for the study of IT adoption. IDT not only describes factors which motivate users to adopt an innovation, but also explains the process. The four important elements that Roger uses to define diffusion of innovation are *"the* *process by which an innovation is communicated through certain channels over time among the members of a social system"* (1995, p. 5). This is in contrast to TAM and UTAUT, which describe the factors but say nothing about the process.

The first key element of IDT is an **innovation**. It is defined "*as an idea, practice or object perceived as new by an individual or other unit of adoption" (Roger, 2003)*. Although an innovation might have been created a long time ago, if the users perceived it as new, it is still an innovation. Further, Roger emphasizes that the level of perceived innovation characteristics, namely relative advantage, compatibility, complexity, trialability and observability, could determine the ultimate rate and pattern of adoption (Fichman, 2000). Of these characteristics, relative advantage and compatibility were usually but not always consistently found as the predictors of the adoption decision process in IS study (Moon & Kim, 2001; Moore & Benbasat, 1991; Venkatesh *et al.*, 2003). Relative advantage could be measured in economic terms, social prestige factors, convenience or satisfaction (Roger, 2003). Other theories describe relative advantage as Perceived Usefulness of TAM (Davis, 1989) or Performance expectation and Effort expectation of UTAUT (Venkatesh *et al.*, 2003). Compatibility is determined by measuring the compatibility with existing work practices, preferred work style, prior experiences and values (Agarwal & Karahanna, 1998) and these factors have been validated in many prior studies (Hovav *et al.*, 2004).

The second element is the **communication channel**. It refers to "*a process in which participants create and share information with one another in order to reach a mutual understanding*" (Roger, 2003). The effectiveness of a communication channel could increase the rate of adoption. Mass media channels such as television, magazines and the Internet, appear significantly in many diffusion processes due to their ability to disseminate information to a wide audience within a short amount of time. Another useful communication channel for the diffusion process is interpersonal communication.

Time is the third important aspect of the diffusion process. Time is involved in the process of technology diffusion in many respects. For example, to diffuse innovation, it needs time for people or organizations to decide whether to adopt or reject an innovation. Potential users in a social system adopt an innovation not at the same time but over a period of time. Roger (1995) introduces an innovation-decision process theory to explain that the innovation decision process is not an instantaneous act. However, it consists of a series of actions, namely (1) the knowledge stage where users are exposed to the innovation, become aware and begin to obtain some understanding on the technology; (2) persuasion where users become more involved and form a favourable or unfavourable attitude toward the innovation; (3) decision where users make a decision whether to adopt or to reject the innovation; (4) implementation where user has decided to adopt and put the innovation into use; and (5) confirmation where users seek reinforcement of an innovation decision already made.

Finally, a **social system** is a set of interrelated units engaged in joint problem-solving to accomplish a common goal. The members of a social system could be individuals, groups of people or organizations who work toward a common goal. Roger emphasizes that the nature of the social system affects people's innovativeness which significantly leads to adopter criteria which is categorized into five levels according to how quickly decisions are made to adopt the innovation: innovators (venturesome), early adopters (respectable), early majority (deliberate), late majority (sceptical), and laggards (traditional).

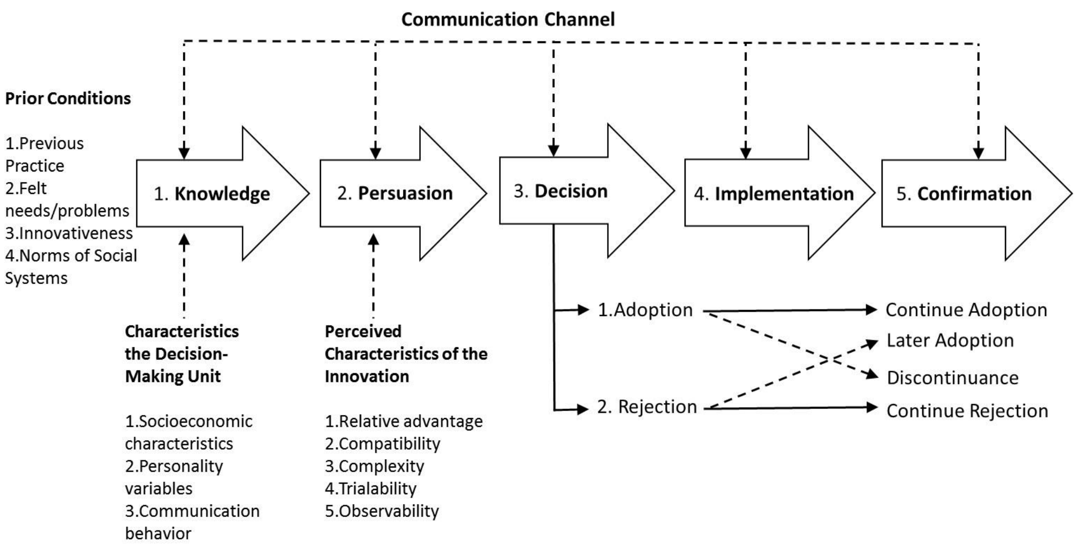

Figure 3.1. Innovation Decision Process

Figure 3.1 present a sequential innovation adoption process which helps to predict the innovation of diffusion over time and space (Roger, 2003). However, Karahanna *et al.*

(1999) argue that IDT does not provide evidence on how attitude develops into whether to accept or reject decision. Lyytinen and Damsgaard (2001) believe that IDT does not provide an adequate construct to deal with collective behaviors. In addition, the adoption decision does not always follow a sequential process; instead, it is an iterative process between the stages of the innovation-decision process; as Rogers stated, rejection can occur at any stage of the decision process.

3.2.2.2 Technological-Organizational-Environmental (TOE) Framework

Tornatzky and Fleischer (1990) introduced the TOE framework to explain organization level adoption. "*As generic theory of technology diffusion, the TOE can be used for studying the adoption of IS innovation*" (Zhu *et al.*, 2003, p.252). Previous studies indicate that the TOE has been used to explain and predict organizational adoption in several empirical studies on various IS areas (Chau & Tam, 1997; Kuan & Chau, 2001; Lippert & Govindarajulu, 2006; Pan & Jang, 2008; Zhu *et al.*, 2003). According to TOE, the decision to adopt an innovation could be influenced by three elements, namely technological, organizational and environmental context. These elements display "*both constraints and opportunities for technological innovation*" (Tornatzky & Fleischer, 1990, p. 154).

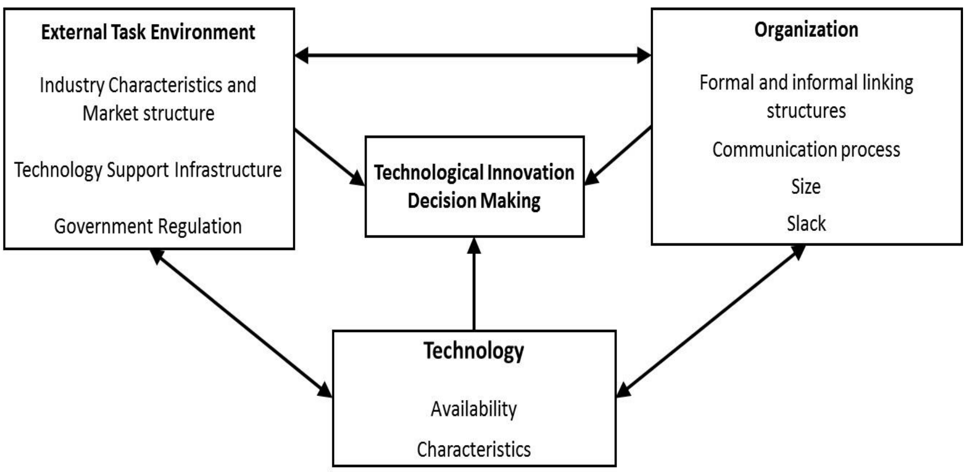

Figure 3.2. Technological Organization Environment Framework

Firstly, the technological element involves both internal and external technologies relevant to the firm (Tornatzky & Fleischer, 1990). "*This includes current practices and equipment internal to the firm … as well as the pool of available technologies external to the firm*" (p. 153). Moreover, the authors argue that internal technology has an effect at least similar to or more than external technology. If the existing equipment and internal competence align with the new technology, this will reduce the cost of adoption significantly.

Secondly, the organizational element is related to the internal conditions or resources available to support the adoption. An organization's characteristics usually include size, degree of centralization, formalization, complexity of its managerial structure, the quality of its human resource and the amount of slack resource (Chau & Tam, 1997). Tornatzky and Fleischer (1990) emphasize the importance of the size of organization as a determinant of the adoption of a new technology. The size could be viewed from various angles such as the number of employees, revenue, and amount of installed equipment. Zhu, *et al.* (2003) believe that larger organizations have several advantages over small ones since they usually have sufficient financial or human resources. Studies on organizational adoption also suggest that the capability of IT staff is an important factor in the successful implementation of a technology (Mijinyawa, 2008). The study of Kuan and Chau (2001) indicates that the firms that have a better perception of their competence tend to be the adopters. To see the benefit of an innovation, a potential adopter has to aware of the technology (Hovav & Kim, 2006). In relation to IDT (Roger, 1995), the potential adopter starts to gain knowledge at this point. Dell, *et al.* (2007) argue that awareness itself is a pre-condition of adoption when people try to obtain knowledge related to the issue. IT staff with sufficient competency could influence management to see the benefit of a new technology. Management support also plays a crucial role in the adoption of complex technologies (Premkumar & Ramamurthy, 1995). Top management has the power to ensure the successful implementation of a new technology. Given their role in the organization, top management could influence and encourage other members of the organization to proactively learn about and adopt a certain technology. On the other hand, the adoption will encounter obstacles when top management does not give consistent support.

Finally, the environmental context is the arena in which the firm conducts its business, its industry, accesses resources, and deals with competitors (Tornatzky & Fleischer, 1990). The environment will influence the technology adoption. Tornatzky & Fleischer stress the importance of government regulation to facilitate the adoption of technology. Several articles also suggest the contribution of government, vendor and IT organization in raising awareness and facilitating the implementation of the IPv6 (Bohlin & Lindmark, 2002; Dell *et al.*, 2007; Hovav & Kim, 2006). Kuan and Chau (2001) argue the importance of government pressure on the EDI adoption.

Various researchers have proposed and tested the factors relating to organizational adoption (Roger, 1995; Tornatzky & Fleischer, 1990) as summarised in the Table 3.1

Table 3.1. Organisational Level Study based on TOE framework

Reference - Innovation	Technology	Organization	Environment
Zhu et al. (2003) – E-business	Internet skill, E-business know-how, IT infrastructure	Firm scope, firm size	Consumer readiness (consumer willingness and Internet Penetration), Partner readiness
Lippert and Govindarajulu (2006) – Web services	Security concerns, reliability, deployability	Firm scope, firm size, technological knowledge, perceived benefit	Regulatory Influence, competitive pressure, partner readiness, trusted service provider
Kuan and Chau (2001) – EDI	Perceived indirect benefit, perceived direct benefit	Perceived financial cost, Perceived technical competence	Perceived industrial pressure, Perceived government pressure
Pan and Jang (2008) – ERP	IT infrastructure, technology readiness	Size, perceived of barrier	Production and operation improvement, enhancement of product and services, competitive pressure, regulatory policy
Chau and Tam (1997) – Open system	Perceived benefit, perceived barriers, perceived importance of compliance	Complexity of IT infra-structure, Satisfaction with existing system, Formalization on system development & management	Market uncertainty

3.3 Overview of Resistance Theories

Whereas the previous section highlights the adoption by asking why do people or organizations use an innovation, other researchers (Bhattacherjee & Hikmet, 2007; Cenfetelli, 2004a; Gatignon & Robertson, 1989; Hirschheim & Newman, 1988; Kleijnen *et al.*, 2009; Lapointe & Rivard, 2005; Markus, 1983) see the adoption from a different angle – the resistance perspective. The study of resistance to change was firstly introduced by Lewin (1947) and since then many researchers in, their studies on adoption, have attempted to explain the importance of resistance. Prior studies have shown that understanding the reasons for resistance is very important as a means of identifying the factors which inhibit or encourage the adoption of new technology (Cenfetelli & Schwarz, 2011; Lapointe & Rivard, 2005), and provide a better strategy (Bhattacherjee & Hikmet, 2007) to facilitate the implementation.

There is a lot evidence to suggest the importance of identifying IS adoption from the resistance perspective (Ford *et al.*, 2008). Therefore, there have been a number of studies discussing the phenomenon (Lapointe & Rivard, 2005), investigating the predictor(s) of resistance (Bhattacherjee & Hikmet, 2007; Ellen *et al.*, 1991; Jiang *et al.*, 2000; Kim & Kankahalli, 2009; Kleijnen *et al.*, 2009; Venkatesh & Brown, 2001), and introducing resistance frameworks to investigate the resistance phenomenon (Bhattacherjee & Hikmet, 2007; Kim & Kankahalli, 2009). However, Lapointe and Rivard (2005) claimed that only four articles actually opened the black box and proposed a better explanation for how and why resistance occurs (Joshi, 1991; Marakas & Hornik, 1996; Markus, 1983; Martinko *et al.*, 1996).

Some authors believe that resistance to change is contrary to the adoption factors (Guha *et al.*, 2004; Kramer, 1999; Venkatesh & Brown, 2001). For example, Venkatesh and Brown (2001) state that:

> *"Prior technology adoption research has typically seen the presence of certain factors (e.g., perceived usefulness) as leading to adoption, while a lack of those factors is seen as the cause of rejection." (p.91)*

However, the reason for resistance to change is not a simple, single causal factor (Hirschheim & Newman, 1988) and could vary from one technology to another (Kleijnen *et al.*, 2009). As noted by Markus (1983), resistance could have either a negative or positive effect on the technology adoption process; therefore, an understanding of resistance factors could lead to a better implementation strategy. Similarly, Gatignon and Robertson (1989) believed that resistance is not simply a mirror opposite of IS adoption by stating "*rejection is not the mirror image of adoption, but different form of behaviour*" (p. 47). They examined rejection factors along with the adoption factors in assessing the innovation decision process. Ford *et al.* (2008) agreed that resistance should not only be viewed as a negative aspect of the changing process, but also as an important and beneficial aspect of the technological adoption process. Those factors which inhibit the adoption can be used to explain the adoption phenomenon (Bhattacherjee & Hikmet, 2007; Cenfetelli, 2004b).

3.3.1 User resistance definition

Resistance to change has been identified as an important aspect which needs to be considered in IS studies (Cenfetelli, 2004a; Ford *et al.*, 2008). Although adoption theories are more dominant than resistance studies, there is increasing interest in investigating the role of inhibitor factors (Cenfetelli & Schwarz, 2011). However, Lapointe and Rivard (2005) point out the lack of consensus regarding the definition of resistance to change. In addition, Laumer and Eckhardt (2010) argue that there is no unified definition and precise description of resistance. Therefore, some definitions of resistance are mentioned here in order to obtain the current understanding of resistance to change.

Markus (1983, p. 433) defines resistance "*as behaviour intended to prevent the implementation or use of a system or to prevent system designer from achieving their objectives*". Klaus and Blanton (2010, p. 3) define resistance to change as "*the behavioural expression of a user's opposition to a system implementation during the implementation*". Subsequently, Klaus and Blanton adopted the psychological contract theory and empirically investigated resistance in terms of four different issues, namely individual, system, organizational and process.

Since IPv6 was introduced to replace IPv4, this study adapted the definition which corresponds to the phenomenon which is the desire to preserve the status quo. For example, Zaltman & Duncan (1977 cited in Bhattacherjee & Hikmet, 2007) define resistance to change as '*any conduct that serves to maintain the status quo in the face of pressure to alter the status quo*'. Similarly, Ellen *et al.* (1991) define resistance to change as an evaluative response to maintain the status quo. Satisfaction with the current system and absence of attractive motivation (Ellen *et al.*, 1991) tend to make people maintain the status quo. User resistance is also defined as the user opposing any change associated with a new IS implementation (Kim & Kankahalli, 2009).

Resistance to the technology implementation can be bad or good (Gatignon & Robertson, 1989; Hirschheim & Newman, 1988). The resistance is bad when it causes conflict and wastes time and attention (Lapointe & Rivard, 2005). Cenfetelli and Schwarz (2011) argued that *"understanding why users reject technology is important so as to avoid its occurrence"*(p.808). Then, the authors describe that punishment is more effective than reward in learning and people respond more quickly to negative things rather than positive ones. Moreover, Cenfetelli (2004a) posits that bad is stronger than good and negative information leads to faster and more confident decisions. Since there was no consensus about the definition, Lapointe and Rivard (2005) conducted a semantic analysis of nine definitions of resistance to change from previous studies. They propose five basics element of resistance, namely resistance behaviour, object of resistance, perceived threat, initial condition, and subject of resistance.

Object of resistance relates to the target of the resistance behaviors (Rivard & Lapointe, 2012). The authors stated that the object could be the system or the feature itself (Wagner & Newell, 2007), consequence of resistance (Markus, 1983), or the implementer itself (Lapointe & Rivard, 2006).

Perceived threat is one of the significant factors investigated by researchers (Bhattacherjee & Hikmet, 2007; Joshi, 1991). It refers to the negative assessment that users make of the IT implementation (Rivard & Lapointe, 2012). When the innovation is considered favourable, and fair to the existing culture, users will not resist and will welcome the innovation (Joshi, 1991).

Subject of resistance represents "*the actor or actors exhibiting resistance behaviors*" (Rivard & Lapointe, 2012, p. 899). Prior studies indicate that the subject could be an individual (Lin *et al.*, 2012; Marakas & Hornik, 1996), a group (Kim & Kankahalli, 2009; Markus, 1983) or an organization (Meissonier, 2010).

Initial conditions correspond to the "*characteristics of the environment that interact with the objective of resistance and influence the assessment that users make of the situation*" (Rivard & Lapointe, 2012). The initial condition cannot be denied as a reason to resist. For example, a user's experience with success or failure of implementing a technology will strongly influence the user's beliefs (Martinko *et al.*, 1996).

Resistance behaviour is the manifestation of resistance which is "*the core element of resistance to IT, which is generally defined as a set of behaviors enacted by users to manifest some discontent with the implementation of a new IT*" (Rivard & Lapointe, 2012, p. 899). The effect of resistance is not merely the absence of adoption, but it could be an active decision to reject. For example, Coetsee (1999) describes four types of resistance ranging from soft reaction to destructive behaviour, including apathy, passive resistance, active resistance and aggressive resistance. In this case, Kleijnen et al. (2009) categorize the resistance behaviour according to three levels, namely postpone, rejection and opposition. At the very weak resistance level, users or potential users indicate their lack of interest and tend to wait and see. Roger (2003) classified those users as laggards who typically have an aversion to change. In another sides, active and aggressive resistance could lead to disturbing behaviour, such negative communication, complaining and boycott (Kleijnen *et al.*, 2009).

Markus (1983) argues that while individual level resistance is influenced more by psychological factors, organizational level resistance is motivated by socio-political factors. Understanding the key factors of resistance is an important determinant of the success of IT adoption in an organization (Meissonier, 2010). Therefore, identifying the resistance factors can help to develop a better implementation strategy (Bhattacherjee & Hikmet, 2007). The next section reviews existing literature related to the reasons for resistance.

3.3.2 Why user resistance?

Although an innovation may be significantly superior and offers better features and capabilities than the previous one, it does not necessarily mean that potential users will easily adopt it (Roger, 1995). In many cases, adoption innovations have failed. A well-known example of innovation failure is the Dvorak keyboard introduced to replace the QWERTY keyboard (Farrell & Saloner, 1986).

The QWERTY keyboard was designed in 1873 by Christopher Latham Scholes. At that time, typewriters could not handle speed, and the speed needed to be slowed down in order to prevent the mechanism from jamming (Noyes, 1983). The basic idea of the layout of the keyboard is to reorganise the letters so that those most frequently used require the fingers to be extended further (David, 1985). In 1932, the Dvorak keyboard was introduced as a successor that could significantly increase typing speed. Moreover, based on experiments, the Dvorak design could efficiently increase finger travel, significantly decrease typist fatigue, and improve typing accuracy. However, people still use the QWERTY keyboard almost exclusively and the Dvorak keyboard never managed to replace it. Many authors believed that several factors contributed to the failure of the Dvorak to gain a foothold, including no perceived advantage (Liebowitz & Margolis, 1990), network effect (Clements, 2005), satisfaction with the current system, cost of switching (Liebowitz & Margolis, 1995), and perceived threat (Farrell & Saloner, 1986).

As mentioned previously, the study of user resistance to an innovation has attracted significant attention in the literature (Jiang *et al.*, 2000). Numerous researchers have examined the innovation resistance in many different areas, with a variety of strategies and several different purposes. The nature and cause of organizations' resistance to change can also be identified from several dimensions (Jiang *et al.*, 2000; Markus, 1983). Various factors have been identified including environmental influence (Ellen *et al.*, 1991; Gatignon & Robertson, 1989; Robey *et al.*, 2008), innovation characteristics (Hirschheim & Newman, 1988; Kim & Kankahalli, 2009; Venkatesh & Brown, 2001) and organizational dimension (Chwelos *et al.*, 2001; Jiang *et al.*, 2000;

Kleijnen *et al.*, 2009). Table 3.2 provides a summary of resistance studies and their relevant findings.

Table 3.2. Summary of Resistance Studies

Reference	Investigated factors	Nature of the Study	Finding
(Furneaux & Wade, 2011)	Change Forces (system performance shortcomings, system reliability, system support available, system support cost) and Continue inertia (system investment, technical integration)	Mixed-method	There are two variable, system performing shortcoming and technical integration found to be significant to influence the replacement intention
(Meissonier, 2010)	Task-oriented (conflict about the system, conflict about the task, and conflict about competency required) Socio-political oriented (cultural conflict and conflict due to a loss of power)	Qualitative	User's resistance is strongly correlated with various conflict occurred within the organization.
(Ellen *et al.*, 1991)	Self-efficacy Performance satisfaction	Quantitative	A person's perceived ability to use a product successfully affects their evaluative and behavioural response to the product and the level of satisfaction experienced with an existing behavior increases resistance to change
(Bhattacherjee & Hikmet, 2007)	Perceived threat Perceived usefulness Perceived ease of use Perceived compatibility Related knowledge Resistance to change	Quantitative	Important to combine adoption and resistance studies to research technological resistance phenomenon
(Kim & Kankahalli, 2009)	Switching Cost Perceived value Switching benefit Organizational support	Quantitative	Switching cost increase user resistance directly or is mediated by perceived value. Perceived value and organizational support reduce user resistance

(Lapointe & Rivard, 2005)	Perceived threats Initial condition Interaction between object and initial condition	Qualitative	A group resistance emerges from individual resistance behavior to a group resistance. The resistance behaviour changes over time depend on the influence of triggers.
(Markus, 1983)	People-determined, System-determined, Interaction of system and context of use	Conceptual	Resistance behavior occurs as the result of interaction among the system being implemented and the context of use
(Kleijnen *et al.*, 2009)	Degree of change required and conflict with prior believe	Qualitative	Both factors suggest user resistance to either postpone, reject or oppose the innovation

For example, Markus (1983) suggests that resistance should be examined from three main perspectives that cause people or organizations to be resistant, namely people-oriented, system-oriented and interaction-oriented. First, people resist technological innovation because of their own internal factors related to the people or organizations (Chwelos *et al.*, 2001; Jiang *et al.*, 2000; Kleijnen *et al.*, 2009). Second, resistance occurs because of factors inherent in the technology being introduced (Ellen *et al.*, 1991; Hirschheim & Newman, 1988; Kim & Kankahalli, 2009; Venkatesh & Brown, 2001). Finally, the interaction between people and the characteristics of technological innovation are also another reason to make people or organizations resist changing (Ellen *et al.*, 1991; Gatignon & Robertson, 1989; Robey *et al.*, 2008). Markus concludes that resistance is a result of the interaction among people/organization, technology and the organizational environment. Markus's concept is very popular since many other resistance studies (Jiang *et al.*, 2000; Klaus & Blanton, 2010; Lapointe & Rivard, 2005) have adopted her concept to explain the resistance phenomenon. These dimensions are quite similar to those in the TOE framework (Tornatzky & Fleischer, 1990), which suggest examining the adoption in terms of three dimensions, namely technology, organization and environment (see section 3.2.2.2 for detail). Tornatzky & Fleischer believe that these three dimensions can become facilitators or inhibitors for the new technological innovation.

Prior studies also indicate that many researchers have proposed theoretical explanations of resistance to change and develop an understanding of how and why resistance occurs. For example, Markus (1983) states that resistance to change occurs as a result of the interaction between system characteristics and the social environment. This idea is adapted by Lapointe and Rivard (2005) to explain resistance to IT implementation from a multilevel approach in which individual level resistance potentially leads to group level resistance. They argue that group level resistance is a result of individual resistance and the manifestation of resistance varies over time. The interaction between initial condition with the object leads to the perception of threat and then determines resistance behaviours, from apathy to aggressive resistance (Coetsee, 1999).

Kim and Kankahalli (2009) combine adoption and resistance theories to explain resistance to change and integrate them with the status quo bias theory. While the objective of the first two theories is to determine the factors that influence user intention to adopt an innovation from positive and negative perspectives, the status quo bias (SQB) theory intends to explain users' decisions to maintain their current situation. SQB suggests that users preserve a status quo based on rational decision making, cognitive misperception and psychological commitment (Samuelson & Zeckhauser, 1988). Kim & Kankahalli found that the cost of switching significantly contributes to resistance to change either directly or mediated by perceived value. The switching cost includes transition cost, uncertainty cost and sunk cost. Clearly, in order to move to a new technology, an organization has to make some upgrade to the current technology, especially when the innovation is not compatible with the existing technology. The cost consideration has been previously validated by Venkatesh and Brown (2001) in their study of the PC adoption; they found that high cost along with rapid change and lack of knowledge were the reasons that people resisted. Polites and Karahanna (2012) also described how the cost of switching can influence a user's decision to change.

Ellen *et al.* (1991) examine two factors to explain the resistance to change, namely performance satisfaction with the current system and self-efficacy with the innovation. They conclude that both factors are important in the decision to change. Those who experience high self-efficacy will be less resistant to change and those who are satisfied with the current system tend to reject the innovation. Polites and Karahanna (2012) explain the negative effect of the incumbent system on an innovation and usage intentions. Kleijnen *et al.* (2009) point to two main factors that discourage people from using a new system: the innovation requires a change in consumer's behaviours, norms, habits and traditions; and an innovation causes psychological conflicts or problems for consumers.

As noted by Marakas and Hornik (1996), resistance behavior is a response to threats that may occur as a result of the implementation of an innovation. In their study, Bhattacherjee and Hikmet (2007) investigated the role of perceived threat by integrating adoption theories and resistance to change literatures. The key finding of their study is that perceived threat by respondents contributes significantly as the resistance to change factors in the implementation of a health information system. Related to the threat, Joshi (1991) introduces the equity-implementation model to explain the resistance to change phenomenon. Based on this theory, potential users will (1) evaluate the impact of changing on their equity status; (2) assess the change equity in terms of their input and what they have gained and compare the outcome with other users. Joshi believe that perceived inequity leads users to resist change.

Hirschheim and Newman (1988) stressed the lack of felt need as one of the factors which contribute to user resistance. An organization will evaluate the benefit of the innovation based on its business needs and whether the technology will be advantageous and how much the innovation contributes to the business growth. Premkumar and Ramamurthy (1995) argue that an organization is willing to adopt an innovation if there is a genuine internal need. On the other hand, lack of felt need has a negative impact on the adoption of technology (Blin & Munro, 2008).

3.4 Comparison of Adoption and Resistance Theories

Adoption and resistance have been widely examined as crucial factors in IS adoption studies (Van Offenbeek *et al.*, 2013). Therefore, both research areas have generated many useful theories to explain user reaction to the introduction of an innovation (see Section 3.2 and Section 3.3). Unlike adoption theory in which Venkatesh *et al.* (2003)

successfully unified eight common adoption theories into a single theory - UTAUT, there is lack of unified theory in resistance research (Bhattacherjee & Hikmet, 2007). Laumer and Eckhardt (2012) emphasize the need to unify various concepts in user resistance studies into a single understanding. Laumer and Echhardt argue that a unified understanding of user resistance might *"lead to a deeper investigation of organizational change and user resistance research in order to provide both design science and implementation process"* (p.84).

Cenfetelli (2004a) believes that adoption and resistance factors are inseparable in technology usage. Hence, we find that numerous researchers have attempted to integrate adoption and resistance factors into a single study (Bhattacherjee & Hikmet, 2007; Kim & Kankahalli, 2009; Van Offenbeek *et al.*, 2013). Some authors use different terminology to express the negative perspective of adoption, such as IT failure (Dwivedi *et al.*, 2014) as opposed of IT success; or non-adoption (Eckhardt *et al.*, 2009) instead of adoption; and continue versus discontinue (Furneaux & Wade, 2011).

Dwivedi *et al.* (2014) state that numerous examples of research focused on either failure or success of IS implementation. They point out the model of information system success by DeLone and McLean (1992) as a well-known theory in this area. Many available studies have adapted, modified or extended the theory to identify IS success factors (Delone & McLean, 2003; Karahanna *et al.*, 1999). Other studies have described and investigated the consequences of IT failures (Pan *et al.*, 2008). For example, Pan *et al*. posit that IT failure could be the result of multiple factors such as unrealistic expectations, lack of resources, uncooperative customers and lack of appropriate management. Fitzgerald and Russo (2005) believe that organizational and social factors contribute more than technical factors to cause IT failure.

As noted by Eckhardt *et al.* (2009), research on adoption technologies has yielded many useful theories, such as TAM (Davis, 1989), TPB (Ajzen, 1991), IDT (Roger, 1995), TOE (Tornatzky & Fleischer, 1990) and UTAUT (Venkatesh *et al.*, 2003). These theories have been successfully applied in many adoption studies to explain and predict user intention toward new technology. Other researchers have investigated the adoption phenomenon from the negative side of adoption phenomenon – from resistance perspective (Furneaux & Wade, 2011; Joshi, 1991; Marakas & Hornik, 1996; Markus, 1983). Furneaux and Wade (2011) underline the importance of investigating IS discontinuance. The adoption of an innovation is strongly related to the discontinuance of an existing system. They explain that while continuance indicates the desire to preserve the status quo, discontinuance indicates a rejection of the status quo and the willingness to adopt an innovation.

In the case of IPv6, although many parties have urged, cajoled, persuaded and encouraged (Huston, 2013) the move to IPv6, the rate of adoption is still very low and most Internet users still continue to maintain the status quo and are reluctant to move to IPv6. The next section highlights the knowledge available from prior IPv6 adoption studies.

3.5 Prior IPv6 Adoption Studies

For years there have been debates and discussions about the slow adoption of IPv6 on today's Internet. Since the protocol was standardized on 1998, until recently there has not been a significant increase number of adoptions (OECD, 2014). Hovav *et al.* (2004) believe that the Internet adoption faces unique challenges where there is a lack of central control and the need for interoperability. IP addresses are allocated on a first-come-first-served basis to those who need the addresses. Based on this policy, the majority of IP address allocations went to developed countries (DeNardis, 2009; Zielinski, 2006). In contrast, the major demand for IP addresses today comes from developing countries (Che & Lewis, 2010).

As explained in section 2.5.1.1, numerous authors have attempted to quantify the adoption from the deployment perspective (Colitti *et al.*, 2010; Czyz *et al.*, 2014; Dhamdhere *et al.*, 2012) and obtained a similar result - that the IPv6 adoption rate is quite low. OECD (2015) reported that the IPv6 global penetration increased by only about 2% between 2012 (0.71%) and 2014 (2.53%). Figure 3.3 shows the number of IPv6 allocations from the top 15 OECD countries. The U.S. government mandated that IPv6 be adopted by government departments and this was then followed by business organizations. The report also shows that the IPv6 allocation reached a peak in 2011

(926 allocations). Despite a tendency to decrease in the following years, the U.S. was still the leader with 384 allocations.

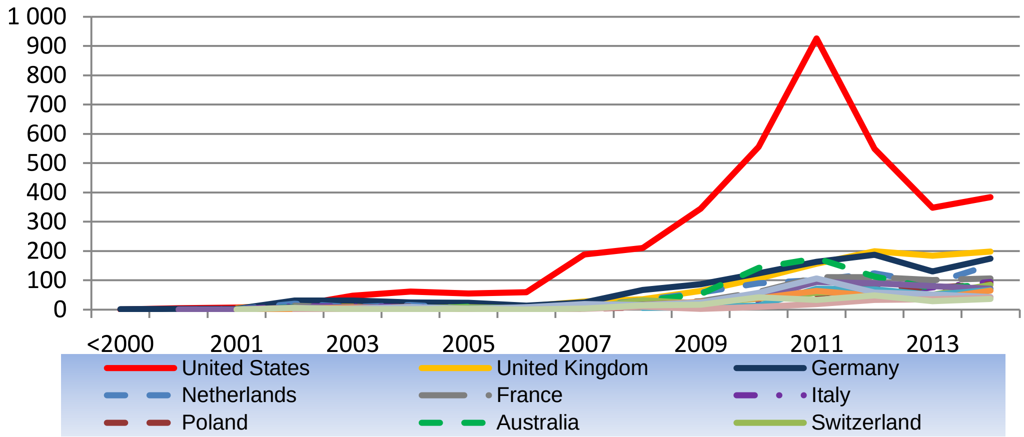

Figure 3.3 Number of IPv6 Allocations, top 15 OECD countries 1999-2014 (source: OECD (2015))

Furthermore, some researchers attempted to explain the IPv6 adoption issue by using adoption theories, such as Hovav *et al.* (2004) with IDT, Pickard (2014) with TOE and Martey (2014) with UTAUT.

Hovav *et al.* (2004) introduced the Internet Standard Adoption (ISA) model which combines IDT and economics of adoption literature to explain the IPv6 adoption phenomenon. As presented in Figure 3.4, the ISA model is dependent upon two dimensions, namely usefulness of the feature (UF) and conduciveness of environment (EC). They adapt the factors of perceived characteristics of the innovation proposed by Roger (2003) to explain UF. Meanwhile, EC was about the influence of community effects (such as network externalities, sunk cost, sponsorship). Both factors can be low or high and the combination of the level determines the quadrant of adoption, namely status quo, co-exist, replacement and full implementation.

		Conduciveness of Environment (EC)	
		Low	High
Usefullness of Features (UF)	Low	I. Status quo	III. Replacement
	High	II. Co-existence for the best use (niche)	IV. Full Implementation

Figure 3.4. Internet Standard Adoption (ISA)

Dell (2010) argues that the current condition is extremely unfavourable for IPv6 adoption. Therefore, Dell believes that given current situation, both UF and EC are clearly low, leading to status quo. This argument aligns with SQB theory (Samuelson & Zeckhauser, 1988) which states that the rational decision making to maintain a current status is based on assessment of relative benefits before switching to a new alternative (Kim & Kankahalli, 2009). In the current condition, those who adopt the technology do not directly obtain any competitive advantage compared with those that do not (Huston, 2013).

Recently, Pickard (2014) adapted the TOE as his research framework and combined it with the innovation adoption factors to investigate IPv6 readiness among U.S. enterprise networks. As noted by Oliveira and Martins (2011), it is important to combine several theoretical models to achieve a better understanding of the complex technology adoption phenomenon. Pickard found that the level of adoption was very low and that organizations made insignificant preparations for IPv6 because of several factors. Of the nine technological adoption factors investigated, only three factors were found to be significant, namely relative advantage, coercive pressure (pressure from trading partners) and normative pressure (influence from various forums, associations and professional organizations).

Another study by Martey (2014) investigated the level of IPv6 acceptance in U.S. enterprise networks using the UTAUT as the theoretical guideline. He concluded that the UTAUT could not be considered as an appropriate model to explain the IPv6 adoption phenomenon. For example, he pointed out the study design flaw to measure the relationship between behavioural intention and user behaviour – these were measured simultaneously instead of by means of a longitudinal study.

In addition to these studies, Pazdrowski (2013) attempted to explain organizations' resistance to IPv6 in the U.S. He stressed the importance of the relationship between leadership and innovation. In this case, he measured the relationship of business prosperity and technological innovation along with technical factors (replacement of hardware, software, reconfiguration of infrastructure and training IT worker) and organizational challenge (business support and resistance to change). He concluded that there was a lack of awareness among business leaderships of the IPv6 benefits as the reason for organizations resisting the technology.

The similarity of the four previous empirical studies is that all of them targeted organizations in developed countries. The phenomenon of IPv6 adoption in developing countries remains unexplored. This study addresses this gap by investigating the resistance to IPv6 in a developing country. In addition, while the three previous empirical studies deployed the adoption theory to explain the IPv6 adoption phenomenon, the current study combines both adoption and resistance theories to investigate the IPv6 resistance phenomenon in organizations as end-users of the Internet.

Prior researchers (Dell, 2010; Levin & Schmidt, 2014) suggested conducting further studies to improve our understanding of the factors underlying IPv6 resistance among organizations as end-users. Greater understanding of IPv6 adoption might therefore need to be achieved by integrating two research areas. Prior researchers suggest combining both adoption and resistance factors (Bhattacherjee & Hikmet, 2007; Cenfetelli, 2004a; Kim & Kankahalli, 2009) to explain the adoption of a complex technology (Oliveira & Martins, 2011) and to gain a better understanding of the IPv6 adoption phenomenon.

Studies and academic literatures on IPv6 adoption have predominantly focused on several challenges including technical issues (Chasser, 2010; Che & Lewis, 2010; Czyz *et al.*, 2013; Karpilovsky *et al.*, 2009), economic factors (Dell, 2010; Rowe & Gallaher, 2005b) and policy (DeNardis, 2009; Mueller, 2006; Mueller, 2010a) and social (Dell, 2011; Hovav *et al.*, 2011; Hovav & Kim, 2006). Several have also examined the enabler and inhibitor factors which contribute to IPv6 adoption or otherwise (see Table 3.3), and have discussed why the standard is ignored although

IPv6 is considered to be the de facto standard designed to replace the current protocol. Some researchers also identify the factors which were expected to become enablers of the IPv6 adoption (Bohlin & Lindmark, 2002; Che & Lewis, 2010; Dell, 2010; Hovav *et al.*, 2011; Hovav & Kim, 2006). The following discussion highlights these challenges.

Table 3.3. Summary of Facilitator and Inhibitor of IPv6 Adoption

Reference	Facilitator	Inhibitor
Bohlin and Lindmark (2002)	• Incentive • Government involvement	• Switching cost • Long term benefit • Network effect • High cost being a pioneer • IPv4's supplemental technology
Mueller (2010a)	• Internet policy • Incentive	• IP trading
Dell (2010)	• Government policy • Perceived usefulness	• Skill and experience • Few incentives • No sponsorship • Network effect • Cost effect
Lehr *et al.* (2008)		• Power of IPv4 holder to maintain the status quo
Che and Lewis (2010)	• IPv4 address depletion • Lack of IPv4's scalability • End to end model communication • Ease to manage	• Compatibility • Perceived of benefit • Lack of experience • Business uncertainty
Hovav *et al.* (2011)	• Government sponsorship • Normative pressure	
Dell *et al.* (2007)		• Satisfied with the current system • Switching costs • Lack of IPv6 information
Gallaher and Rowe (2006)	• Government involvement • Benefit over cost	• Supplemental technology
Claffy (2011)	• IPv4 address scarcity	• IPv6 will not solve fundamental problem
Pazdrowski (2013)		• Satisfactory performance of current network

		• Unclear benefit of adoption • No tangible outcome
Pickard (2014)		• Lack of relative advantage • Lack of pressure from industry partner and customer

Firstly, the problem of slow adoption could be seen from the technical perspective. The urgency of the address depletion issue appeared early in 1990 along with other IPv4's shortcomings. Hence, it led to the introduction of parallel technical counters to deal with the problems as a temporary solution (See Section 2.5.1). The Internet authority introduced them before a long-term and comprehensive solution became widely deployed (Dell *et al.*, 2007; DeNardis, 2009). Meanwhile, the Internet authority prepared a totally new technology, IPv6, to replace the current Internet protocol (Section 2.5.2). However, some authors (Bohlin & Lindmark, 2002; DeNardis, 2009; Wellman & Haythornthwaite, 2008) believe that the optional technologies are the reasons why people resist moving, and prefer to maintain the status quo. Meanwhile, several studies attempt to measure the level of adoption in various ways. Colitti *et al.* (2010) quantify IPv6 adoption from the perspective of a web site operator. The result indicates that, despite growing significantly, the IPv6 adoption is still low (OECD, 2014). The study of Karpilovsky *et al.* (2009) quantifies the IPv6 deployment, and they find that most of the traffic concerns DNS queries and ICMP packets, indicating a lack of "productive" use of IPv6.

Secondly, some studies also discuss IPv6 adoption from the perspective of economy; people still hesitate to move due to financial considerations because the IPv6 technology is not compatible with the IPv4. As a result, the cost of moving has become one of the barriers (Bohlin & Lindmark, 2002; Dell, 2010; Hovav *et al.*, 2004). The OECD (2010) stated that the transition from IPv4 to IPv6 will take a long time since the dominant IPv4 technology is installed on current networks. While IPv6 is not backward compatible with IPv4, it becomes a substantial barrier for those who want to integrate IPv6 into their network (Limkar *et al.*, 2010). Because most of the Internet infrastructures are using IPv4, it would create high drag, inertia and conversion costs for any organization that decides to adopt IPv6 (Dell, 2010; Hovav & Schuff, 2005). Obviously, to move from a technology to a new one is costly, especially in this case when most of the Internet infrastructures rely on IPv4. Some authors (Bohlin & Lindmark, 2002; Che & Lewis, 2010; Rowe & Gallaher, 2005b) argue that at the beginning, the cost involved is not only for replacing network equipment and software, but involves other costs such as expenditures for training, hiring experienced consultants, establishing new policies and procedures, creating a supporting infrastructure and absorbing losses in productivity during transition (Fichman, 2004). Rowe & Gallaher (2005b) estimate that the U.S. needs an estimated $25.4 billion to adopt IPv6 during between 1997 and 2025. However, the authors believe that the benefits far outweigh the cost. This is because IPv6 can increase the network efficiency and decrease the maintenance cost of the global Internet (Hovav *et al.*, 2011; Rowe & Gallaher, 2005b). Furthermore, IPv6 could provide opportunities to implement more advanced IP communications that IPv4 cannot provide (Grossetete *et al.*, 2008) such as end-to-end communication, better quality of services and mobility. Some authors suggest an early anticipation for users to minimize the cost of moving (Dell, 2010; Mueller, 2010a).

Recently, as most of the allocated addresses are not actually used by users, four RIRs propose ‘IP trading’ or the transfer market (Dell, 2010; Mueller, 2008; Mueller & Kuerbis, 2013) as an incentive for those who want to sell their IPv4. This initiative is basically to encourage users to sell unused IP addresses to those who need the address. However, it also encourages people to stick with the current IP, and discourages the adoption of IPv6 (Mueller, 2008). It is even more difficult to achieve worldwide IPv6 adoption, when the IPv4 price is less than the cost involved in adopting IPv6. But the result would be different if the cost of IPv4 exceeds the cost of moving to IPv6 (Dell, 2010). Perhaps, therefore, organizations will seriously consider adopting IPv6.

The third consideration is policy which has a strong relationship with financial aspect. Hovav and Kim (2006) suggest the importance of government financial support and regulation to create a situation conducive to accelerated IPv6 adoption. They note that the speed of implementation is slow because of perceived lack of business value among Internet users. This is triggered by the risks of the adoption itself since the technology has not been globally implemented and is not compatible with the current system. Hovav and Schuff (2005) conducted an empirical study by investigating early and late adopters among eight ISPs (Internet Service Providers) from six countries. The results indicated that the young ISPs having IPv6-ready equipment had not adopted the IPv6, and they had not even turned on the feature. Similarly, Dell (2011) reported that although Australian organizations were highly aware of the IPv6, they had not yet started to integrate the IPv6 into their network. Other literatures also argue that the lack of incentive or sponsorship makes the transition much slower than expected (Bohlin & Lindmark, 2002; Dell, 2010; Hovav & Schuff, 2005). The installed base effect is one element of the network conversion to IPv6 which can be quite expensive (Tassey *et al.*, 2009). Hence the importance of government or major players' support to reduce economic risk (Hovav *et al.*, 2011), which is likely involved in the adoption. As suggested by Roger (1995), the incentive or sponsorship can decrease the cost of moving. Mueller (2006) highlighted the significance of the incentive to bridge the need of users and the need of supplier in terms of connectivity. Similarly, Hovav and Kim (2006) suggest the importance of government action via financial support and regulation to encourage the IPv6 adoption.

Finally, previous IPv6 studies also discuss the social aspect. The slow adoption might also be because there is a lack of shared values that can hold together all people's needs and expectations. Many agree that IPv6 is better than IPv4, but they have not yet deployed it. Dell *et al.* (2007) highlight the absence of motivation or willingness as users have satisfied with current technology – "if it is not broken, do not fix it". Currently, those who adopt the IPv6 still need to accommodate the IPv4 (Leavitt, 2011). The IPv6 is not a stand-alone technology and needs inter-organization participation to make it work. IT adoption studies (Kuan & Chau, 2001; Teo *et al.*, 1998) indicate the importance of environmental pressure in the success of adoption technology. Handley (2006) argues that in order to change, users need sufficient motivation. Another study (Lippert & Govindarajulu, 2006; Pan & Jang, 2008) uses a different terminology to express the same thing, namely competitive pressure. This situation will produce negative externalities when the environment is not conducive (Hovav & Popoviciu, 2009) to the adoption of IPv6. It leads to the network effect of not adopting IPv6 since the Internet needs a universal standard and the internal network needs to communicate with others.

3.6 Chapter Summary

This chapter reviews the literature on adoption and resistance theories. A review of IPv6 adoption studies is also presented. The purpose of this chapter is to identify the common perspective with regards to the adoption or resistance technology in general, and more specifically the IPv6.

The review indicated research gaps which provide the opportunity for further study. Firstly, although several empirical studies attempt to explain IPv6 adoption phenomenon, the factors responsible for the resistance have not been clearly identified. Moreover, none of the studies has investigated the IPv6 adoption phenomenon in developing countries. Although Dasgupta et al. (1999) found that the factors which influenced information technology adoption was similar between developed and developing countries, Huang and Palvia (2001) noted several challenges faced by developing countries, including lack of infrastructure, lack of a long-term strategy and lack of a computer culture for doing business. The OECD (2008b) shows that many developing countries are far behind the developed countries in their IT spending. However, more and more developing countries continue to enhance their IT infrastructure. The world economy forum (2013) reported that 70% of individuals in advanced economic countries use the Internet in their daily activities compare to 25% in developing countries. This figure indicate the different culture among the countries in using the Internet leading to a different effect of adoption factors (Baker et al., 2011).

Secondly, most of the previous IPv6 studies (Hovav et al., 2004; Martey, 2014; Pickard, 2014) were based on adoption enabler factors to explain the IPv6 adoption phenomenon. The current study also includes adoption inhibitor factors (Cenfetelli, 2004a; Cenfetelli & Schwarz, 2011) in order to understand more thoroughly the problem of why organizations resist changing to IPv6. As noted by numerous authors (Bhattacherjee & Hikmet, 2007; Cenfetelli & Schwarz, 2011; Kim & Kankahalli, 2009), the consideration of enabler or resistance factors that influence an organization's intention to use or resist IPv6 could provide a better explanation. The purpose of this study is to explore and understand the reasons why organizations as the end users of the Internet protocol resist adopting and implementing IPv6. An understanding of the barriers and the enabler factors is extremely important since the current technology is showing its age and is completely exhausted at world level; only some resources are left at the regional and provider level.

Based on the above insight and discussion along with the research gaps identified from the review of the literatures in this chapter and in the previous chapter, the next chapter discusses the research methodology for the current research project.

Chapter 4. Research Methodology

4.1 Introduction

The objective of this chapter is to explore, discuss and justify the philosophical and methodological issues which are used in the current study. This chapter discusses the rationale behind the researcher's decision to choose a particular research strategy, process, or design in order to meet the aims and objectives of the research in the most effective and appropriate way.

As noted by Fellows and Liu (2009), research methodology is related to the principles and logical procedure by applying a scientific investigation. Nunamaker *et al.* (1990) state that "*A research methodology consists of the combination of the process, methods and tools which are used in conducting research in a research domain*" (p. 632). In other words, it deals with the strategy which consists of the research paradigm, approach and techniques. Therefore, this chapter is organized as follows: Firstly, the available research paradigm is highlighted (Section 4.2), followed by a discussion of the research approaches which are used in social research (Section 4.3). Secondly, the research paradigm positioning is presented. This is followed by a description of the design adopted for this study. Fourthly, the ethical considerations related to the current study are considered. The final section is a summary of the chapter.

4.2 Research Paradigm

Research philosophy is the fundamental orientation of theory and research (Lincoln *et al.*, 2011; Neuman, 2003) which is strongly correlated to the way in which the world is viewed in order to conduct good research. Every research is guided and directed by beliefs and assumptions (Galliers, 1991; Lincoln & Guba, 1985; Neuman, 2003). There are three characteristics of belief which frame the nature of research in scientific inquiry: the existence and nature of reality (ontology); knowledge of reality (epistemology); and the process and ways of knowing that reality (methodology) (Creswell, 2009; Lincoln *et al.*, 2011). These fundamental principles inform and guide how a research is conducted (Lincoln & Guba, 1985; Neuman, 2003).

Within this domain, there are two research paradigms commonly used in Information System studies (Er, 1989; Galliers, 1991); they are positivism and interpretivism. Neuman (2003) identifies critical social science as another paradigm although it is less commonly used in IS studies. The research paradigm is interpreted differently by researchers (Goles & Hirschheim, 2000). For example, Neuman (2003) describes a paradigm as a basic orientation to theory and research. Other researchers, Burrel and Morgan (1979), defined the research paradigm as a communality of perspective which binds together the work of a group of theorists.

The positivism paradigm is based on scientific tradition (Galliers, 1991) and is a widely-used approach in the natural sciences domain (Neuman, 2003). Positivist-oriented research typically observes the phenomenon under investigation objectively and rigorously (Galliers, 1991). According to the positivist, there is an objective world that can be systematically and logically examined through empirical investigation (Sharks *et al.*, 1993; Weber, 2004). It is associated with the deductive approach in which study moves from a general relationship to specific instances (Neuman, 2003). Positivist researchers commonly use quantitative measures that present the data numerically and analyse the data using statistical tools (Sharks *et al.*, 1993). Neuman (2003) argues that positivist researchers can replicate and reproduce the results in other subjects. A positivist researcher usually uses laboratory experiments, field experiments and surveys as the research methods (Weber, 2004).

Meanwhile, the interpretivism paradigm is a research method that identifies the impact of the social system (Galliers, 1991). The objective of this paradigm is to increase the understanding of the research subject through the collection of rich data from which ideas are produced (Creswell, 2009). These paradigms influence the ways of thinking of researchers to see the relationship between knowledge and the process used to generate it. Interpretivist research is generally associated with qualitative research and inductive approaches whereby the study begins with observation and then moves to general principles (Neuman, 2003). Under this paradigm, a researcher tends to use research methods such as case studies, ethnographic studies, phenomenographic studies, and ethnomethological studies (Creswell, 2009).

Table 4.1 summarises the difference between the two paradigms, based on the works of Neuman (2003), Creswell (2009), Creswell and Clark (2011), Lincoln *et al.* (2011), Orlikowski (1991), Er (1989) and Guba and Lincoln (2005). These paradigms influence a researcher's perspective ontologically, epistemologically and methodologically.

Table 4.1. Basic Characteristics of Views Used in Research

	Positivism	**Interpretivism**
Ontology (What is the nature of reality?)	• One truth exists • Object has singular reality • The world is structured and therefore the findings can be generalized • To discover natural laws so people can predict and control the events	• Many truths and realities • Different objects have different perceptions • Findings cannot be generalised since each object is uniquely different • The reality is created through human an social interaction
Epistemology (What is the nature of knowledge and how it could be acquired and accepted?)	• Objective • Distance and partial • Generalizations are derived from experience and are independent of the researcher	• Subjective • Closeness • Generalisations are derived from experience and are dependent upon the researcher
Methodology (What is the process of research?)	• Deductive approach • Quantitative methodology	• Inductive approach • Qualitative methodology

Ontology is the study of the nature of reality (Creswell, 2009). It focuses on the question of the existence of a real world and deals with questions about what entities exist, and how the entities can be grouped and related each other's (Lewis *et al.*, 2007). There are two important aspects of ontology: realism and nominalism (Er, 1989). Realism is the main principle of positivism and nominalism is the main principle of interpretivism. According to positivism, the view of the world is structured and the entire world is subject to uniformity and the knowledge can be generalised (Neuman, 2003). However, this idea is strongly criticised by interpretivism that suggests the possibility of many interpretations of social phenomena that can occur and cannot be generalized to the whole picture of reality (Galliers, 1991). Further, interpretivism suggests that the reality is created through human and social interaction (Goles & Hirschheim, 2000).

Epistemology is the theory of knowledge and how it can be obtained (Lincoln *et al.*, 2011). Epistemology is concerned with the philosophy of how the nature of knowledge should be interpreted and how valid knowledge could be acquired and accepted. However, epistemology is not sterile from debate related to the objectivity of producing knowledge. For example, positivists believe that only observable objects are real and worthy to be studied (Guba & Lincoln, 2005). They believe that social reality can be objectively measured by using traditional scientific methods. Hence, they use quantitative measurements and statistical analysis when conducting studies. Meanwhile, interpretivists presume that scientific knowledge should be obtained by understanding the human and social interaction by means of which the meaning of reality is constructed (Walsham, 1995). Interpretivism research is generally associated with qualitative data and the inductive approach which begins with observation and moves to general principles (Neuman, 2003).

Methodology is the theory of how researchers conduct their empirical study of a phenomenon (Guba & Lincoln, 2005; Neuman, 2011). It is used to generate valid evidence and derive scientific knowledge (Orlikowski, 1991). It includes the principles, procedures and process of knowing a phenomenon thought applying a scientific investigation (Neuman, 2003). Guba and Lincoln (2005) illustrate that the research methodology basically contains an overall strategy for careful search and systematic investigation of the phenomenon in order to acquire knowledge as well as providing data collection and analysis techniques. Positivism is commonly associated with the quantitative approach and interpretivism relates to the qualitative approach. Cronholm and Hjalmarsson (2011) argue that both approaches have advantages and disadvantages. For example, the qualitative approach provides a better opportunity to achieve a deeper understanding of the phenomenon (Creswell, 2009; Neuman, 2003) and the quantitative study results can be generalized and the results are more objective and easy to replicate (Bryman, 2012; Creswell, 2009). Another approach is the mixed methods approach which is a combination of the qualitative and quantitative approaches (Cronholm & Hjalmarsson, 2011). The reason for combining the two approaches is to reduce the weaknesses and at the same time to preserve the strengths of the approaches (Bryman, 2012). In the next sections, the three research approaches will be discussed in more detail.

4.3 Research Approaches

According to Benbasat *et al.* (1987), no one strategy is more appropriate than all others for all research purposes. The choice of the approach is depending on the nature of the research. Similarly, Neuman (2003) believes that no single approach is all-powerful, and approaches should not compete with each other. Table 4.2 summarises several of the research methods which are commonly used in IS research and also states each one's weaknesses and strengths.

Galliers (1991) points out two approaches commonly-deployed in IS research: namely empirical and interpretive. While DeSanctis (1993) underlines three approaches commonly used in IS studies: positivist, interpretive and integrated approach. The current study follows Creswell (2009) in differentiating these three approaches as quantitative, qualitative and mixed-methods. The quantitative approach is primarily inspired by the positivism paradigm used to develop knowledge; this approach makes use of specific measurements to test the theory, and data is collected by means of a predetermined instrument. The qualitative approach is used by interpretivists as a means of understanding a certain phenomenon based on an in-depth and insightful investigation and analysis. Mixed-methods is the third approach which combines both qualitative and quantitative strategies in order to better understand an issue.

Table 4.2. Research Methods in Information System

Approach	Method	Key features	Strengths	Weaknesses
Quantitative	Laboratory experiment (Galliers, 1991)	Identification of precise relationships between variables via a designed laboratory setting using quantitative analytical technique with a view to making generalizable statement applicable to real-life situation	Ability to isolate and control a small number of variables which may be studied intensively	The identified relationship might have a limited application in the real world due to the oversimplification of the experiment situation and the isolation from most variables that are found in the real world
Quantitative	Field experiment (Galliers, 1991)	Extension of the laboratory experiment into the real world of organisation or society	Greater realism versus laboratory and less artificial or sanitised environments	Difficulty of finding organizations prepared to be experimented on and replication inability due to difficulty of control with only the study variables being altered
Qualitative or Quantitative	Case Study (Bhattacherjee, 2012)	An attempt to describe the relationships that exist in reality. It could help to generate new thinking and theory. Interview is primary source of data.	Describes the real picture in great detail and potentially yields the result that may not be known in advance. It can be either quantitative if it is used for hypotheses testing or qualitative if used for theory building	Restriction to a single event or organisation; difficulty in acquiring similar data from a statistically meaningful number of similar organisation; and different interpretations of events by individual researcher
Quantitative or Qualitative	Survey (Creswell, 2012)	Obtaining snapshot of practice, situations, or views at a particular point in time via questionnaires or structured interview from which inferences can be made; uses quantitative analytical techniques regarding relations existing in past, present and future	Ability to investigate a great number of variables; reasonably accurate description of real world; and more appropriate generalization	Provides little insight regarding the causes or process behind the studied phenomenon and the possibility of respondent or researcher bias occurring.

Qualitative	Action research (Bhattacherjee, 2012; Galliers, 1991)	Applied research where there is an attempt to obtain results of practical value to groups that the research allies with while at the same time adding to theoretical knowledge	Practical and theoretical anticipated benefit for both researcher and researched object. Biases of researcher are made known	Similar to case study, but additionally responsibility resides with the researcher when objectives are at odds with other groups. Research ethics are the key issue
Qualitative	Focus group (Bhattacherjee, 2012)	Involves a small group of subjects in one location	Ability to explore and build a holistic understanding of the phenomenon based on participants' comments and experiences	Single participant can dominate the discussion and internal validity cannot be established due to lack of control and the findings cannot be generalized
Qualitative	Ethnography (Bhattacherjee, 2012)	Emphasizes that the research phenomenon must be studied within the context of its culture	Sensitivity to the context, the rich and nuanced understandings it generates, and has minimal respondent bias	Takes a long time, is a resource-intensive approach, and findings are specific to a given culture and less generalizable to other cultures

4.3.1 Qualitative approach

The qualitative research approach has been used by researchers to investigate social phenomena in Information Systems. The approach was introduced into the social science domain to allow researchers to understand social phenomena (Myers & Avison, 1997). Leech and Onwuegbuzie (2007) argue that this approach allows researchers to obtain more naturalistic context and holistic understanding of human beings in society. Denzin and Lincoln (2005, p. 3) define qualitative research as:

> *"…a situated activity that located the observer in the world. It consists of a set of interpretive, material practice that makes the world visible. These practice transform the world … involves an interpretive, naturalistic approach to the world"*

According to this definition, qualitative research follows the interpretivism paradigm and inductive approach whereby the qualitative researchers are not forced to accept or reject hypotheses; rather, the goal is to acquire an in-depth understanding of the phenomenon under investigation. Qualitative researchers tend to be more concerned with the richness, texture and feeling of raw data (Neuman, 2003). The supporters of this approach believe that there are many truths and multiple realities. Therefore, the results are difficult, if not impossible, to generalise (Creswell, 2009).

However, since the findings are based on the interpretations made by researchers, positivists question the trustworthiness of qualitative research (Shenton, 2004). To deal with this issue, Lincoln and Guba (1985) proposed four criteria to measure the trustworthiness of naturalistic research: credibility, transferability, dependability and confirmability.

Lincoln and Guba (1985) point out that credibility is the most important factor for trustworthiness. It is about having confidence in the truth of findings and how they are consistent with reality. Transferability means that the findings can be applied to other situations. Meanwhile, dependability indicates that the findings are consistent and could be generated again. The last criterion is confirmability which is a "*degree of neutrality, or the extent to which the findings of a study are shaped by the respondent and not researcher bias, motivation or interest*" (p.299). Shenton (2004) summarized the trustworthy strategies based on previous qualitative studies and suggested several possible provisions to ensure the trustworthiness of a qualitative study.

Table 4.3. Trustworthiness in Qualitative Study

Quality criterion	Possible provision made by researcher
Credibility	• Adoption of appropriate, well-recognised research methods • Development of early familiarity with culture of participating organizations • Random sampling of individuals serving as informants • Triangulation via use of different methods, different types of informants and different sites • Tactics to help ensure honesty in informants • Iterative questioning in data collection dialogues • Negative case analysis • Debriefing sessions between researcher and superiors • Peer scrutiny of project • Use of "reflective commentary" • Description of background, qualifications and experience of the researcher • Member checks of data collected and interpretations/theories formed • Detailed description of the phenomenon under scrutiny • Examination of previous research to frame findings
Transferability	• Provision of background data to establish context of study and detailed description of phenomenon in question to allow comparisons to be made
Dependability	• Employment of "overlapping methods" • In-depth methodological description to allow study to be repeated
Confirmability	• Triangulation to reduce effect of investigator bias • Admission of researcher's beliefs and assumptions • Recognition of shortcomings in study's methods and their potential effects • In-depth methodological description to allow integrity of research results to be scrutinised • Use of diagrams to demonstrate "audit trail"

(source: Shenton, 2004, p. 73)

4.3.2 Quantitative approach

The quantitative approach is defined as the research which explains phenomena by collecting numerical data that is analysed using mathematics-based methods (Neuman, 2011). According to the definition, the quantitative approach is more concerned with using numerical data to explain a particular phenomenon. This type of research tends to learn ‘what’, ‘how much’ and ‘how many’ (Pinsonneault & Kraemer, 1993) and greater focus is on design measurement and sampling (Creswell, 2009). The benefit of this approach is that the result can be generalized and may be replicated or repeated for others subject to provide generalization (Neuman, 2003).

The quantitative approach is appropriate to quantify the relationship between variables in order to test study hypotheses using statistical analysis. According to Creswell (2009), quantitative data is most valuable when the hypothesis and theory have been developed and need to be validated. The investigator and investigated entities stand separately. Consequently, the investigator can independently investigate a phenomenon without influencing it or being influenced by it (Guba & Lincoln, 1994), and measure the causal relationship between variable scientifically (Lincoln *et al.*, 2011). However, although the quantitative approach produces objective results which are easy to generalise (Bryman, 2012; Creswell, 2009), some authors also emphasize the weaknesses of the quantitative such as providing very little insight in the related causes of the issue (Galliers, 1992); using irrelevant hypotheses (Neuman, 2003); and offering descriptions that are too superficial (Cronholm & Hjalmarsson, 2011).

Lincoln and Guba (1985) suggest four criteria for ensuring the trustworthiness of quantitative research: internal validity, external validity, reliability and objectivity. Internal validity refers to the extent to which it is possible to make an inference, or causal claim that the independent variables are truly influencing the dependent variable. Hair *et al.* (2010) argue that while validity is concerned with how well the concept is defined by the measure, and the reliability is related to the consistency of the measure, external validity is more concerned with the generalizability of the findings to the population. Hair *et al.* (2010) describe reliability as the extent to which a variable or set of variables is consistent in what it is intended to measure. Meanwhile objectivity is related to findings which are free from contamination in any way and could be replicated or repeated using other subjects.

4.3.3 Mixed methods

The third approach used in IS research is the mixed-methods which is a combination of qualitative and quantitative approaches into single study. According to Bryman (2012), a mixed-methods approach allows researchers to select the strengths of each approach being used and eliminate the weaknesses. Sale *et al.* (2002) argue that qualitative and quantitative methods are underpinned by several distinct philosophical assumptions. The qualitative method is based on interpretivism (Creswell, 2009); therefore there are ontologically multiple realities based on a single constructed reality and the reality constantly changes. On the other hand, the quantitative approach is based on positivism which believes that one truth exists for social phenomena.

Although both qualitative and quantitative approaches differ in many ways, Neuman (2003) believes that both methods complement each other. Other authors (Bryman, 2012; Creswell, 2009) suggest combining both qualitative and quantitative methods in order to obtain a better picture of the problem. By combining both of these approaches, the researcher has the opportunity to exploit the strengths of each approach, and decrease their disadvantages (Johnson & Onwuegbuzie, 2004). Further, a mixed-methods approach will: provide methodological triangulation of the observed object (Johnson, R. B. *et al.*, 2007); increase confidence in the study's findings more so than by using the approaches individually (Cronholm & Hjalmarsson, 2011); and yield a better result (Mingers, 2001).

The mixed-methods approach is becoming increasingly popular as a major research approach (Johnson & Onwuegbuzie, 2004) in social research. Creswell (2012) lists several reasons for using mixed methods design to conduct a study, including providing a better understanding of research problems; seeking a comprehensive picture when a single research approach is not enough to address and answer the research questions; and providing an alternative perspective in a study. Gable (1994) suggests combining the strengths of various methods in IS studies so as to obtain a comprehensive understanding of the issue. In addition, a mixed-methods design can provide more trustworthy and relevant findings (Creswell, 2009) and more complete knowledge (Cronholm & Hjalmarsson, 2011) than using either single approach individually.

Creswell (2009) defines a mixed-methods research as an approach to inquiry which combines the qualitative and quantitative form. The combination includes a procedure for collecting data, analysing, and combining both methods in a single study or series of studies in order to understand a research problem (Creswell, 2012). Similarly, Johnson, R. B. *et al.* (2007, p. 123) have considered 19 definitions before arriving at the following definition of mixed-methods:

> *"Mixed methods research is the type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e.g., use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the broad purposes of breadth and depth of understanding and corroboration"*

There are six general strategies involved in mixed-methods research (Creswell, 2009, 2012) as shown in Figure 4.1, namely (a) convergent parallel design, (b) explanatory sequential procedures, (c) explanatory sequential procedures, (d) embedded design, (e) transformative design, and (f) multiphase design.

Under the convergent parallel design, a researcher merges both qualitative and quantitative data in order to provide a comprehensive analysis of the research problem (Creswell, 2009, 2012). The researcher collects both qualitative and quantitative data concurrently and then integrates both types of data to interpret the findings. The design enables the researcher to combine the strengths of both approaches and compare the two datasets to find similar or dissimilar results.

Using sequential procedures, the researcher tries to expand upon and reinforce the findings of one method with another (Creswell, 2009). Creswell (2012) point out two kinds of sequential procedures based on the nature of procedure: explanatory sequential design and exploration sequential design. An explanatory sequential mixed-methods design involves first collecting quantitative data to provide a general picture of the research problem; this is followed by collecting qualitative data to help explain and elaborate on the quantitative result.

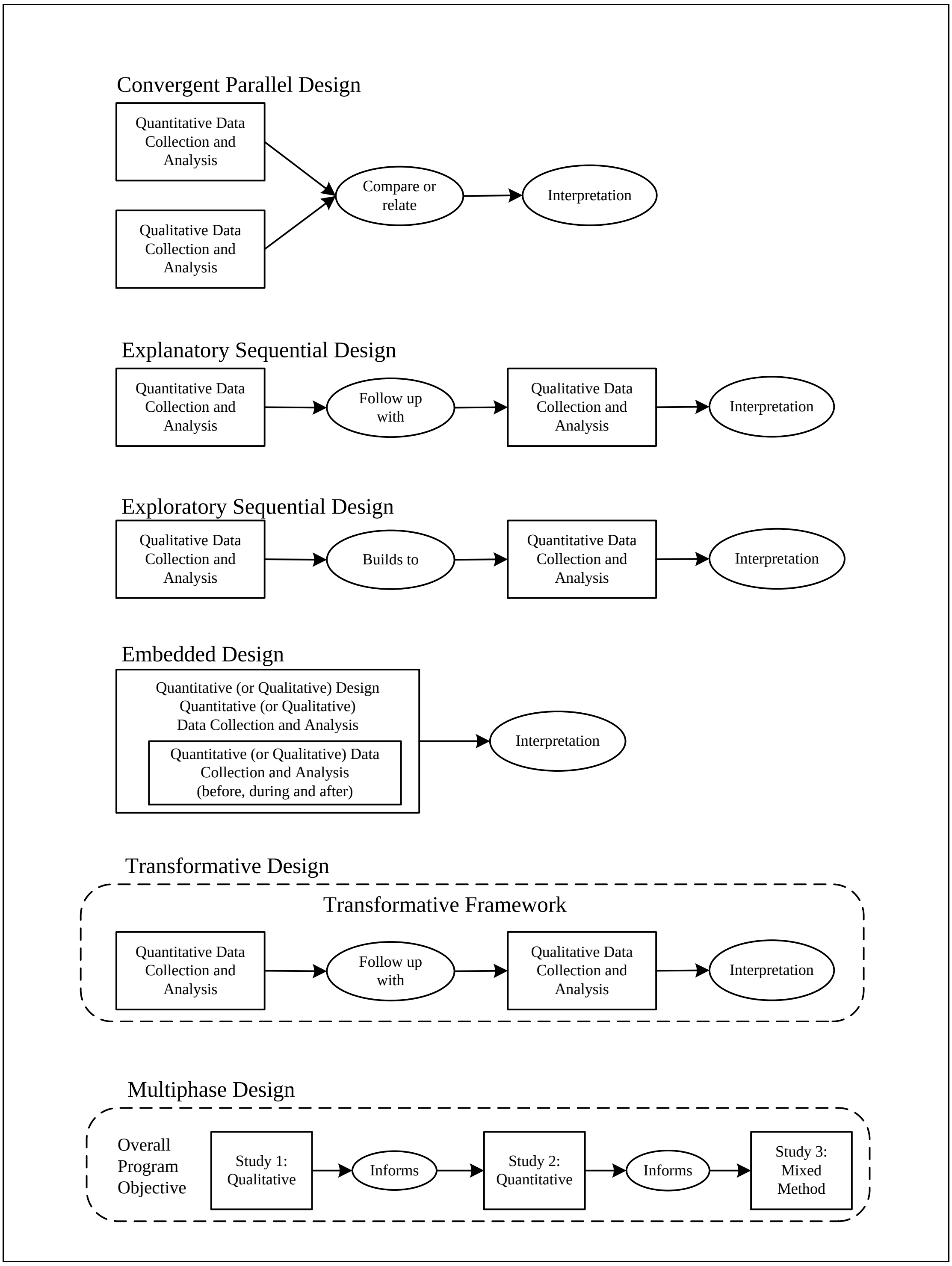

Figure 4.1. Types of Mixed-methods Strategies
(Source: Cresswell 2012)

In exploratory sequential mixed-methods design, a research begins with a qualitative study to gain an in-depth understanding of the issue and to build theory. This is followed by conducting a quantitative study in which the instruments derived from phase one are used to test and validate the theory and generalise the findings.

In the embedded design, the researcher collects qualitative and quantitative data simultaneously or sequentially. One set of data will be used as the primary data, and the other one acts as secondary data to support the findings.

Creswell (2012) classified the transformative and multiphase design as complex level design of mixed-methods. While in the transformative design, the researcher is guided by a theoretical framework for formulating hypothesis, designing instrument and method for collecting data, and predicting the conclusion (Creswell, 2009), in the multiphase design a series of studies is conducted to examine a single research problem. The idea of these designs is to understand the research problem rigorously.

4.4 Research Paradigm Positioning

Based on the ontological and epistemological stances, this study is predominantly positivist in nature. Firstly, from ontological perspective, positivist believes that an object reality can be systematically and rationally measured through empirical investigation and is strongly correlated with natural law (Sharks *et al.*, 1993). This is relevant with the research objective to uncover the valuable insight of IPv6 resistance phenomenon. Secondly, the purpose of the current research is to identify the factors that might explain organizations' resistance to adopting IPv6through in-depth interviews to obtain valuable insights regarding the cause of IPv6 resistance among organization in Indonesia. Based on the literature review (Chapter 2 and Chapter 3), a preliminary study (Chapter 4) and the findings from the qualitative phase (Chapter 6), a theoretical model is developed consisting of hypothesis to see the relationship between the research variables (Chapter 7). As Orlikowski (1991) argues, a research is considered to be positivist if there is

> *"… evidence of formal propositions, quantifiable measures of variables, hypothesis testing and the drawing of inferences about a phenomenon from the sample to a stated population" (p.5).*

Therefore, it is relevant to this study which intends to thoroughly understand the IPv6 resistance phenomenon in the context of a developing country. The theoretical model is developed based on perspectives derived from previous literatures, a preliminary study, and an exploratory study. The researcher utilised statistical tools to test and validate the measurement and structural model using SEM-PLS (Structure Equation Model – Partial Least Squares). These characteristics are aligned with the ontological and epistemological stance of the positivist paradigm.

The research methodology used for the current study is mixed-methods; a qualitative study is conducted first, followed by a quantitative study. Both qualitative and quantitative approaches have disadvantages and advantages. As stated by Creswell (2009), combining two approaches into a single study can provide a better understanding of research problems than either approach can do alone. The next section discusses the research design used to achieve the research objectives and answer the research questions.

4.5 Research Design

Burns and Grove (2010) define a research design as a blueprint for conducting a study. As described by Kerlinger (1986), a research design includes an outline of what the investigator will do with the plan, structure and strategy of a study, conceived in order to obtain answers to research questions and to control variance. Furthermore, according to Creswell and Clark (2011), research design consists of procedures for collecting, analysing, interpreting and reporting data in a research study.

After reviewing the available research approaches as discussed in the previous section, the current study follows the sequential mixed-methods strategy, more specifically, an exploratory sequential design research as described by Creswell (2012):

> *"The mixed methods researcher has a sequence to data collection that involves first collecting qualitative data followed by quantitative data. Typically in these designs, the researcher presents the study in two phases, with the first phase involving qualitative data collection (e.g., interviews, observations) with a small number of individuals, followed by quantitative data collection (e.g., a survey) with a large, randomly selected number of participants."* (pp. 543-544)

Mingers (2001) emphasizes that the reason for using mixed methods is to deal effectively with the full richness of the real world and produce a better result by examining the problem through a number of phases. Axinn and Pearce (2006) extend this view by stating that "*mixed methods strategies are extremely valuable tools for social research*" (p.2). Based on the definition above, the research process for the current study has been designed as illustrated in Figure 4.2

The preliminary study is conducted in order to obtain the recent status of readiness of Indonesian's organizations regarding the adoption of IPv6 and to deal with the research question 1 (R1). This is followed by the main study involving a sequential exploration mixed-methods approach. Neuman (2003) suggests an exploratory research in order to formulate more precise questions and then follow this up with a more systematic and extensive study. In the case of IPv6, many have discussed or investigated IPv6 adoption issues (Hovav *et al.*, 2011; Hovav & Kim, 2006; Mueller, 2010a); however, the factors involved are not well understood (Dell, 2010). Therefore, the first phase involves a qualitative study to address the 'why' and 'how' questions (Lincoln *et al.*, 2011) to obtain insights into Indonesian organizations' resistance to changing to the IPv6.

According to Creswell (2007), an understanding can only be established by becoming directly involved with the subject. He describes that the goal of a qualitative study is to identity genuinely valuable knowledge from the respondents. Furthermore, he argues that the purpose of the qualitative phase is to

> *"…develop theories when partial or inadequate theories exist for certain populations and samples or existing theory do not adequately capture the complexity of the problem we are examining"* (p. 40)

To generalise the findings, this leads to the second phase which is the quantitative study, which builds on knowledge derived mainly from the first phase (qualitative). According to Neuman (2011), quantitative methodology can produce objective, quantifiable and reliable data that is important for generalising and replicating the result. However, quantitative methodology provides very little insight into the reasons for the issues arising from the study (Galliers, 1992).

Study Phase		Process	Methods
Literature Review			
Preliminary Study (Readiness Survey)		Data Collection	- Survey - Web-based questionnaire
		Data Analysis	Descriptive analysis
Mixed-Methods	Phase 1 : Qualitative	Data Collection	Semi-structured Interview
		Data Analysis	Domain Analysis (Atkinson & El-Haj, 1996) - Preliminary Category - Taxonomy Analysis - Specifying Component - Relating the domains
	Phase 2: Quantitative	Data Collection	- Survey - Web-based questionnaire
		Data Analysis	- Data Preparation (Missing Value, Unengaged Responses, Test for Normality, Sample Adequacy, CMB) - Measurement Model Validity o Indicator Reliability o Internal Consistency Reliability o Construct Validity - Structural Model Validity o Collinearity assessment o Path Coefficients o Level R^2 assessment
Writing up final thesis			

Figure 4.2. Research Flow Process

The conceptual frameworks, developed from the previous information system study and qualitative study, is validated and the hypotheses are tested during this phase. While the strength of the quantitative data is that it produces generalizable findings, this study also develops a model of resistance to change among organizations regarding IPv6 adoption. Creswell and Clark (2011) also stressed the advantage of an explanatory sequential research design which is straightforward and easy to implement.

Table 4.4. Relationship of Objectives, Question and Research Approaches

Objectives	Questions	Approaches
OB1. To investigate Indonesia's IPv6 readiness;	R1. What is the current status of IPv6 readiness among organizations in Indonesia?	• Preliminary study – IP readiness survey
OB2. To explore, evaluate and synthesise relevant literature related to adoption of and resistance to technology;	R3. What factors lead organizations to resist changing to IPv6?	• Literature review
OB3. To identify factors that might influence IPv6 resistance among organizations;	R2. Why do organizations resist changing to IPv6? R3. What factors lead organizations to resist changing to IPv6? R4. What is the relationship between these factors?	• Literature review • Phase 1 mixed-methods (qualitative study)
OB4. To develop a conceptual model based on findings from 3	R3. What factors lead organizations to resist changing to IPv6? R4. What is the relationship between these factors?	• Literature review • Phase1 mixed-methods (qualitative study) • Phase 2 mixed-methods (quantitative study)
OB5. To validate the model in order to generalize the findings.	R5. To what extent do these factors contribute to make organizations resistant to change?	• Phase 2 mixed-methods (quantitative study)

Table 4.4 presents the relationship between research objectives, the research questions and the research approaches. In the following section, the phases of the study, namely

(a) the preliminary study, (b) the qualitative phase and (c) the quantitative phase, are discussed in detail.

4.5.1 Preliminary study (IPv6 readiness survey)

Researchers' understanding of the implementation of IPv6 in Indonesian organizations is limited. Therefore, given that so little is known about the development of IPv6 in Indonesia, the current study conducted an initial survey to examine the technology-readiness status of a wide range of organizations. The purpose of this initial study is to obtain a comprehensive empirical overview of the problem domain and to increase the researcher's confidence about the issue of the status quo of the Internet protocol adoption by the Indonesian organizations. Before conducting the main study, the researcher conducted a readiness survey as preliminary step in order to increase confidence in extrapolating findings from previous readiness studies (Dell, 2011; Pickard *et al.*, 2015) of this issue in Indonesia.

Ward and Peppard (2002) suggest assessing and evaluating the readiness level of the organisation as the first step when implementing a new technology. In terms of IPv6, Grossetete *et al.* (2008) provide a guideline to assess the readiness of IPv6 technology. Based on the guideline, Dell (2011) investigates the organisational readiness of Australian organizations and found that most Australian organizations were not ready to IPv6. Similarly, a recent study in the U.S. found that very few organizations had plans to implement it (Pickard *et al.*, 2015).

Replicating Dell's study, the initial phase of the study investigates Indonesian organizations' readiness to adopt IPv6. Five main readiness areas as suggested by Grossetete *et al.* (2008) were investigated in this study: (1) level of training, (2) planning, (3) assessment of the IT environment, (4) policy to support IPv6, and (5) status of deployment.

4.5.1.1 Participants

Since IPv6 adoption and implementation decisions are made at the organizational level, this research targeted a wide range of organizations as the end users of the Internet Protocol. As mentioned previously, there is still very little known about IPv6 development in Indonesia, especially regarding end-user organizations. The current study defines the end users as those organizations which use computer networks in their operations. Roger (1995) stated that key persons or a group of staff within the organization, which considered knowledgeable in this area, could become the organization's representatives. Therefore, the research sample was the IT policy makers or those who were responsible for managing their computer network; this included middle or senior managers and other people in IT-related positions in the computer network. Middle and senior managers hold very important positions and play a major role in determining whether or not they need to adopt a new technology. The network administrator is also a crucial position in the network environment, since they are directly involved in managing their computer networks.

4.5.1.2 Data collection

The preliminary study used a web-based survey to collect the data because of its advantages as explained in Section 4.5.3.2. The invitation email was sent to a total of 386 respondents. There were two groups of the respondents. The first group consisted of a wide range of organizations sourced from social media (LinkedIn), supplemented by snowball sampling of further organizations recommended by participants. It was ensured that respondents' organizations utilized computer network technology in their operations. The second group consisted of the top 100 Indonesian universities listed on Webometric. The researcher also surveyed the local sector of the Indonesia High Education Network (Inherent) which was not listed on Webometric. The data distribution is discussed in Section 5.3.

4.5.1.3 Data analysis

The data was analysed by using a descriptive analysis technique. Descriptive analysis provides basic features of the data and about the observations that have been made. Neuman (2003) explains that there are three major characteristics that need to be examined: (1) distribution which is a summary of the frequency of values of variable; (2) central tendency which is related to an estimation of the important point of a distribution value; and (3) variation which refers to the spread of the values around the central tendency.

4.5.2 Main study phase I: Qualitative study

As described in Sections 4.3.1 and 4.3.3, the qualitative approach is used to acquire an understanding of the practical experiences of organizations regarding IPv6. The qualitative approach is research in which one studies a few people or cases in great detail over time (Neuman, 2003). According to Walton (1992), the qualitative approach can help to generate new thinking and theory. Galliers (1991) argues that the advantage of the qualitative approach is that it can give the real picture in greater detail. Numerous previous works have contributed extensively to improving the researcher's understanding of the factors which contribute to resistance to new technology. Therefore, the objective of this phase is to explore factors that potentially contribute to IPv6 resistance – research objective OB3.

Regarding the qualitative phase, the next discussion in this section is about (1) trustworthiness considerations, (2) protocol development, (3) participants, (4) data collection method, and (5) data analysis technique.

4.5.2.1 Trustworthiness Considerations

To ensure trustworthiness as suggested by Lincoln and Guba (1985), the following discussion presents the analysis element that is implemented to ensure the quality research in the current study.

Firstly, the credibility is achieved by implementing several suggestions made by Shenton (2004). For example, the data is collected from different organizations and various sources within the organization. To increase the credibility, a friendly introduction is made to obtain early information about potential participating organizations. In order to obtain rich information, the researcher applies source triangulation by ensuring that an organization is represented by one or more key persons who are responsible for the network in the organization. The interview transcripts are sent to the study participants to ensure that thoughts and opinions have been accurately recorded. Participants are also encouraged to provide additional information and feedback. The researcher also asks the study participants' permission to be contacted via email in case there is anything that needs to be clarified.

Secondly, transferability refers to the degree to which the results of qualitative research can be generalised or transferred to other contexts and settings. In the current study, the strategies that are used to increase transferability included descriptive data and provide sufficient contextual information about the fieldwork sites (Shenton, 2004) in the form of direct quotations from the interviews. As noted by Lincoln and Guba (1985), this information enables the reader to decide whether the findings can be applied to other settings.

Thirdly, dependability is related to the consistency of the findings and possibility of being repeated in other contexts. Lincoln and Guba (1985) suggested deploying "overlapping methods" to address this issue. For this study, the dependability was achieved by combining individual interviews and focus group discussions. The process of the study is reported in detail to allow future research to repeat the current work (Shenton, 2004).

Finally, the confirmability is related to the degree of neutrality, free from researcher bias, motivation or interest. Shenton (2004) suggested increasing the confirmability level by applying triangulation. For this study, the process triangulation involves multiple sources of evidence from a wide range of organizations from a wide range of industries. The domain analysis (Atkinson & El-Haj, 1996; Spradley, 1979) method has been adopted as a proven means of data analysis which has been successfully applied in many qualitative studies (Briguglio & Smith, 2012; Molyneux *et al.*, 2005; Tow *et al.*, 2010).

4.5.2.2 Protocol development

The first step was an in-depth literature review (Chapter 2 & Chapter 3). The review had three specific purposes. First, it was conducted to acquire a basic understanding of the recent issues regarding the Internet in general. Secondly, a more detailed literature review yielded knowledge about theories related to the adoption of or resistance to technology (Section 3.2. and 3.3). Moreover, it serves to identify the current understanding regarding IPv6 adoption issues. It has been argued that the adoption of IPv6 remains silent among the stake-holders of Internet (Dell, 2011).

Based on the insights gained and lessons learned from previous literature review chapters, the researcher designed the questions intended to explore the resistance to IPv6 by integrating adoption and resistance factors. The questions consisted of salient factors from both areas as well as the factors identified from IPv6 adoption studies (see Appendix E). The more specific objective of this phase is to answer the research questions R2, R3 and R4. It is important to note that the questions are not delivered in sequence, but serve only as guides for the interviews. In the development process, the questions were revised several times in order to minimize interview bias.

The purpose of the first two questions is to discover how the Internet is used in the participants' organizations and their understanding over the existence of IPv6. As discussed previously, Internet Protocol is the most important protocol in the Internet and the only permission available to connect to it. Therefore, the researcher designed the first two questions to determine the importance of Internet technology in the organisation's operations, and the extent to which there is technology awareness. Questions 3 and 4 were designed to ascertain whether the participants' organizations had made any preparation for the implementation of IPv6. Questions 5 to 11 are related to the issues of IPv4 and IPv6. The part that the environment plays in encouraging or discouraging adoption of IPv6 inspired questions 12 to 15. Questions 16-21 required the participants to comment on the adoption of IPv6 from the organisational perspective.

Since this phase is intended to identify the enabling or inhibiting factors that might influence IPv6 resistance, any information that the participants shared regarding their reasons for resisting is treated as valuable information and then tested for confirmation during the next interview session.

4.5.2.3 Participants

Neuman (2003) stresses the importance of the sample in ensuring the accuracy and validity of a research. Pinsonneault and Kraemer (1993) argue that the selected sample has to be related to the research topic. In this phase, the current study adopted the purposive sampling technique which selects participants based on the specific purposes of the research objective (Teddlie & Yu, 2007).

The research topic of this study is related to IP address and its implementation. Therefore, the most appropriate target participants were those responsible for policy decision-making related to IT deployment in an organization. Top level management plays a significant role in encouraging or facilitating the implementation of new technology within an organization. Despite being a common term used in computing, networking and Internet areas, not all networking users are familiar with IP address terminology. Furthermore, some questions require technical knowledge which makes it difficult for those who do not have adequate knowledge to respond to them. Therefore, the sample participants should have knowledge about or expertise in Information Technology, more specific to network or Internet technology.

This step begins by identifying potential research organizations or participants for this study. The unit analysis for this study is the organizations which use IP technology in their organizational operations. As suggested by previous studies (Hovav *et al.*, 2011; Tornatzky & Fleischer, 1990), one or more key persons within the organization could be interviewed to obtain a triangulation (Flick, 2007; Neuman, 2003), such as Chief Information Officer (CIO), network manager, network administrator and system developer. These are considered as good informants in this study since they are very close to and have responsibility for the networking area (Grossetete *et al.*, 2008), either by being responsible for the network policy or conducting day to day operation. The samples were carefully selected to represent organizations using the Internet in their operations.

The samples are obtained through convenience sampling techniques, such as sending a direct invitation to potential organizations and recommendation via snowballing samples. Public information relating to potential candidates is examined, such as companies which are listed on the Indonesian stock exchange, official websites of companies or organizations, social media (LinkedIn) or other relevant sources. Once the potential participants have been identified, the interview invitation is sent together with the participant information sheet (Appendix C) and letter of consent (Appendix D) required for ethical purposes, in order to give potential participants the confidence to take part in the study. Several participants from the readiness survey are also contacted to invite them to participate in the study. The interview schedule is discussed based on the participants' convenience. Todd and Benbasat (1987) argue that the sample size in qualitative research is usually small and involves a small group of people or organizations as research subjects. Creswell (2009) states that in a qualitative study, there is no rule regarding sample size. Bowen (2008) underlines the importance of reaching theoretical saturation to ensure that no new information emerges during coding, and that existing dimensions and themes have been identified. A total of 17 organizations participated in this study. Details are provided in Chapter 6.

4.5.2.4 Data collection method

There are several data collection methods in qualitative research including observation, in-depth interviews, focus group and document study. Each of them has its advantages and disadvantages with respect to coverage, time, cost, and opportunity to clarify either questions or answers (Frechtling & Sharp, 1997) as summarized in Table 4.5.

Regarding mixed-methods data collection, Axinn and Pearce (2006) list five types of data collection methods commonly used in the mixed-methods approach, including survey, semi-structured interview, focus group, observation and historical/archival research. The current study deployed two data collection techniques: the semi-structured interview for the qualitative phase and the survey for the quantitative phase.

Table 4.6 summarizes the advantages and disadvantages of the interview techniques. Interviews play an important role in the data collection process of qualitative research (DiCicco-Bloom & Crabtree, 2006). Similarly, Neuman (2003) believes that the interview is the main tool used for gathering data in qualitative research studies. Furthermore, Yin (2003) recommends the use of exploratory qualitative study when there is little known information available to explain the phenomenon and to construct the research model. According to DiCicco-Bloom and Crabtree (2006), the semi-structured interview is guided by a set of predetermined open-ended questions but the order can be modified based on the nature of the topic. The technique gives the interviewer the opportunity to interact with participants and provides an insight into participants' behaviours, views, attitudes and feelings that cannot be directly observed (Patton, 1990). According to Neuman (2003), the interview technique can provide flexibility both to the interviewer and interviewee. In this case, Spradley (1979) states that the interviewer can deliver more explicit purposes in the interview, ask more questions, clarify what was meant more often, encourage the interviewees to provide more detailed opinions and ideas.

The interview can take various forms, such as face-to-face or by telephone (Fontana & Frey, 2005). Due to the development of communication technology, interviews can be conducted using all computer-mediated communication tools (Opdenakker, 2006).

Table 4.5. Data collection methods (adapted from Frechtling & Sharp, 1997)

Collection Methods	Description	Advantages	Disadvantages
Semi-structured interview	A dialogue between a skilled interviewer and an interviewee	- Usually yields richest data, details, new insights - Permits face-to-face contact with respondents - Provides opportunity to explore topics in depth - Affords ability to experience the affective as well as cognitive aspects of responses - Allows interviewer to explain or help clarify questions, increasing the likelihood of useful responses - Allows interviewer to be flexible in administering interview to particular individuals or circumstances	- Expensive and time-consuming - Needs well-qualified, highly trained interviewers - Interviewees may distort information through recall error, selective perceptions, desire to please interviewer - Flexibility can result in inconsistencies across interviews - Volume of information too large; may be difficult to transcribe and reduce data
Observation	Method by which an individual or individuals gather firsthand data on programs, processes, or behaviors being studied	- Provides direct information about behavior of individuals and groups - Permits evaluator to enter into and understand situation/context - Provides good opportunities for identifying unanticipated outcomes - Exists in natural, unstructured, and flexible setting	- Expensive and time consuming - Needs well-qualified, highly trained observers; may need to be content experts - May affect behavior of participants - Selective perception of observer may distort data - Investigator has little control over situation - Behavior or set of behaviors observed may be atypical
Focus group	combine elements of both interviewing and participant observation	- Quick & relatively easy to set up - Respondents feel more confident - Allows observation of group dynamics, discussion, and firsthand insights into the respondents' behaviors, attitudes, language, etc.	- Susceptible to facilitator bias - Discussion can be dominated or side-tracked by a few individuals - Data analysis is time consuming and needs to be well planned in advance

		- Useful in gaining insight into a topic that may be more difficult to gather through other data collection methods	- Does not provide valid information at the individual level - Information is not representative of other groups
Document study	Existing records often provide insights into a setting and/or group of people that cannot be observed or noted in another way	- Available locally - Inexpensive - Grounded in setting and language in which they occur - Useful for determining value, interest, positions, political climate, public attitudes, historical trends or sequences - Provide opportunity for study of trends over time - Unobtrusive	- May be incomplete - May be inaccurate; questionable authenticity - Locating suitable documents may pose challenges - Analysis may be time-consuming - Access may be difficult

Table 4.6. Interview Methods (Neuman, 2003)

Interview	Advantages	Disadvantages
Face-to-face	- Provides a highest response rate - Allow longest questions - Provides opportunity to explore topics in depth - Allows interviewer to explain, clarify which generates useful responses - Gives opportunity to observe the surrounding - Can use non-verbal communication and visual aids	- Expensive and time-consuming - Needs well-qualified interviewer - Leads to interview bias - Volume of information too large could lead to difficulty of extracting the meaning.
Email	- Give opportunity to reach a wide geographical area - Provide anonymity - Provide convenient for participant to complete the responses	- Low response rate - Responses could be late - Difficult to clarify answers - Incomplete responses
Telephone	- Quickly reaches many people across long distances - Provides a high response - Provides most of the advantages of face-to-face	- Expensive - Limited interview length - The call may come at an inconvenient time - Inconvenient when there is poor communication destruction due to background noise, interference signal etc.

The current study employed the face-to-face interview technique due to its many advantages. Two popular interview techniques used for collecting data are the individual and the group interview (Frey & Fontana, 1991). DiCicco-Bloom and Crabtree (2006) state that the individual interview allows an in-depth exploration of social and personal issues; the group interview allows the interviewer to obtain a holistic picture of the topic.

The current study used both of these interview techniques to collect data at the participants' convenience. In the Information Systems area, decisions can be made by either an individual or a group of people (Tornatzky & Fleischer, 1990). To ensure ethical considerations were accommodated, the participants were informed of the purpose of the study and were reminded that their participation was voluntary, anonymity was ensured, and they could withdraw at any time without any penalty if they felt threatened or uncomfortable with the situation. Also, the researcher asked participants' permission to have the interview recorded. To maintain participants' anonymity and avoid breach of ethics, the current study used aliases to hide the real names of participants and their organizations.

Spradley (1979) emphasizes the importance of establishing a rapport which involves trust and respect for the participants and the information they provide. It is important to develop a close and harmonious relationship in order to create a safe and comfortable environment (DiCicco-Bloom & Crabtree, 2006) for the interview process. The rapport development process commences upon making first contact with potential participants. During the interview, the respondents were asked the questions based on the interview guideline. In addition, since it was a semi-structured interview, other questions that arose during the interview provided the opportunity to capture more information from research participants. The interview session was recorded and transcripts were made to prevent interviewer bias (Rabson, 2002). Either English or Indonesian could be spoken during the interview sessions depending on the respondent's convenience. In this case, all interviews were conducted in the Indonesian language. To ensure data validation, after the interview transcripts had been done, they were discussed with the respondents to ensure their accuracy. Respondents were contacted by email if any information needed to be clarified.

4.5.2.5 Data analysis

The third step is analysing the data obtained from the interviews. Leech and Onwuegbuzie (2007) criticize the lack of guidelines available for qualitative researchers to apply qualitative data analysis strategies. Moreover, they argue that most of the leading textbooks provide information that is only very conceptual in nature and do not provide details of how to analyse qualitative data. Among available literatures, the researcher found that several authors provide guidelines on how to analyse qualitative data. For example, Spradley (1979) explains a six-step process involved in domain analysis. He argues that the objective of domain analysis is to identify the domains which represent knowledge identified from the interviews. The current study followed Atkinson and El-Haj (1996) who simplify Spradley's process into four interrelated steps: identifying the domains, constructing a taxonomy of sub-categories under each domain, specifying the components, and associating the domains. This analysis methods has been applied successfully in information systems research (Dell, 2009; Tow *et al.*, 2010) and others research fields (Briguglio & Smith, 2012; Johnson, D. *et al.*, 2007; Molyneux *et al.*, 2005).

The initial domain analysis process begins with an examination of the data in order to become familiar with the interview information and the main issues that have emerged in order to segment and categorise the themes identified from the interview data (Tow *et al.*, 2010). Creswell (2012) argues that there is no single accepted approach for analysing qualitative data and, in many cases, it requires an iterative process. Clearly, in order to become familiar with the data, the researcher needs to read the transcripts multiple times (Atkinson & El-Haj, 1996; Mills, 2010). This is followed by developing a general sense about the data and identifying the units of meaning emerging from the data. Creswell then provides a generic guideline for analysing the qualitative data as presented in Figure 4.3.

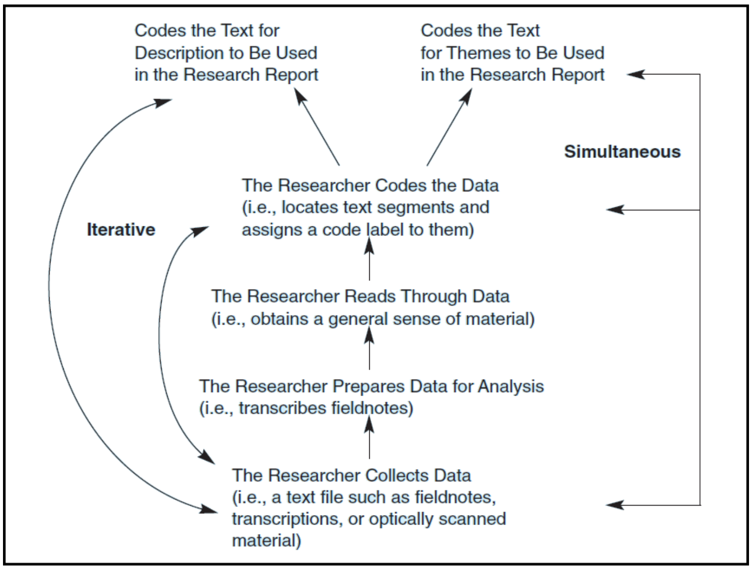

Figure 4.3. Qualitative process data analysis
(adapted from Creswell, 2012)

In extracting each unit of meaning, annotation or code can be used which accurately indicate the meaning of the text segments (Creswell, 2012). Atkinson and El-Haj (1996) recommend line-by-line coding in order to recognize the unit of meaning. This method helps the researcher to focus on the content of the text and become familiar with it. However, Moghaddam (2006) mentions two disadvantages of this technique: it is time-consuming and confusing. Since the transcription contains a mass of data, it takes a lot of time to locate the relevant information and this leads to confusion when identifying the key points in the information.

Another alternative is to analyse the text based on syntactic units such as sentences (Hillman, 1999) or paragraphs (Hara *et al.*, 2000). However, Rourke *et al.* (2001) highlight the difficulties of this method, especially for informal conversation and the less-structured flow of oral communication. Moreover, a paragraph can potentially contain multiple codes or a single code may span multiple paragraphs.

Henri (1992) proposed a thematic method to refine the two previous methods. Henri believed that the unit of meaning is lodged within meaning. Following this idea, several authors (Aviv, 2000; Henri, 1992) suggest that the unit of meaning should be extracted based on their meaning, not syntactical structures. However, this method potentially increases coding subjectivity (Rourke *et al.*, 2001), although subjectivity is an integral part of the qualitative approach where the findings are based on an interpretation of the qualitative data. In addition, in order to extract the unit of meaning, Howell-Richardson and Mellar (1996) suggest that when the participant's purposes change, this means that a new unit is created. The current study adopted this method for identifying unit of meaning. Table 4.7 illustrates the process of segmenting and categorising the unit of meaning into preliminary categories.

The researcher continues the process in order to make a list of all codes, to look for similarities and patterns in data, to reduce redundant codes and further to group them. At the end of this process, preliminary categories are produced. In the next step, the preliminary categories are refined and similar categories are aggregated to obtain a list of the dominant categories which are then termed 'domains'.

Table 4.7. Segmenting and Categorising Responses of Interviewees

Unit of meaning	Preliminary Categories
i dunno ay when i was younger i always used to put fake information up because i never really wanted people to know who i was but as i got older i got over that	*Acting*
but i guess in a way i spose from tv, ads and people talking you learn that it's not such a safe thing to put everything up about yourself. Like if you have any common sense your not gonna put up all this personal information because you know anyone can access it.	Influence from media and people *Awareness of risk*

Source: Tow *et al.* (2010)

The second process of domain analysis involves conducting an analysis of taxonomy. Taxonomy analysis is defined as a process used to identify major domains and themes in the interview data and to find relationships among subsets of domains (Spradley, 1979). As noted by Atkinson and El-Haj (1996), this stage is a useful start to arranging the actual text into the primary domains. It provides an opportunity to group all phrases together and leads to the identification of sub-categories directly from interviewees' comments. Leech and Onwuegbuzie (2007) summarize Spradley's taxonomy analysis process into eight steps, namely (1) selecting a domain; (2) identifying an appropriate substitution frame; (3) searching for possible subsets; (4) searching for more inclusive domains; (5) constructing a tentative taxonomy; (6) formulating structural questions; (7) conducting additional interviews when needed and (8) constructing a completed taxonomy. These steps are presented in detail in Section 6.3.2.

Having successfully completed the first two processes, the researcher continues to describe and support all findings that had emerged. Atkinson and El-Haj (1996) suggest using direct quotations from interviewees as supportive arguments. This is a convincing means of providing more detailed information to support the findings.

Identifying the relationship between the domain and the categories is the final step in domain analysis (Atkinson & El-Haj, 1996). In this step, the researcher attempts to develop and *"build up an overall picture"* (p. 440). As noted by the founder of domain analysis (Spradley, 1979), this step leads to hypothesis development which needs to be validated in more intensive study, since the domain analysis has two goals *"to identify native categories of though and to gain a preliminary overview"* (p. 117). After this step has been completed, the findings provide the basis for the quantitative phase of the study. The results of this step are presented in more detail in Chapter 6.

4.5.3 Main study phase 2: Quantitative study

A quantitative approach using the survey method was used to test and validate the adoption model developed previously, and to examine research objectives 4 and 5. According to Galliers (1991), this method is appropriate when the purpose of the research is to identify a great number of variables and will "*provide a reasonably accurate description of real world situation …*" (pp. 333-334). Another goal of this phase is to identify the importance of factors that influence the resistance to IPv6 adoption. It is also important to find an appropriate strategy that will encourage the adoption of IPv6. The discussion of the quantitative phase can be divided into three sections.

4.5.3.1 Participants

In general, the criteria for the participants in this phase are similar to those for the qualitative phase. However, quantitative study usually requires a large sample. According to Neuman (2003), probability sampling techniques are primarily used in quantitative research. The goal of this sampling technique is to achieve representativeness of the entire population. The next discussion is about the sample frame, sample size and participant criteria.

Firstly, the sample frame of this study is defined as organizations which use the Internet to support their activities. To implement this frame, organizations that represent a wide range of industries in Indonesia are chosen. Section 2.6 has briefly described the Internet in Indonesia. With a Gross National Index (GNI) of $3,650 on 2014, Indonesia is classified as a low-middle-income developing country. The World Bank reported that the GDP has a consistent growth above 5.0% with an average of 5.8 % for the last five years. In 2009, when many countries experienced a decline in economic growth, Indonesia still recorded a growth of 4.6%. With a large population of 256 million inhabitants[20] and a significant increase in the number of Internet users in recent years (www.InternetWorldStats.com, 2015), the need for IP addresses is expected to increase significantly in this region.

Secondly, it is suggested that for a quantitative study, the sample size should be based on the level of confidence required and the acceptable margin of error. Sekaran (2006) provides general guidelines to determine sample size in a quantitative study. He argues that a sample size of 500 is appropriate for most quantitative studies. Furthermore, the sample size is adequate if the sample size is ten times from the number of variables to be measured in a study, using the structural equation modelling (SEM) technique (Barclay *et al.*, 1995). However, a larger sample could produce a more accurate result (Neuman, 2003).

Furthermore, Bryman (2012) stresses the importance of sample size in order to generalise findings. He also emphasizes the importance of determining the minimum required sample size (MRSS). Barrlett *et al.* (2001) suggests that several factors need to be considered when determining MRSS such as the population size, level of accuracy, the type of data analysis and the impact of a lower response rate. Meanwhile, Hair *et al.* (2010) discusses the type of data analysis to be used and the rate of missing data.

The current study used SEM-PLS (see section 4.5.3.3) for analysing data which still works well with small data (Hair *et al.*, 2011). However, to ensure the adequacy of the sample, the researcher performed Kaiser-Meyer-Olkin (KMO) and Bartlett's Test of Sphericity (BToS) as suggested by Hair *et al.* (2010). The adequacy test results are presented in Section 7.5.3.

Finally, the target participants for this study were the key persons within the organizations in charge in policy decision-making or managing their network. In an organisational level study, the respondents should be the organizations' most informed and knowledgeable people in matters pertaining to the issue under investigation (Huber & Power, 1985). Similar to the previous phase, the researcher invited those

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[20] Indonesia Statistics Central Body (Government department), www.bps.go.id

who were considered to be the most appropriate people with the best knowledge and expertise within their organisation’s network.

4.5.3.2 Data Collection

As mentioned by Axinn and Pearce (2006), a varying data collection approach can provide more information and increase confidence in the empirical results. In the second stage, the survey method is used for the collection of data. Survey responses can provide an overview of a situation at a certain point in time and surveys are appropriate when the purpose of the research is to investigate a number of variables (Galliers, 1991). This method is widely used to sample a population and discover a general relationship across the population. Surveys are extremely valuable for the study of self-reported beliefs or behaviours (Neuman, 2003). Neuman lists several types of surveys such as postal mail survey, telephone interview, and face-to-face interview. Another survey method that has recently emerged is conducted online via either email surveys or web-based surveys (Lazar & Preece, 1999).

Firstly, mail survey has the advantage of being able to cover a wide geographical area, offering anonymity and avoiding interviewer bias (Neuman, 2003). However, the response rate is often low as the result of respondents late return of responses or returning incomplete questionnaires (Neuman, 2011). In addition, in some cases organizations may be reluctant to allow company time for the survey (Sekaran, 2006).

Secondly, the telephone survey is a very effective method for collecting data since nowadays most parts of a region can be reached by telephone. Neuman (2003) points out the relatively high cost and limited amount of interview time as the disadvantages of this method. If the respondent does not have access to a telephone, it is difficult or even impossible to conduct an interview.

Thirdly, the face-to-face interview survey provides the highest response rate compared to other methods (Neuman, 2003) and, furthermore, it give the interviewer the opportunity to clarify the question (Sekaran, 2006). The disadvantages of this method are that it is not economical and it takes a relatively longer time to obtain data.

Finally, since the Internet is now available in many areas, surveys can be conducted online. According to Lazar and Preece (1999), online surveys give flexibility to both interviewee and interviewer to interact, and the researcher can obtain the responses quickly. There are two popular online survey methods: e-mail based survey and web-based survey (Cobanoglu *et al.*, 2001). Recently, the cost of computer-related technology has decreased significantly with a subsequent dramatic increase in the popularity of the Internet. Wright (2005) believes that this situation offers the ability to reach a wide area very quickly and considers the online survey to be the least expensive of all survey methods.

For the quantitative phase, the researcher adopted the web-based survey as the main data collection method. Cobanoglu et al. (2001) believe that the web-based survey has significant advantages in terms of coverage, cost and response rate. Lazar and Preece (1999) argue that the web-based survey can provide data validation and provides the respondent with a more convenient means of interaction. According to Sekaran (2006), the web-based survey can provide several advantages: it is easy to administer; it can cover a wide area; it is inexpensive; the survey and the responses can be delivered quickly; and it is convenient for respondents who can answer at a time that suits them. In the case of a wide geographical sample spread, the web-based survey can efficiently reach potential respondents. Furthermore, since this study relates to Internet technology, the web-based survey could increase confidence that the respondents do use the Internet to conduct their organizations' activities. The objective of this invitation was to obtain a sufficient size to further analyse and adequately test the research hypothesis.

There were three ways in which the survey questionnaire was sent. Firstly, the invitation with the questionnaire link was directly sent to potential respondents that were identified from the preliminary study, personal references, and the industrial database (companies listed on the stock exchange). Secondly, social media (LinkedIn) was used to identify potential respondents and their organization. Once they were identified, a personal message was sent to invite them to participate in the study. More detailed discussion of this process is presented in Section 8.4 (sample design), and Section 8.5 presents sample descriptions resulting from the data collection.

4.5.3.3 Data Analysis Approach and Tools

In the third stage, data analysis is performed. This study applies the PLS-SEM (Partial Least Squares PLS-Structure Equation Model) technique to test the proposed relationship among variables in the model. SEM is a widely accepted procedure for testing theoretical relationships among constructs (Hair *et al.*, 2010). PLS-SEM can describe real-world processes better than a simple correlation model of both theory and practice (Gefen *et al.*, 2000). Venable and Baskerville (2012) believe that PLS-SEM has the primary goal of supporting the rigorous analysis of quantitative data. To be more specific, the data analysis used this method to find the relationship between variables in the context of SEM which has been applied in wide range of research topics in social and behavioural research (Goodhue *et al.*, 2012; Hair *et al.*, 2014; Hair *et al.*, 2011; Lowry & Gaskin, 2014; Venable & Baskerville, 2012).

Although some researchers question and criticise the use of PLS-SEM (Gefen *et al.*, 2011; Ringle *et al.*, 2012; Rönkkö & Evermann, 2013), the PLS method has enjoyed popularity and been used intensively in information systems and marketing (Hair *et al.*, 2011) as well as in management and organizational research (Van Offenbeek *et al.*, 2013). Rönkkö (2014) identified 247 articles that used PLS based on the Financial Times' 45-journal list published from 2003-2012, and its popularity has been increasing. PLS has been successfully applied in many complex models of IS research, such as UTAUT (Venkatesh *et al.*, 2003) and UTAUT2 (Venkatesh *et al.*, 2012). It also has widely been used in the IS research area (Kim & Kankahalli, 2009; Polites & Karahanna, 2012; Straub *et al.*, 2004; Urbach & Ahlemann, 2010).

PLS has several advantages over traditional statistical techniques (Gefen & Straub, 2005). It also can handle smaller samples which cannot be done by other structural techniques (Straub *et al.*, 2004). This is because of the statistical power of PLS always equal or larger (Hair *et al.*, 2011) than other CB-SEM, such as LISREL or AMOS. Moreover, Hair *et al.* argues that PLS can provide recommendation although the data is not normally distributed. Henseler *et al.* (2014) argued that "*PLS can help to detect a wide spectrum of measurement model misspecification*" (p. 195). This study uses SmartPLS (Ringle *et al.*, 2005) as the tool to evaluate the proposed model. Further discussion on the application of PLS as a data analysis method is presented in Chapter 8.

4.6 Ethical Considerations

The research was commenced in accordance with the ethical guidelines in the NHMRC National Statement on Ethical Conduct in Research Involving Humans and the researcher was granted ethical approval to conduct a qualitative study and quantitative study by Curtin University (Ethical Approval letters see Appendix A and Appendix B for the first phase and the second phase main study respectively). In the invitation, potential participants were clearly informed (1) about the goal of the study; (2) that their participation was voluntary, and (3) that participant confidentiality was guaranteed.

4.7 Chapter Summary

This chapter described the paradigm, approaches and techniques used to guide the current study, in addition to the research design and the details of the research process. This current study comprises a preliminary readiness study in order to obtain a general picture of the Indonesian readiness for IPv6. Then, the main study, which uses an exploratory sequential mixed-methods approach, is undertaken to identify the reasons for organizations resisting the adoption of IPv6, and to develop a model of resistance to change. The sample frame was those Indonesian organizations which use the Internet in their operations. The next three chapters present the results and findings for each phase.

Chapter 5. Readiness Survey Report

5.1 Introduction

As previously explained, the adoption of IPv6 is very rare and not widely implemented (Che & Lewis, 2010; Limoncelli, 2011). Moreover, the current protocol, IPv4, has been completely exhausted at the world level (Dell, 2011). According to the OECD (2008a, p. 4), organizations should prepare themselves for IPv6 since "*the Internet has rapidly grown to become a fundamental infrastructure for economy and social activity around the world*". Similarly, several studies (Hagen, 2011; OECD, 2010) have also raised the warning that organizations should be ready to anticipate the IP address issues. Recently, the Internet has become an integral part of various organizations to support their operations. It allows an organization to communicate effectively not only between departments or sections within the organization, but also it allows direct and convenient communication with industry partners and customers. Therefore, any problems with the Internet will significantly affect the operations of those organizations.

This chapter reports and discusses the preliminary study, which empirically examines the readiness of Indonesian organizations to adopt IPv6 technology. Furthermore, as explained in Section 4.5.1, the results of this study are used to increase our understanding of how Indonesian organizations perceive the technology in terms of their own network, and to provide a high-level empirical overview of the problem domain.

5.2 Research Methodology

This initial survey is intended to examine the technology readiness of Indonesian organizations for IPv6. As explained in Section 4.5.1.1, this survey targeted a wide range of organizations as the end users of the Internet Protocol to become research participants. The current study defines an end-user organization as an organization which uses computer networks or the Internet in its operations. The Internet has been implemented as an integral part of the business process in many organisations and to many different degrees (Smith & Fingar, 2003).

As discussed in Section 2.6, about 19.1 million IPv4 addresses have been allocated to Internet users in Indonesia and, in proportion to its 256 million inhabitants, this number is very small (1 address per 13.35 inhabitants). Moreover, there is still very little known about IPv6 development in Indonesia, especially regarding end-user organizations. Therefore, this preliminary study is used to answer research question R1 which relates to the current status of IPv6 readiness among organizations in Indonesia. The research sample criterion has been discussed in Section 4.5.1.1. Section 4.5.1.2 presented the data collection technique used to gather data from potential organizations. Section 4.5.1.3 discussed the analysis strategy which is to be deployed to analyse the collected data.

To remind the reader, the targeted participants for the current study were IT policy makers or those who were responsible for managing their organization's computer networks, including middle or senior management and other IT-related positions associated with the network. Based on the instrument from a previous readiness study (Dell, 2011), there are five aspects measured in this study related to organizations' readiness: (1) training, (2) planning, (3) assessing of the current environment, (4) policy, and (5) deployment status (see Appendix F). Grossetete *et al.* (2008) emphasize the importance of training in ensuring the smooth adoption of IPv6 technology and its integration into the organization's network and business. Organizations need to establish an early and comprehensive plan to accommodate IPv6 at some point (Svedek *et al.*, 2011). The adoption of IPv6 might not provide immediate benefit to organizations (Hagen, 2011), but it could make the transition to IPv6 smoother and less costly (Grossetete *et al.*, 2008). While there are some paradigm differences between the two protocols, it is critical to conduct an assessment of the current environment. IPv6 implementation requires a specific policy to facilitate its integration into an organisation's network. Therefore, it is essential to upgrade the current policy to incorporate IPv6 requirements. Regardless of whether IPv6 will be deployed as a short-term or long-term project, upgrading the purchasing policy is the best way to reduce the cost of implementation (Grossetete *et al.*, 2008). The last readiness criterion is the deployment status. The current study also assessed respondents' opinions about the importance and urgency of IPv6.

An online survey was used to obtain data from respondents. The invitation email was sent to a total of 386 respondents. There were two groups of respondents. The first group consisted of a wide range of organizations which were obtained from social media (LinkedIn), supplemented by snowball sampling of further organizations recommended by participants. The researcher used key words such as IT manager, IT network admin, ICT professional, Indonesia Technology Professionals or IT world Indonesia to attract potential respondents. It was ensured that respondents' organizations were utilizing computer network technology in their operations. Of the 264 invitations that were sent, two respondents refused to participate. The first respondent rejected because they were only an affiliated branch of an international company and their IT policy was determined by the headquarters. The second respondent replied that they only followed the prevailing trend and IPv6 was not their concern. Fifty-nine respondents accessed the survey page, with 47 valid responses, giving a 17.8% response rate.

The second group consisted of the top 100 universities listed on Webometric. The researcher also surveyed the local sector of the Indonesia Higher Education Network (Inherent) if they were not listed on Webometric. The reason for selecting both of these groups is that they are likely to rely heavily on computer network technology for their operations. There were total of 122 invitations sent in this category, resulting in 22 valid responses, giving a response rate of 18%.

Both groups were combined and the distribution is illustrated in Table 5.1. Since respondents could nominate more than one industry, ten respondents nominated more than one. The data indicated that six out of the eight IT consultants also belonged to other categories, such as education or communication/ telecommunication industries.

Figure 5.1 indicated that almost 70% of respondents' organizations had more than 500 employees. In terms of the respondents' position, policy makers (such as CIOs and IT managers) and network administrators accounted for 71% of the total respondents. The remaining 29% of respondents were in other IT professional positions that also have a strong connection to the network environment, such as those who are responsible for network security and design (see Figure 5.2).

Table 5.1. Respondent Industries (self-reported)

Industry	Responses
Agriculture (plantations, livestock, fisheries and other)	4
Communication/Telecommunication	5
Education and Training	27
Finance and Insurance	7
Government Administration and Defence	2
Health and Community Services	2
IT Consultant	8
Manufacturing	4
Mining	7
Property (building construction, property, real estate and other)	2
Retail Trade	5
Software Developer (Internet Content Providers, Software solution, web	4
Transport and Storage	1
Vendors (software / hardware)	1
Wholesale Trade	1
Other Organizations	8

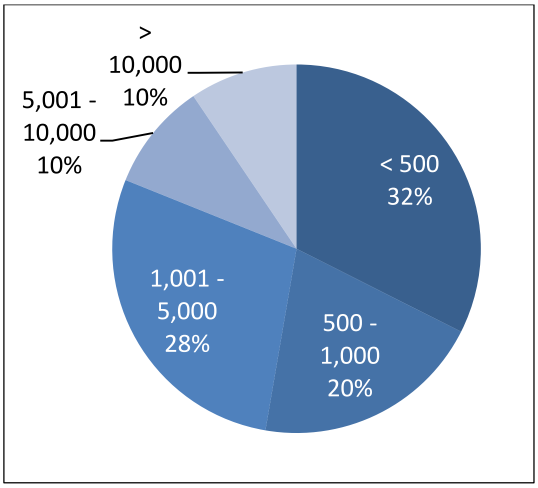

Figure 5.1. Size of Organizations

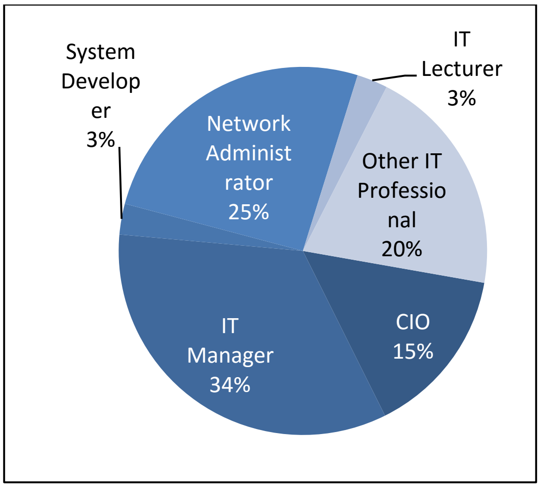

Figure 5.2. Position of Respondents

5.3 Research Findings

The level of IPv6 awareness was extremely high: only 7% respondents had not heard of the technology. The respondents who had heard of IPv6 continued with the survey; those who indicated they had not heard of IPv6 were excluded and thanked for their participation. There was no significant difference in awareness between respondents in the Education and Training category and those in other organization types (t=-1.010, p=.316), or between managerial and other position types (t=.751, p=.455).

Respondents were asked how important they believed IPv6 to be: 73% believed that IPv6 is important and only 10% believed it is not. An independent samples t-test was conducted to examine whether there was a significant difference between groups of respondents. The p-value between Education and non-education institutions was .603. Because of this, it can be concluded that there is no statistically significant difference between these categories. A similar result between managerial and non-managerial positions (p-value pf .371) also indicated no statistical difference between them. Further, respondents were asked to provide reasons for their choice. The most frequently cited reasons for a belief in the importance – or lack of importance – are summarized below:

Table 5.2. Reason for belief in the importance of IPv6

• Lack of capacity of IPv4 • To anticipate technological development • To provide better security • Reputational benefit from ipv6 deployment	• The issue was not perceived as relevant to the respondent's organisation • Minimal need for public address space • Satisfaction with the IPv4

In terms of urgency to move, the numbers of respondents who believe IPv6 adoption is urgent are slightly different from those who believed it is not: 42% of respondents believe it is an urgent issue and 38% do not. The remainder were uncertain about the urgency. The most common answers are presented in Table 5.3 .

A simple t-test was also performed to ensure non-response bias among the group of respondents on the five readiness criteria. Non-response bias potentially causes sample bias and therefore it can create difficulty in generalising the findings. In this study, non-response bias was tested in two different group categories by firstly comparing education and non-education industries, and then comparing managerial and non-managerial respondent positions in the organization.

Table 5.3. Reason for belief in the urgency of IPv6

• IPv4 has been fully allocated • Nat prevents end-to-end communication • A significant increase in IP-connected technology • Every organization needs	• IPv4 is still able to accommodate the internet connection • Nat solves the problem • The issue was not perceived as relevant to the respondent's organisation • The respondent's organisation has sufficient IPv4 address space

The result indicated that there was no non-response bias with only two indicators (deployments status) being significant. The differences were observed for the deployment status criterion between education and non-education industries which suggests that the education sector is more ready in terms of deployment status. For this reason, the data were combined for further analysis. A summary of t-test results is provided in the table below.

Table 5.4. t-Testing of Potential Sample Bias

	Education vs non-education	Managerial vs non-managerial
Level of training		
IPv6 technology	t=.334, p=.740	t=-.030, p=.976
IPv6 deployment	t=.643, p=.523	t=-.507, p=.614
IPv6 security	t=.158, p=.875	t=.075, p=.940
Configuring network	t=.995, p=.323	t=-.786, p=.436
Configuring OS & application	t=1.267, p=.210	t=-.333, p=.740
Developing application	t=.138, p=.891	t=-.634, p=.529
Planning		
Commenced IPv6 planning	t=1.907, p=.061	t=.019, p=.985
Developed an IPv6 strategy	t=1.468, p=.147	t=-.379, p=.706
Created an IPv6 project	t=1.348, p=.182	t=-.479, p=.634
Assessment of the IT Environment		
Assessed training requirement	t=1.700, p=.094	t=-.010, p=.992
Assessed IT assets	t=1.802, p=.076	t=.492, p=.625
Assessed applications portfolio	t=1.293, p=.216	t=-.006, p=.996
IT Policy readiness		
Updated purchasing policies	t=1.180, p=.242	t=-.408, p=.685
Updated application development policies	t=1.021, p=.310	t=-.166, p=.869
Updated security policies	t=1.721, p=.084	t=.293, p=.770
Deployment status		
Done IPv6 address planning	t=2.978, p=.004	t=-.681, p=.498
Deployed IPv6	t=2.645, p=.010	t=-.901, p=-.294

5.3.1 Level of training

There were six questions about the extent to which organizations had conducted IPv6 training. The results are presented in Figure 5.3.

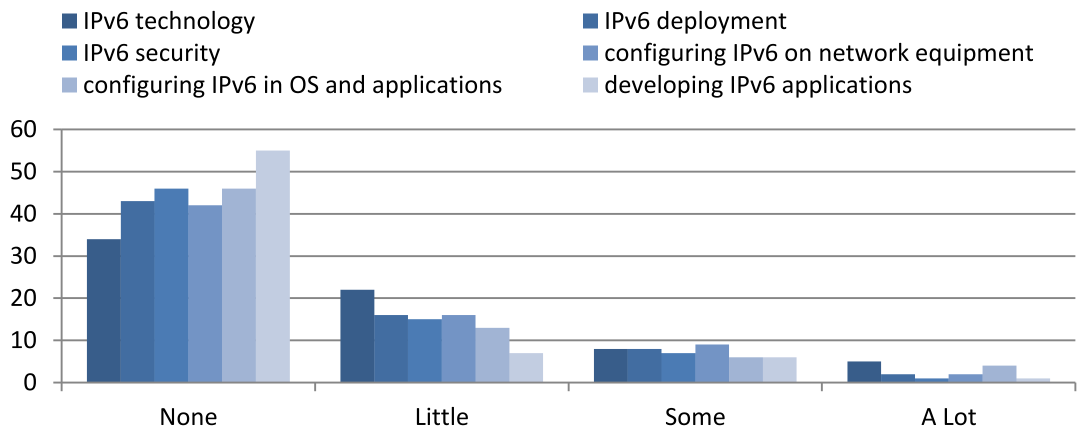

Figure 5.3. Level of IPv6 training

Very few Indonesian organizations have conducted much IPv6 training. Among the training categories, only general training about IPv6 had been conducted by roughly half the respondents. This low level of training in Indonesian organizations will affect the availability of IPv6 skills among IT people – it will likely not be possible simply to hire people from outside the organization when necessary.

IP is not only about addressing; it is a foundation technology that allows communication through the Internet or computer network. IPv6 is not backward compatible and is quite different from the previous version; hence, organizations should increase their employees' IPv6 knowledge in order to facilitate a successful IPv6 transition and implementation.

5.3.2 Planning

Respondent organizations were questioned about the extent to which they had commenced IPv6 planning, developed an IPv6 strategy, and created IPv6 projects. The responses are summarised in Figure 5.4.

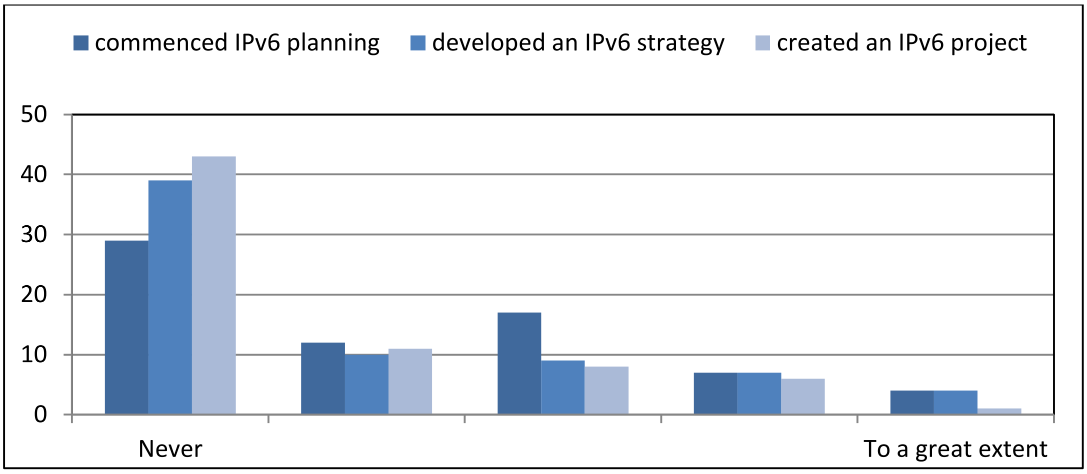

Figure 5.4. Level of IPv6 Planning

Consistent with the perceived importance of IPv6 among most of organizations, approximately half of the respondents indicated that they have already commenced planning for IPv6 at least to a small extent. However, far fewer organizations had developed an IPv6 strategy or created an IPv6 project, indicating that planning in Indonesian organizations has generally been conducted only at a basic level.

In terms of planning, one respondent highlighted the importance of planning thus: 'it will be difficult if we take action in a short time'. Indeed, according to Grossetete *et al.* (2008), early planning and having an IPv6 strategy could significantly reduce the cost of switching and operational risk (Grossetete *et al.*, 2008). An organization needs a clear direction to implement a new technology since it involves people, devices, applications and services. Planning is also important to prevent unnecessary work and minimise the possibility of implementation failure.

5.3.3 Assessment of the IT environment

Respondents were questioned about the extent to which they had assessed their training needs to implement IPv6, their IT assets and their application portfolio. The responses are summarized in Figure 5.5. It is important to ensure that an organization has sufficient resources for the broad deployment of IPV6. The results indicate that very few organizations have taken significant steps to determine the potential impact of IPv6.

Vint Cert,[21] one of the Internet's founders, argues that IPv4 will not be able to provide the necessary IP addresses, and hence migration to IPv6 is a matter of time. Organizations need to determine the resources that have to be provided to start IPv6 implementation (Hagen, 2011). This step will assist the organization to introduce a specific policy in order to make a smooth transition.

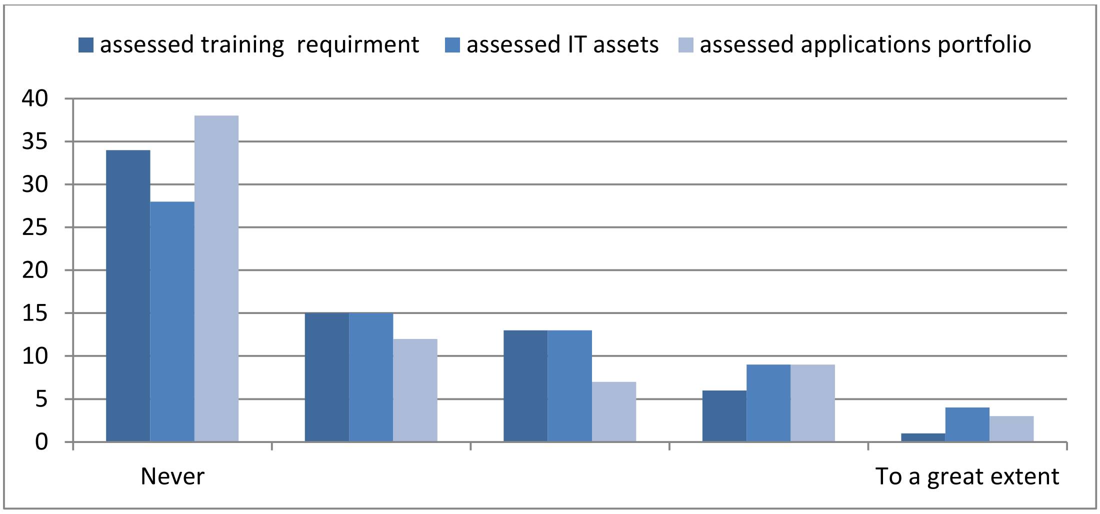

Figure 5.5. Assessment of the IT environment

The results also indicate that very few respondents have reviewed their application portfolio. In some cases, applications do not care which IP version is used in the underlying network. However, ensuring that applications support IPv6 is also important to decrease the cost of upgrade as network-aware applications will likely be affected by the transition to IPv6.

5.3.4 Policy

The organizations were also questioned about the extent to which they had updated their policy framework to prepare for IPv6. The responses are summarized in Figure 5.6.

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[21] McNamara (2010), "Why IPv6? Vint Cerf keeps blaming himself" available on http://www.networkworld.com/community/blog/why-ipv6-vint-cerf-keeps-blaming-himself, accessed on September 2012.

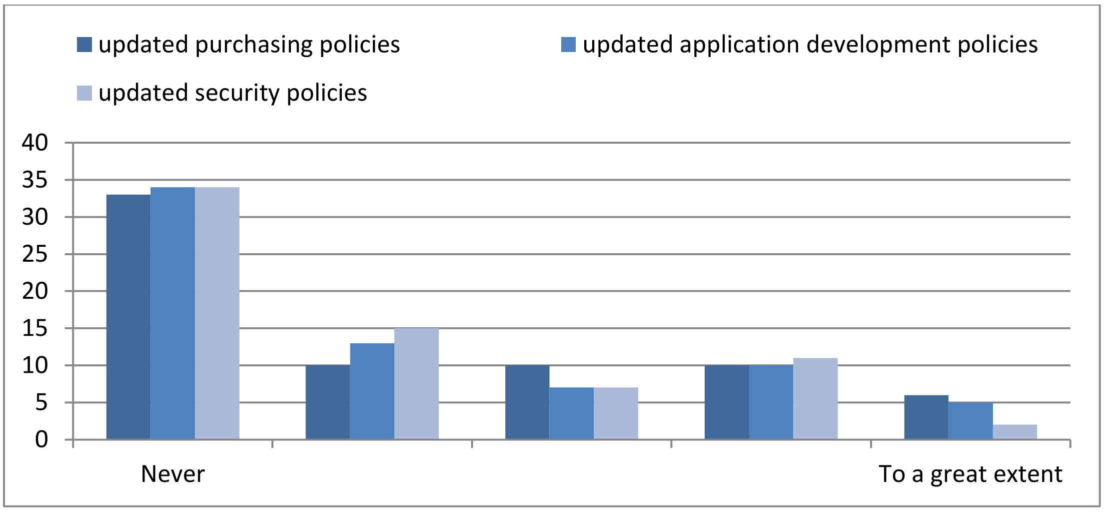

Figure 5.6. Policy Readiness

Very few organizations have updated relevant policies to prepare for IPv6. Only a small proportion of organizations have updated purchasing policies, although the cost to do so is minimal: almost 50% of organizations have not updated their purchasing policy to ensure the purchasing of IPv6-capable equipment. However, it could potentially cost a lot when they have to implement IPv6 if they have to replace IPv6-incompatible equipment. Hovav and Schuff (2005) argue that one of the barriers to the adoption of a new technology is the cost of switching, especially with incompatible technologies. However, early anticipation can reduce the costs that may arise, such as set conditions in the procurement of IPv6 ready networking devices.

5.3.5 Deployment status

Finally, respondents were asked about IPv6 deployment generally and about IPv6 address planning, which is often associated with deployment. The responses are summarised in Figure 5.7.

Very few Indonesian organizations have deployed IPv6. This is not surprising, given the low level of preparation for IPv6 in other areas. Interestingly, a small proportion of respondents have fully deployed IPv6 in their networks, mostly in the Education and Telecommunication sectors.

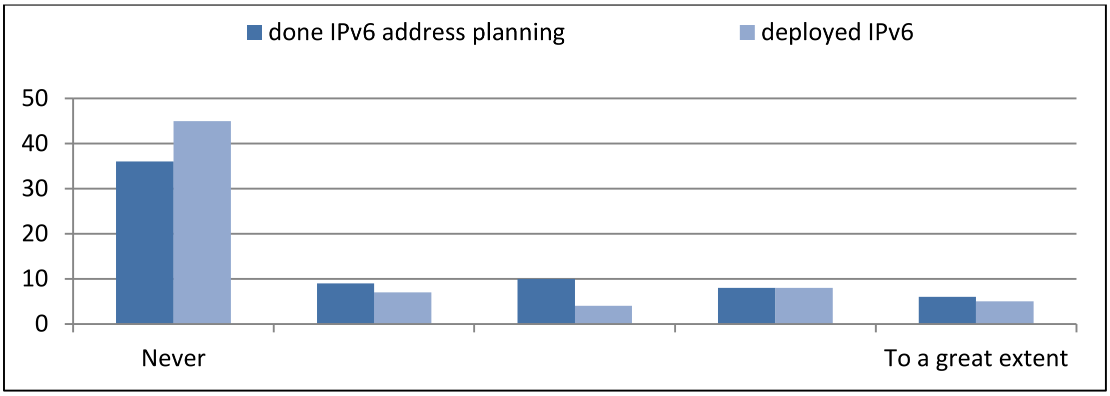

Figure 5.7. IPv6 Deployment

5.4 Discussion

The results from this survey indicate that the level of awareness of IPv6 among Indonesian end-user organizations is extremely high and the majority believe that IPv6 is important, due to problems imposed by continued use of IPv4 and the necessity to cater for the increased demand for Internet-connected devices. However, few consider IPv6 to be an urgent issue, with many believing that the current technology can still accommodate their needs.

Although IPv4 address space has been fully allocated globally, it seems that many Indonesian organizations have not taken significant steps to adopt IPv6y. Deploying IPv6 requires a multi-dimensional effort and needs a comprehensive approach involving people, devices, applications and services, for which many Indonesian organizations seem ill-prepared. The implications of this lack of readiness could include increased costs, risks and unforeseen difficulties that result from hurried and poorly-planned deployment in the future.

Finally, although Indonesia is poorly-served by IPv4 in comparison with many other countries, particularly those in the developed world, the lack of preparation by Indonesian organizations suggests that they will continue to rely on IPv4 in the foreseeable future. Nevertheless, Indonesia has an opportunity to take a leading role in IPv6 adoption and become a world leader in its deployment; given the increasing reliance on the Internet by a vast range of industries and sectors combined with the state of IPv4 in Indonesia compared with other countries.

5.5 Chapter Summary

The purpose of this chapter is to investigate how ready Indonesian organizations are for IPv6. The chapter explains that although IPv6 is considered as an important technology by most of the respondents, some did not see the urgency of adopting it. The findings of five readiness criteria, including level of training, assessment of IPv6 planning, assessment of the IT environment, policy and deployment status, also reveal that there are no significant different with the finding from previous studies with investigate the organisation's readiness on IPv6 in Australia (Dell, 2011) and America (Pickard *et al.*, 2015). These results also indicate that despite strong awareness of IPv6, there is still considerable resistance to the technology in Indonesia. This increased the researcher's confidence that it was worthwhile to conduct further study of the important factors which cause the resistance to IPv6. Therefore, the next step was to conduct a two-phase study, a qualitative phase followed by a quantitative phase, to explore the factors that make an organization resistance to IPv6. The first of these phases is described in the following chapter.

Chapter 6. Qualitative Phase

6.1 Chapter Introduction

The previous chapter found that most of the survey participants were aware of the existence of IPv6, although they had not implemented the technology in their organisation. Although they believe that the IPv6 is important, the results indicate that a minority of the respondents believe the technology is urgent. Furthermore, a majority of them had made no preparation to ensure readiness according to the five readiness criteria.

This chapter describes the qualitative phase which was deployed to enhance our understanding of the phenomenon of why IPv6 has not been widely adopted and why Indonesian organizations resist the change. As Neuman (2003) noted, a qualitative study can provide more comprehensive evidence and usually serves to develop a theory or knowledge. Similarly, Galliers (1991) believes that the qualitative approach allows the researcher to obtain a more thorough picture of the issue in greater detail. This qualitative phase provides an opportunity to increase the researcher's understanding of the factors which make organizations resistant to IPv6. The following discussion outlines in more detail the method adopted for this phase and presents the results of the qualitative investigation.

Firstly, data collection via interviews is described systematically in order to identify the key factors that cause an organization to resist adopting IPv6 (Section 6.2). This is followed by a description of the data analysis process using the domain analysis technique; as also, it presents a discussion of the findings from this phase (Section 6.3). Finally, this chapter is summarized in Section 6.4.

6.2 Data Collection

The aim of the interviews was to identify the most important factors pertaining to the resistance to change to IPv6 among organizations as the end-users of IP technology. The data was collected mainly via semi-structured, face-to-face interviews. According to Furneaux and Wade (2011), semi-structured interviews allow in-depth exploration and assist in developing an understanding of the relevant issue. Furthermore, the semi-structured interview gives the researcher the opportunity to explore any issues that emerge during the interview (Neuman, 2003).

As discussed in Section 4.5.2.3, the unit analysis for this study is organizations as end users, which use computer networks and the Internet for their operations. At the organizational level, the decision to adopt or resist change can be determined by an individual or a group (Lapointe & Rivard, 2005). It is suggested by previous studies (Chau & Tam, 1997; Hovav *et al.*, 2011; Tornatzky & Fleischer, 1990; Zhu *et al.*, 2006) that one or more key persons within the organization could be the respondents in a study of organizations. Anderson *et al.* (2006) underline the importance of representing organizations of different sizes and in different industries in organisational level research, including the information systems studies.

The samples were carefully selected to represent organizations using the Internet in their operations. The participants were also chosen by considering various sizes and operations of a wide range of organisations. Furthermore, various sources also provide triangulation to the study and by combining data from multiple sources, this can provide a more complete picture of the setting (Neuman, 2003) and also for trustworthiness reason (Shenton, 2004).

It was mentioned in the research design (Session 4.5) that the interview process began with the sending of an informal introductory email to prospective participants that described the research, briefly outlined the purposes of the study, and invited them to participate. With those who agreed to participate, a suitable appointment was made for the interview at a time and place that was convenient. A letter of consent which outlined the ethical guidelines pertaining to the study was emailed to each prospective respondent. However, two organizations could not do an interview for various reasons. Twelve organizations were involved in the interview process and five organizations were identified through the use of the snowball sampling technique, giving a total of 17 organizations.

As Frey and Fontana (1991) pointed out, that there are two popular techniques for collecting data using the interview method, namely the individual and the group interview. In this study, some organizations were represented by only one interviewee, while others were represented by more than one. This meant that some interviews were conducted as group discussions in accordance with the wishes of the respondents and at their convenience. To maintain respondent confidentiality, the researcher used pseudonyms for the respondents and their organizations, as presented on Table 6.1 which shows the organizations that participated in this study.

Table 6.1. Qualitative Phase Informants

Name	Industry	Number of Employees	Interviewee (s) role
OG1	Holding company (Agriculture, property, telecommunication)	> 1,000	Network Manager, Project Manager
OG2	Manufacturing	15,000	Infrastructure Manager, IT Planning Manager, Network Engineer
OG3	Banking	18,000	Infrastructure Development Manager
OG4	Food services	7,000	IT Infrastructure and Service Manager
OG5	Wholesale trader	10.490	CIO, Infrastructure Manager
OG6	Energy	6,000	CIO
OG7	Agriculture	12,000	CIO, Infrastructure Manager
OG8	Information Media	900	IT Manager
OG9	Mining	6800	CIO, IS Manager, Infrastructure Engineer
OG10	Gas and oil	400	Network Infrastructure Manager
OG11	Pharmacy	6,000	CIO
OG12	Gas Transportation	660	CIO, Network Manager, Network Engineer
OG13	Public Education	3,980	CIO, Network Engineer, Application Developer
OG14	Cement industry	6,800	CIO, Infrastructure Manager, Application Manager, Network Engineer
OG15	Government	7,686	Head of IT department
OG16	Private Education	7000	Head of IT Department, Network Engineer
OG17	Construction, Property	800	CIO, Network Manager, Application Manager, Network Engineer

The data was collected using face-to-face interviews and at the end of each interview, participants were asked whether the researcher could contact them by email if necessary. The face-to-face interview provides some advantages over other data collection methods as explained in Section 4.5.2.4. As Neuman (2003) pointed out, face-to-face interviews have the highest response rate and allow many questions to be asked. The interviewer can also observe the surroundings and capture non-verbal communication, including body language. The interviewer has opportunities to observe a level of discomfort or enthusiasm of the interviewees regarding the topics being discussed. It is important to maintain a friendly conversation during the interview process (Spradley, 1979). Moreover, face-to-face interviews allow the interviewer to control the interview process and ensure that the informants remain focused (Neuman, 2003). The face-to-face interview is free from technological distraction (Illingworth, 2001), unlike the online interview. Although the online interview is more convenient for the respondents, it is often interrupted by other distractions such as responding to incoming messages, emailing, updating social media status or web surfing. All interviews were conducted from February to March 2013 at the participants' offices. A consent form was provided prior to commencing the interview session to ensure that ethical guidelines were followed and participants had a clear understanding of their rights and position during the interview process. The interview or discussion session was guided by an interview guide (see Appendix E), which was developed based on the literature to allow the researcher to explore in depth the factors which potentially lead to IPv6 resistance. Other questions that arose during interview could capture more data from the respondents (Spradley, 1979). All interviews were conducted in the Indonesian language. Each interview took about 40 minutes on average and was recorded for later analysis of the data.

As suggested by Yin (2010), the permission for digital voice recording was obtained from informants before the interview session began. The use of an audio recorder assisted the interviewer to be more focused on the interview. However, due to a technical problem, the recording of participant OG17's interview was lost. Therefore, the information from OG17 was based on the researcher's notes. All of the audio recordings were transcribed in order to prevent interviewer bias (Rabson, 2002).

Mills (2010) argues that although the transcribing process is time-consuming but it has two purposes in the data analysis process. Firstly, spelling and grammar are features of verbal communication. Therefore, this allows the interview data to be formatted into a usable form. Secondly, the transcription allows the researcher to 'hear' the interview again and become more familiar with the text and extract common themes. The transcripts were discussed with the respondents in case anything needed to be changed or clarified. Only one informant suggested a minor revision, the rest gave no feedback so it was assumed that they accepted the transcripts. Although the interviewer also took some notes during each interview session, the transcript served as the main source for data analysis, except for OG17 due to the reason mentioned previously.

While the Indonesian language was used during the interviews, the transcripts needed to be translated into English. Temple (2002) mentions that cross-language research involves a translation process. For the translation, this study deployed a single-translation process (Neuman, 2011) whereby the source is translated to the target language. Lincoln and Guba (1985) underlined trustworthiness as the degree of rigour in a qualitative study and therefore, to ensure transparency and trustworthiness, the translations were done by a third-party translator who was also a lecturer in English studies at a leading Indonesian University. It was expected that the translator could provide accurate translations. Further, the researcher also performed back-translation (Brislin, 1970) to ensure the consistency of the translations (McGorry, 2000). From the translation process, the study yielded 289 pages of text for further analysis.

Determining a sufficient sample size in a qualitative study is quite challenging (Yin, 2010). Unlike a quantitative study where an adequate sample size can be statistically calculated (Hair *et al.*, 2010), a qualitative study relies on theoretical saturation to justify adequate sample sizes. Theoretical saturation occurs when all relevant dimensions and relationships have been identified and when there is little possibility that new insight will be obtained from continued sampling (Neuman, 2011). Creswell (2012) suggests that when the researcher reaches this point, it is a subjective assessment to ensure the saturation point. Hence, in relation to the number of samples used in this study, the question is whether the sample size has been sufficient enough to provide a thorough understanding of the factors causing organizations to resist IPv6. Although theoretical saturation was reached within the first 13 interviews, after which no new concepts or themes emerged, the researcher continued to interview participants to establish more credible results.

6.3 Data Analysis

This section documents the domain analysis of participants' responses to IPv6 resistance topics. As described in Section 4.5.2.5, the process of domain analysis (Atkinson & El-Haj, 1996) consists of four sequential interrelated steps, including (1) identifying the domains and subdomains, (2) construction a taxonomy analysis of the domain and sub-domains, (3) specifying the components, and finally (4) relating the domains. The next sections describe each domain analysis process.

6.3.1 Preliminary analysis

The analysis process started after all transcripts had been done and an impressionistic reading was used in order to obtain a general sense of the interview data. The researcher read the transcripts in their entirety several times in order to become familiar with emerging topics (Agar, 1996; Atkinson & El-Haj, 1996; Mills, 2010). Annotations were then made to highlight relevant information for further analysis. These annotations were used as an entry point to the coding process. Creswell (2012) explains that the purposes of the coding process include: reducing the interview data, making sense out of text data, labelling the text segment with codes, examining for code overlap and redundancy, and grouping the codes into relevant themes. Madison (2011) emphasizes that the main point of the coding process is to reduce the data to meaningful themes.

Based on Atkinson and El-Haj (1996), the interview contents were analysed, coded and grouped into preliminary themes. Then these preliminary themes were analysed further to identify any regular patterns that emerged to form primary domains. This process identified 16 themes as presented in the Table 6.2.

Table 6.2. Preliminary list of themes

Lack of Motivation:

No business pressure, business still fine, lack of business need, not booming, no burning platform, no problem with the current IP, no urge to move, no business value provided, not urgent, still far away based on the current situation, a lot of vacant public IP addresses, no business justification

Replacement Benefit:

No clear benefit, no advantage, wasting time, worthless, IPv6 less common, very rare implementer, no need for the features, no immediate and direct effect on company's profit.

Need for IPv6 Features:

A limited consumption of public IP addresses, can be solved by some supplementary technologies, just asked the provider for additional address, only need public IP for NAT and public server, virtual server decreases the need for public IP, important but not now, unproven, untested, not common, not commonly used, may be more secure, too advanced, does not make network better.

Replacement Intention:

IPv6 is too advanced, no plan to adopt it, later not now, not urgent,

System Upgrade:

Business still fine with IPv4, no problem with the current IP, limited need for IP public addresses, provider will provide additional address when needed, upgrading only relevant to ISP, prefer to stay with the current system.

Convenience with IPv4:

More dominant, still rely on IPv4 network, more familiar, convenient, easy to administer, easy to remember the address, commonly used in the Internet, less complicated.

NAT contribution:

Mostly rely on NAT, securing the internal network, reducing public IP addresses need, easy to implement networks policy, separating public and local network, acting as gateway, making internal network invisible, allow to fully control internal network, more secure.

IPv4 reliability:

Proven technology, works fine, accommodates business needs, no significant problem, no IP address depletion problem, no major performance issues.

Upgrading effort:

Requires major devices replacement, lack of personnel skill, lack of experience, lack of technical knowledge, lack of human resources, not easy task, remarkable/extraordinary effort, needs to be well planned, requires comprehensively evaluation.

Worry:

> *Interrupts other IT projects, disturbs organisation routine, difficult to implement network security policies, security implementation without NAT.*

System compatibility:

> *Need to upgrade skills, existing technology or application may not comply, problem to communicate with the rest of the world.*

Investments loss:

> *Not an issue as long as businesses require it, technology needs to be refreshed, common things in business, business requirement can justify cost, old devices increase maintenance cost*

Transition cost:

> *Could be a problem, needs careful planning, company will allocate the budget if business required it, most devices are ready for IPv6, some jobs have been outsourced, managed service could reduce the cost.*

Uncertainty cost:

> *Can be reduced by careful and good strategy*

Government pressure:

> *No pressure from government, government doesn't care, government doesn't facilitate the deployment, provides little intention on deployment*

Regulator pressure:

> *No regulation forcing a move, lack of pressure from Internet regulator, no pressure from industrial regulator (such as banking or oil industry), no pressure from vendors, provide incentive but no effect on organization.*

The *lack of motivation* was the most common theme raised by all participants. One participant stated that although his organization has deployed IPv6 to a limited extent, they explained that this did not originally come from organizational need – it occurred because their organization obtained the IPv6 address space for free as part of the regulator's incentive program to accelerate the use of IPv6 among Internet communities. A review of the dataset indicated that several other factors were frequently mentioned by the majority of participants and emerged during analysis were *replacement benefit, IPv6 features need, IPv4 influence, upgrading efforts, worried, system compatibility, convenience with IPv4, IPv4 reliability, NAT effect, replacement intention loss, transition cost, government influence* and *regulator influence and* *system upgrade*. Following Atkinson and El-Haj's method, these factor categories were further analysed to identify broad domains in which the preliminary topics above could be grouped together. Table 6.3 illustrates the final list of primary domains.

Table 6.3. Primary Domains identified

Resistance to change
Lack of felt need
Satisfied with the current system
Perceived threat
Switching Cost
Lack of environmental Influence

The first domain, *resistance to change*, refers to the group of comments which related to preserving status quo and resisting the transition to IPv6. This domain was not surprising due to the fact that IPv6 adoption is extremely rare among participants' organizations, with only OG13 having deployed IPv6 within their network to a limited extent.

The second domain, *lack of felt need,* refers to comments about the absence of perceived direct or indirect advantages of adopting IPv6. As suggested by prior study (Premkumar & Ramamurthy, 1995), potential users will adopt and implement a new technology if there is a genuine internal need and business will benefit from the adoption.

The third domain, *satisfaction with the current system* refers to comments about IPv4 as the common protocol deployed to serve the network connection participants' organizations. Based on the status quo bias theory (Samuelson & Zeckhauser, 1988), humans will preserve the status quo and maintain the current status or situation when they feel satisfied with the current system.

The fourth domain, p*erceived threat,* refers to the possible threat associated with the adoption of IPv6. Perceived threat has been recognized in adoption and resistance studies as a perception that determines resistance behaviour (Bhattacherjee & Hikmet, 2007).

The fifth domain, *switching cost,* emerged from the data related to the cost associated with the switching of technology. The dataset revealed that the participants would assess and compare the cost and business benefit obtained from the implementation of new technology. Remarks made by study participants clearly indicate that switching cost is a less important consideration when making a decision about whether or not to adopt and implement a new technology within an organization.

Finally, *lack of environmental influence* refers to the comments related to the lack of external influences which might encourage organizations to adopt IPv6. In this study, the regulator consists of (1) the institution which manages and distributes IP addresses (such as IANA, APNIC, IDNIC and ISPs), (2) the industrial regulator which is responsible for determining the standard used in the industry (such as Bank Indonesia as the banking regulator in Indonesia), (3) the government which can assist in developing a supportive environment and policy to stimulate and accelerate the adoption of a new technology, and (4) other organizations, such as industry partners or other affiliated organizations.

6.3.2 Taxonomic analysis

Atkinson and El-Haj (1996) state that the second stage of domain analysis involves the identification of the main issues and grouping the actual text from the interviews which called Taxonomic analysis. It is scientific tools for classifying observations into groups (Ivens & Valta, 2012) and to provide a conceptual framework for discussion, analysis or information retrieval (Spradley, 1979). Onwuegbuzie *et al.* (2012) describe that taxonomic analysis help the researcher to understand the relationship among the domains by creating a classification system that categorized the domain in a pictorial representation.

In this stage, the interrelationships between the domains identified in the previous stage are discussed. As suggested by Atkinson & El-Haj, the interviewee's own words to group the actual phrases together and describe the identification of sub-categories in conducting a taxonomy analysis. Figure 6.1 presents the diagram of taxonomy analysis

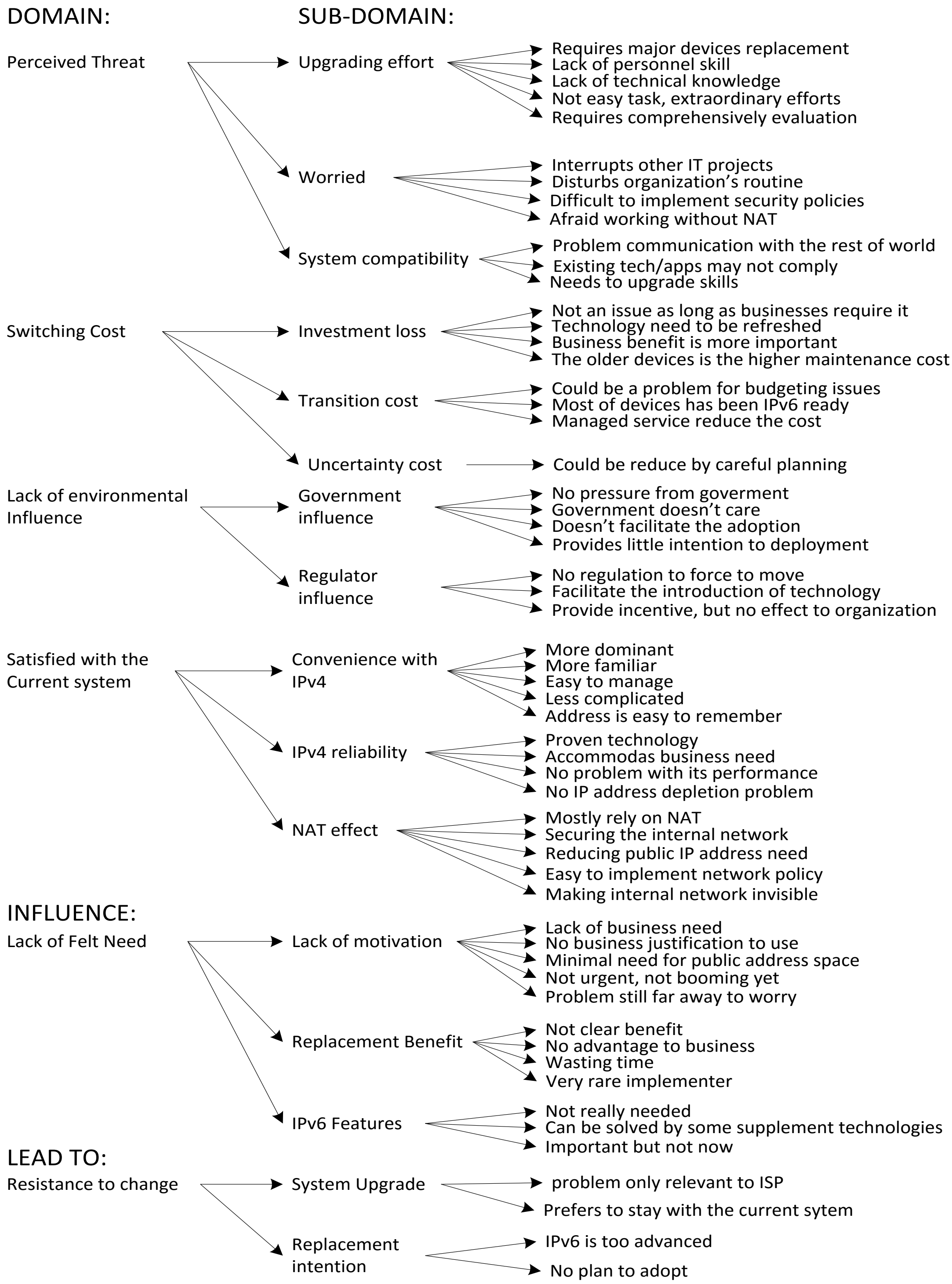

Figure 6.1. Taxonomy Analysis of IPv6 resistance

This taxonomy describes how the domains identified in the previous stage contribute to organizations' resistance to IPv6. The figure indicates that there are four domains that highly contribute. First, high upgrade effort, feeling worried about compatibility contributes to perceived threat. Second, the absence of government and internet regulator support constitute the second domain, lack of environmental influence. The next domain, satisfied with the current system, was determined by participants' experience with IPv4, including convenience, reliability and IPv4 features. Finally, lack of felt need was identified as an important domain as the result of participants having low motivation to adopt IPv6; adoption provides no benefit to the organization and the features offered have not been needed. On the other hand, switching cost has little influence to make participants resist IPv6.

Next on the following section will specify more specific the component which allow the researcher to provide adequate sources for discovering domains.

6.3.3 Specifying the components

The third step of domain analysis is specifying the components. In this case, Atkinson and El-Haj (1996) suggest that direct quotations from the interview participant's responses be included as evidence. Based on the previous two steps, the rest of this section will specify each of the primary domains and provide contextual evidence in the form of direct quotations from the interview data.

6.3.3.1 Resistance to change

It should not be surprising that resistance to change became the central concern of this study. Despite its more advanced features and the fact that it is the only standard to replace IPv4, the adoption of IPv6 is still very rare. Although resistance to IPv6 was the topic most frequently discussed during the data collection process, several additional insights were provided by interview participants as presented in Figure 6.1. An examination of each of these insights is provided in the following discussion.

The interview with the participants indicated that the majority of them had little intention to replace IPv4 as the common protocol which they currently used with IPv6, as the following comments indicate:

> *"… One day perhaps our company will use it. It may be yes, but not now"*
> *.. [OG02]*

"Frankly, we got this kind of insight about two or three years ago about the need of IPv6 and so on. But at that time we also see… I don't think we're ready… what is the necessity for us? .... *[OG06]*

Even though at the global level it has been made known that IPv4 addresses have been completely exhausted, IPv6 has not been a priority for organizations and there have been no plans to implement the technology. The following remarks attest to this:

"We haven't started arranging the roadmap toward it, even on the latest roadmap. We just finished organizing IT strategy for year 2013 up to 2016. And we haven't mentioned IPv6 there" .... *[OG03]*

"…we haven't implemented it. Not yet, even the planning we haven't done it. Also we haven't planned to move to an IPv6 based network" .... *[OG04]*

Lack of intention to move to IPv6 was also due to the fact that some participants believed IPv6 was too advanced for their organization. The following remark illustrates this:

"For our organization, IPv6 is too advanced. We only use very basic Internet such as browsing, emailing. And the current protocol has sufficiently accommodated our network. Till recently, we don't have any plan to use IPv6 within our network" .... *[OG01]*

Furthermore, system update is meaningful only if the system contributes to business performance, obtains business advantage or increases organizational competiveness. Another reason for upgrading the current system is if there is a problem with it. However, when the existing system works well and is still able to accommodate the organization's business needs, a system update will not be worthwhile. As Dell *et al.* (2007) note "if it's not broken, don't fix it". Participants' comments indicate that they do not any issue with the current system.

"It doesn't mean we're not aware but IPv6 is not booming. Just like 3G, or now we have 4G, WiMAX. We know the advantages, but well … we haven't needed it. For our organisation, we've heard about the issues. However, it may be later on. I have heard, but just like 4G, it may be next time. It is still like a dreaming. We are wasting our time to learn about it" .... *[OG05]*

Moreover, all participant organizations utilized public IP for public connection only, to allow their server to be accessible from the Internet. Hence, the number of public IP addresses was limited and the current stock has been sufficient for their needs. The majority of participants believed that the problem was not perceived as relevant for them as the end-users of the technology. They believed that it was mainly the ISPs that would have to deal with the issue. These responses were similar to the findings of readiness studies and the literature. The following opinions illustrate this concern.

> *"Frankly, two or three years ago we got such kinds of insight about the need of IPv6 technology and so on. But at the same time we also believed that ISPs and NAP[22] should be forced to adopt it first" .... [OG06]*

> *"If ISP or provider can endorse the implementation of the technology, Enterprise will automatically follow it. Also what I see, people fell that there is no urgency to use IPv6, despite run out of IPv4 addresses" .... [OG11]*

> *"Well we think as long as our devices support the system, it doesn't matter. We need public IP only for NAT. We are internally still using IPv4. It is fine for our internal needs. We use private IP for LAN. Public IP actually concerns only for external. So as long as we can use network address translation, the rest is a part of the provider's job" .... [OG10]*

6.3.3.2 Lack of felt need

The domain of *lack of felt need* consists of three sub-domains, including *lack of motivation*, *replacement benefit*, and *IPv6 features*. The first sub-domain, *lack of motivation*, refers to comments that there was no strong reason for participants' organizations to adopt IPv6 and this leads them to resist the technology. Lack of motivation from business perspective or lack of business case was the most common factor mentioned by all participants. Although they agree in certain things, for example, they agree that IPv6 was important but lack of business case discouraged them from using it. By definition, a business case captures the rationales or justification why the business communities should accept and adopt a certain technology (Carroll & Shabana, 2010). According to Berghout and Tan (2013), business case is an essential criterion for project success. Also, it is important to note that a technology in organizations is intended to support their business process and

[22] NAP (Network Access Point or Network Access Provider) provides both logical and physical connections which allow ISPs (Internet Service Provider) to interconnect to each other.

organizations can obtain business advantages from the implementation (Peppard *et al.*, 2007).

For several years now, the issue of exhausted IP address space has become a hot topic among the Internet communities. However, these problems were not necessarily serious issues in the participants' organisations. Although IPv4 has been exhausted at the global level, in the internal organizations, the issue has no effect on the organization's operations. Furthermore, some participants also emphasized that their business was still fine and did not have any problem with address space. The following remarks are typical of comments made in this regard:

> *"... The global level it has been depleted. But internally, we haven't got any problem over the exhausted of IPv4 yet"* .... *[OG09]*

Although IPv6 offers more attractive feature than IPv4, this does not mean that an organization will quickly adopt it. IPv6 appears to be less attractive as illustrated by the following participants' comments:

> *"We will explore the IPv6 further, but not this year. Maybe it will be in the next two or three years"*.. *[OG01]*

> *"Not even the planning… Yes because we haven't needed it. But we are aware of it. But if we associate it to our need, we haven't needed it"* .... *[OG10]*

> *"It doesn't mean that we don't want to use it. But maybe it will take a long time to be applied for the current organizational need for IP address"*.. *[OG09]*

> *"If we are talking about business, the people are not really aware of the IPv6. Even in the IT world, it is not so attractive"* .... *[OG11]*

Currently, all participants' organizations relied on private address space for their internal network and public addresses were used only to serve the devices which were directly connected to the Internet or as a gateway to allow the internal network access the Internet. Therefore, there was little need for public address space. Even the current public addresses have not been completely utilised. Additionally, it is very common that organizations in Indonesia obtain the public address space from their providers, not directly from IDNIC or APNIC, for example. Among the participants' organisations, it was only OG03 and OG13 who obtained their public IP addresses directly from IDNIC. Commonly, the allocated public addresses are a part of the procurement contract for Internet connection to the provider. The following comments are representative of the responses:

> *"…. We have 32 public IP addresses, and only a half are currently used" ……………………………………………………………………………………(OG09)*

> *"We don't have a lot of public IP addresses. The address is based on our current need. If I'm not mistaken, it's about 8 IP addresses are being used, but we have reserved 16 addresses. The address space is from our provider" ……………………………………………………………………………………(OG04)*

> *"Our public IP addresses, it's 16 plus 16, [makes] 32 addresses and [plus] 8 addresses. So the total is 40 addresses. Yes, there are 3 providers. There are two [providers] in there [the main branch office], and one [provider] is here…That's pretty sufficient"……………………………………………(OG10)*

The second identified sub-domain is *lack of replacement benefits* which relates to having less concern about the benefits obtained from IPv6 adoption. Although IPv6 was considered as an important technology, the majority of participants could not see the benefit of their organization adopting IPv6 for several reasons, as noted in the following comments.

> *"Of course it will [give benefit], although we haven't known yet how far the benefit will be. But I'm sure all technology development, whatever it is, it surely gives benefit… We don't know exactly whether or not the IPv6 gives benefit to our company" ……………………………………………………………(OG07)*

> *"Well, for my and Mr. XX's level, before we talk about a project, we have to do a [feasibility] study first. We have to see what the technology is and what our expectations of the technology are. Also, we investigate the cost and the benefit. Further, it should be considered whether it has been aligned with the group decision or not. So today we cannot comment on the loss and the benefit since we haven't conducted the study" ……………………………………… (OG05)*

> *"…what is the real need for us? Although many say it is important and so on. I try to challenge." ………………………………………………………………(OG06)*

Because there is still great reliance on IPv4 technology, any transition would require a huge effort and possible loss of performance. The majority of participants made negative comments, and perceived that there was no advantage to be gained from moving to another technology, it would require a huge effort and would be time-wasting, as illustrated in the following:

> *"As I said before, for implementing IPv6 it means the infrastructure has to be ready, so we need to prepare our infrastructure. On the other side, the numbers of our devices can be counted, not too many. So we believe the adoption will not be worthwhile"..(OG02)*

The third-sub domain is *IPv6 features* which refers to the comments made by respondents regarding the features of IPv6. As explained in Section 2.5.1.1, IPv6 is superior to IPv4 and addresses the shortcomings of IPv4. IPv6 was mainly introduced to anticipate the imminent exhaustion of the IPv4 address spaces. A 128-bit address space is very large and is it predicted that it could accommodate the development of the Internet in the future (Hovav & Schuff, 2005). Wiljakka (2002) believes that even if every grain of sand on Earth were assigned an IP address, then this address space could still accommodate it. However, many comments about technical incentives related to the address space and other better features were less appreciated. Some participants concur that they do not really need the advanced features of IPv6 for their network for various reasons. Firstly, the huge address space which is the most important feature of IPv6 did not attract them as almost all participants' networks deployed private IP addresses for their internal networks. Meanwhile, the public IP address plays only a limited role in connecting the internal network to the Internet. Secondly, some participants also argued that there were several technologies which could be used to reduce the need for public IP addresses. For example, the comments made by OG17 who significantly utilized the internet technology in their organization, indicate that they use NAT, PAT (Port Address Translation) and server virtualization. OG17 also adopted cloud technology to host their services on the Internet. Another participant, OG09, also made a similar response:

> *"There are 100 virtual servers. Most of them are used to support our internal activities. For the addressing, VMWare has its own mechanism which limits the need to use a public IP address" .... [OG09]*

On the other hand, OG13 was the only organization which already deployed IPv6 in their network. Also, OG13 had been allocated IPv4 addresses (/24) by IDNIC. Unlike OG09, OG13 had directly assigned a public IP address to each virtual server. Therefore, the public IP consumption was high.

> *"Because we are currently deploying virtual server in which one physical server consists of about 20 virtual servers. Those servers are differentiated based on several groups. So, one physical server can have not only one IP address, but it consumed a lot of existing public IP addresses" .... [OG13]*

Furthermore, although OG13 has implemented IPv6, the participant stated that it was not originally based on their needs, but rather due to the policy of the regulator. The protocol was obtained from IDNIC as an incentive and to anticipate the address space issue. IDNIC have the APNIC mandate to regulate the IP address allocation in Indonesia. Since early 2010, in order to increase the IPv6 adoption rates among ISPs and other institutions, IDNIC has imposed a higher charge for the Internet Protocol. For example, the IPv4 fee is $500 and the IPv6 fee is $400, then the member only needs to pay the higher fee which is $500. So basically, IPv6 is free when people successfully apply for an IPv4 address. Based on the interviews, IPv6 was used in OG13 as an alternative to IPv4 and for research purposes.

The interview participants also stressed the reliability of IPv6 which refers to the perception that IPv6 can perform well, free from technical errors. Kim *et al.* (2007) describe system reliability to be whether the system is error-free, consistently available and secure. System reliability is extremely important in technological implementation (Walker *et al.*, 2002). Even though IPv6 offers several more advanced communication features, these did not attract the participants. Most of the comments under this domain were negative. For example, OG05 believes IPv6 has not proven itself yet in terms of serving the Internet.

OG13 explained the poor performance of IPv6 on the current Internet based on their experience that the quality of the IPv6 network was far lower than the IPv4 network. Since IPv4 is deployed as the main internet protocol in most Internet infrastructures, IPv6 traffic has to rely on IPv4 networks. As OECD (2014) states, the inherent value of the IPv6 is low due to its low level of deployment. OG13 explained that the IPv6 traffic is routed to overseas first in order to reach web-based IPv6 networks in Indonesia. This participant also indicated that the low concentration of Internet providers has set up their router to accommodate IPv6 traffic. OG13 highlighted several challenges of IPv6 implementation as indicated by the following response, when they were asked whether the organization really needs IPv6.

> *"Actually not yet, sir, especially the resistance comes from our users ... Another reason is that the access speed is much faster if we use IPv4 due to the fact that some content such as AKAMAI has been locally available. When we use IPv6, the content will be routed to overseas and read overseas' server. Moreover despite AKAMAI is available via OPEN-XPL, it only support IPv4. Other TDN [ed. Top Domain Names] such as Google is also still available on IPv4 only."*

Further, the researcher continued to clarify the last statement since it was not quite right. OG13 elaborated on their response as follows:

> *"That's right. However most of providers pass the traffic [to Google] via IPv4 network. They do not correctly configure their router to facilitate IPv6 traffic. If we look closer, it doesn't mean IPv6 is slower than IPv4, but more to the fact that IPv6 content is very limited and providers poorly facilitate these kinds of traffics".*

6.3.3.3 Switching Cost

In this domain, the comments from participants can be grouped into two categories, problematic and non-problematic. Firstly, cost could be problematic as mentioned by some participants. The adoption cost could possibly be big since most network devices and other IT-related technology need to be ready and need careful and good transition planning. Therefore, it requires careful financial planning, so that the impact of the transition will not burden the budget when many devices that do not support IPv6 have to be replaced.

> *"It [cost] is still a problem. However, we know the benefit. The cost seems very big in the beginning, but the goal is to make the operation much more efficient. So, it is not only about a technology, but we tend to see all aspects such as whether the business value is positive, the business benefit is clear, the business case is justified or the cost of implementation is reasonable" .... […OG6]*

"Because the migration isn't only about, for example, yes, I wanna register, and give me some IPv6 addresses. Then you get it. Well, if later on the device is not suitable to support the system, what would you do? So for me, the difficult part is replacing the device ... Device procurement, not only about configuration, Sir. There are the issue related to procurement, CAPEX, budgeting…" .... [OG07]

However, many participants indicated that cost was not considered to be an obstacle to the adoption of new technology. Updating technology is a normal thing within organizations and it is part of the business process to update their technology in order to remain competitive in their industry. For business-oriented organizations, the technology is their means of staying competitive, increasing business performance, continuing their economic growth and ensuring compliance with industry policy and regulations. Generally, an organisation will see the business benefits in return for any cost incurred (Kim & Kankahalli, 2009) as long as the cost can be justified and has a positive effect on the business, as the following suggests:

"It's about how much money we spend to change the entire system. Further, the cost could also come from the effort to implement it…Surely but it is not a barrier. There is cost and benefit, right? We have to comprehensively examine how much the cost will be. Then we also need to see how much the benefit of IPv6 could be" .... [OG04]

Currently, information technology is a vital part of most modern organizations whose many activities rely on it. Consequently, cost is sometimes less important in terms of dealing with the business demand and business pressure. For example, the phenomenon of Y2K[23] was cited by some participants to show how an organization can spend an enormous amount in anticipation of a disaster that could possibly harm their business. So the cost would not be a problem if the absence of technological anticipation could potentially endanger the business. When asked questions relating to the cost of switching to IPv6, one response was:

"No, it's just like millennium case, Year 2000. People had to be ready. In this case, it was not only about the IT concern, but it increasingly became a

[23] Y2K problem was a problem because of the practice of abbreviating a four digit code to two digits both digital and non-digital documentation at the beginning of the year 2000. It was feared that computer hardware and software would fail to read the date and lead to widespread chaos since a lot of activities relied on computer systems.

business concern. If you didn't anticipate, probably something bad could happen to the business. To be ready, absolutely we needed cost. So this was about something that could harm our business…. It was highly required by the business and our organization had to consider it. So it's business pressure, not only because it was based on IT reasons" ....[…OG5]

In the case of Y2K, Anderson *et al.* (2006) found that organizations were more concerned about possible interruptions to business than the cost incurred by taking precautions. Another interview participant made a similar point:

"If business cannot run by not adopting a certain technology, then we must adopt it, no matter what… Just like several years ago, why did those banks intend to spend millions of dollars just to deal with Y2K … Only fear that their business would not run after January 1st, 2000..." .... [OG03]

Furthermore, switching cost became less significant because the respondents were confident that their devices were IPv6-ready and recent network devices are IPv6-ready by default, as in the following example:

"Well thank God most of our devices are compatible, although we are still using IPv4 but our devices are ready for IPv6. However, we haven't implemented the standard yet" ....(OG07)

"Our current network devices are ready. We have also anticipated and accommodated the development of the technology in the future" ....(OG09)

"…most likely all the new equipment in the current market has already provided the IPv6-ready feature by default…so we just need to activate it" ....(OG04)

At the policy level, usually an organization regularly replaces its network devices. So, whether they want to adopt IPv6 or not, the replacement does not immediately become a cost issue. Replacements are needed by an organization to meet their business operations and to keep up to date with the development of technology, or to exploit the advantages offered by more advanced technology. In addition, the organization would incur increasing maintenance costs, the performance of their existing devices would deteriorate, and it would be difficult to obtain support when a difficulties arise, as noted in the following remark:

> *"… The older our network devices the higher maintenance cost will be. So it was not good not only for supporting organisation operation but also potentially increasing the maintenance cost. The option to regularly replace the devices should be a wise choice. So, it didn't mean that it was a loss. We need to obtain the best performance of all devices to support our operation. In adopting a new system, we always follow this pattern…" .... [OG02]*

Participants mentioned that they outsourced some IT jobs to other companies. It has become common practice in recent years for organizations to outsource some or all of their information technology functions to other companies in order to improve their operations, increase managerial flexibility and enable them to focus on core competencies (Chang & Gurbaxani, 2012). With this model, IT operations were managed by other IT specialist company. Therefore, the technical challenge of implementing IPv6 was not perceived to be a problem.

> *"However, our company's current policy is more to manage services. So it is outsourcing. Leave the IPv6 to them. I just enjoy this situation…That is right. Well, the business is like that. It's very simple. Let's say, I have cooperation with Telkom. Then I can easily say "we want to move to IPv6, will you support it? How do you support us to implement IPv6?" Just like that, very simple, right. We have the design that we want and they just need to implement it. Currently, we also outsource the infrastructure to Telkom, including IPv4 addressing management." .... [OG04]*

> *"Fortunately this sort of thing [IP addressing management] is usually handled by outsourcing companies. Well, our company sometimes transfers some jobs to outsourcing companies. Let these issues be theirs to deal with".. [OG01]*

> *"Well, we are adaptive enough. We are assisted by external parties via outsourcing companies. Our vision is different from theirs. We are purely running a business. So, for example, if because of business demand, our company has to implement the IPv6, we just need to calculate the cost and justify the reason. Then we make a proposal to our management and give reasons why we have to implement it." .... [OG04]*

Also some participants' organizations were affiliated with other companies which specifically operated in the IT solution or Internet provider sectors. Besides providing technical assistance to participants' organizations, these companies also shared and provided appropriate reasons for implementing a certain technology. The following opinion illustrates this:

"… Since we have a sister company, namely INFOKOM, they learn and adopt any kinds of technology… they are part of the group. They become a think tank for the implementation of the latest technology, more specific to the communication and interconnection as well" .... *[OG08]*

The researcher also investigated the effect of incentives or subsidies offered by regulators or government to reduce the cost of switching to another technology. While OG13 explained that they implemented IPv6 in their organization because it was free and an incentive offered by the regulator, many other participants had different opinions about incentives; for example:

"The Company doesn't see the importance of an incentive, but it's about a need when there is a pressure from business or stakeholders. I think we don't need an incentive"... *[OG09]*

"I don't think it will work. It's a must because we need it. If we have to focus about the incentive, then, can we change another thing? For example if you use the IPv6, you will get 5Mb for free. That will be good [laughed]. But that's not the principal one. It should be driven by our organization's business requirement… from business need" .... *[OG04]*

6.3.3.4 Satisfaction with the current system

The third domain, *satisfaction with the current system*, refers to the satisfaction with IPv4 as a common standard used to serve and facilitate the network of participants' organizations. This domain is represented by three sub-domains: *convenience with IPv4, IPv4 reliability* and *NAT effect*.

Firstly, IPv4 has served the Internet connection since the very early days of the Internet before it became widely adopted. Although there are some issues with the current protocol, the problem, however, does not directly affect the operation of the participants' organizations. IPv4 has served the participants' organizations for a long period of time and to date it can still accommodate organisations' needs, as indicated by the responses below:

"So formally for internal use, we decided to still deploy IPv4. There are no plans [to implement IPv6], as yet no advantage for us" .... *[OG02]*

"In this case, a lot of technology is available but if it doesn't directly justify to our business, there is no reason to adopt it. If we can still use IPv4, why should

we use IPv6? It will be another story if we don't have any choice" .... [OG11]

One IPv4 feature which was frequently mentioned by numerous participants was the range of IP address spaces which are allocated for private-use networks. The private IP address option was very common in the current organizations' networks, with all participants stating that their internal network relied on the IP address. The following responses are indicative of this:

"For internal, we are enough with IPv4. We mainly provide internal services. Yes, we have Internet, but it is not really dominant. Intranet, our internal WAN, is the more dominant one and it can be covered by the current technology"... [OG09]

"Most of the devices which are connected to the Internet are located in the internal network. We use private IP and gateway to allow them access to the Internet. I can say our users are very familiar with this model" .... [OG16]

Further, participants explained that it was convenient to deploy a private-IP model on their network. Some participants believed that the private-IP model allowed them to fully control their network.

"We are mostly using private IP in our network and this scenario provides us flexibility to manage our network policy. We only use Public IP for the devices directly connected to the Internet." .... [OG10]

Secondly, regarding the notion of separating public and private networks, NAT is a common technology that was mentioned by all participants in order to separate their public and local networks. The following remarks reflect the issues raised by interviewees.

"We also deploy NAT to let the communication between our local network and the public network" .... [OG09]

"We use private IP for LAN. Public IP actually concerns only for external. So as long as we can use network address translation, the rest is a part of the provider's job" .... [OG10]

> *"All of internal devices use private IP address and separated the network using VLAN. Public IP addressed are only used for public servers and gateway" .... [OG15]*

The majority of participants provided some indications that NAT has significantly contributed to curtailing the need for public IP addresses. The public addresses were used only to facilitate public server connection and NAT provided a gateway for the local computer to connect to the Internet. In addition, the majority of participants described stated that they had no problem with the current number of public IP addresses which they have. The following comments are representative of these sentiments:

> *"That's why only little information needs to be publicly published. It is very limited. Even it is not more than 16 IP addresses" .... [OG02]*

> *We have our own public IP, two C classes ... that's quite enough for us. And important to be noted, it is excluded the public IP for our branches. Our braches obtained the public IP address from Telkom. Those are a lot, thousands. We only use our public IP for our main office. Over there, we only used it for email, gateway...only for DNS, our web server. The point is that it is still very available" .... [OG03]*

However, participant OG13 mentioned that they required more public IP addresses to accommodate their server.

> *"With the amount of IP address space /24 that currently we have, we felt the shortage. However, we are having difficulty obtaining more address spaces. IDNIC is currently waiting for those who return their address pool. When it is available, IDNIC can allocate it. But the problem is that free address space is currently not available" .... [OG13]*

Finally, since the problem with IPv4 does not directly affect their network, participants noted that it was very unlikely they would adopt IPv6 in their network in the near future. It was suggested that organizations resist changing because they are not experiencing any problems with the current IP and the business is still running well. IPv4 has been deployed to support the operation of participants' organizations for many years and has proven to be a reliable technology. A reliable system could be a reason for staying with the status quo and, conversely, an unreliable system would motivate users to switch to an alternative technology, especially when the system is problematic in terms of the smooth operation of the organization.

> *"This organization doesn't have any plans to change its system [to IPv6]. We feel comfortable with the current protocol address and we can still run our business normally" .... [OG07]*

> *"With the system, we don't have any issue … We don't have any problem with the addressing concern. I think it only affects those who look for new address space. But for those who already occupy some address spaces, they will not have any problem. Or for those who look for more additional addresses, they will possibly have the problem" .... [OG14]*

6.3.3.5 Perceived threat

The fourth domain is *perceived threat* which refers to potentially threatening conditions arising from the implementation of a new technology. Perceived threat has been identified as a factor that is strongly associated with resistance to change (Bhattacherjee & Hikmet, 2007; Lapointe & Rivard, 2005). Figure 6.1 indicates that this domain comprises three sub-domains: *feeling worry*, *upgrading effort* and *system compatibility.*

Firstly, *feeling worry* naturally affects potential users' desire to adopt a new technology. IT plays an important role in modern organisations as it supports business operations. Most of the modern organizations have become more dependent on IT and any problem with the system could affect the operation of the entire organization. In this case, the IP address is pivotal to communication among the devices or applications. Although the IP address is a technical aspect of communication, and not all Internet users are familiar with it, if there is something wrong with the connection, then those who responsible for it will be blamed for any subsequent disaster.

> *"What I'm worried about is, many applications especially whether they have supported IPv6 or not. May be device up to OS already support, but not include the application" .... [OG02]*

As discussed previously, NAT is used to extend the lifetime of IPv4. It is very common technology in most of the organizations in Indonesia. Very few organizations in Indonesia use public IP in their internal networks and no participants' organization used the model. Public IP is used only for connecting their network to the public network and the private IP address is for the internal network. The evidence from the qualitative stage is illustrated by the following comment:

> *"Our network heavily depended on NAT and PAT. It significantly reduces the need for public IP. So far, we don't have any problem with it. Even we can control our devices through the Internet. Why should we change it? We haven't known the problem if we removed the NAT" .... [OG17]*

Some participants also emphasized that they had no experience working with IPv6 or working without NAT, as shown by the following comment:

> *"Currently, we are almost zero, we do not understand at all. Even we don't know how the network would be without NAT…" .... [OG02]*

The second category under this domain is *system compatibility* which refers to potential threat due to incompatibility between two protocols. The following responses acknowledge such threat:

> *"I am worried if our concern is only about the IP address. The system consists of several components of hardware, network, etc. IP is only one part on them. Let's say, one device supports the IPv6, but the upper level doesn't support it, so it won't run well" .... [OG02]*

The final category in this domain, *upgrading effort,* refers to the upgrading issue when participants' networks switch to IPv6. A number of upgrading issues have been raised by participants as the reasons for resistance to change. The transition to a new technology is a huge task requiring a number of changes and adaptations to prevent operational difficulties. This potential problem was highlighted by the following comment:

> *"It's not easy to move. Many things should be adjusted. There are too many basic things that need to be fixed, while the technology is not really important. I don't see it … What should I say? The fact is like that … Also if we are back to the effort again yes, I'm in no doubt. Because we'll need much effort, time to check the devices and many other things. It could be a long journey." .... [OG10]*

These remarks quite clearly indicate that this particular perceived threat is reason enough for retaining the status quo.

6.3.3.6 Lack of environmental influence

The final domain covers *lack of environmental influence*, including the influences of government, the internet regulator, the industrial regulator and others. In the current study, while there was no comment regarding normative pressure, comments relating to government and regulators (Internet and Industrial regulator) were common among interview participants - an indication of the importance of external factors influencing organizations' resistance to change.

Participants provided some indications that the nature and scope of government control over organizations will have a significant influence on whether or not they will implement a certain technology, especially if organizations are forced to do so.

> *"...we have to examine the implementation of IPv6 from every angle, unless the government publish a new policy that prohibits the use of IPv4 any longer. That is another story"*.. *[OG04]*

Although this remark indicates that government can trigger the adoption of IPv6, in the case of the Indonesian government, many participants indicated that the government was not active in encouraging the implementation. The following remarks illustrate this concern:

> *"I note, the government has not been there yet. Instead, Telkom itself has its own roadmap. If we talk about the government and its correlation to IT, it always, yeaaah.., doesn't care"* .... *[OG03]*

> *"Especially our government, they don't care about this. They are sleeping. We have to wake them up. What do you want to say? That is the actual fact, our government is sleeping. If it's late means they are aware. They're sleeping. So you have to wake them up. It's like fire. It's been a fire but they haven't woken up yet."*.. *[OG05]*

Participant OG04 stated that the government provided only a little support for IPv6:"*the government had ever issued this, but then it disappeared by itself*". Two other participants commented that most of the knowledge about IPv6 was not obtained from government commentary, but rather from other parties, as the following comments indicate:

> *"Nothing exists yet. How did we know about IPv6? It was from our consultant. We got the information from them" .... [OG06]*

> *"I don't know exactly whether IDNIC is part of the government or not. So in my opinion they have to be independent. So far, we only knew about the IPv6 from IDNIC, such as why we should buy, why we should be aware of IPv4 address depletion, when we could buy it including the information of free IPv6 addresses as bonus if you bought IPv4 addresses" .... [OG02]*

Although the Internet is a self-regulatory industry (DeNardis, 2009), there are some important organizations that play a significant role in ensuring smooth communication via the Internet as discussed in Chapter 2. On this domain, some participants provided explanation and evidence of their perceptions of internet regulator as well as industrial regulator's influence on promoting the IPv6 adoption among Internet communities.

For example, OG07 emphasized the importance of a regulator in encouraging the implementation of IPv6 by stating:

> *"Why don't they actually give some pressures? I have a little bit funny idea then. This should be pushed by those organizations, because they provide the services. Let say, they just need to say, in 2013, I don't want to allocate IPv4 address for you anymore. So everyone should use IPv6. That's the first thing. The second is, starting from 2015, everyone should migrate to IPv6. So, IPv4 will be faced off in the year 2018. Just like the policy of currency changing".*

OG13 which has implemented IPv6 in their network suggest that the regulator's incentive encouraged them to implement IPv6 into their network, as their comment shows:

> *"We got IPv6 address blocks for free after successfully applied IPv4 address" .... [OG13]*

By applying pressure and setting up a boundary line, OG07 believed it would motivate organizations to make preparations for IPv6 to deal with the situation; they stated:

> *"With that situation, people will think, especially as what I said before, the organizations that are unready with the device for IPv6 will start to think. We sometimes find that an organization doesn't support or doesn't want to think*

about changing to new technology periodically. Even we find their available devices only support IPv4 and as long as they feel secure with them, they won't care. Just like us, using a modem at home for almost five years, we are still thinking it's okay. End of live support! It's still fine since we won't need the support. That's why. But with some pressure, we can't. Then if it is said face off…means we cannot make any connection to everything, and then we'll start to plan. So why do people need something like this? It's because when people need to change the device, they can't change it instantly. For example, they have 20-30 devices; they cannot be replaced in one year accordingly"

While most organizations in Indonesia obtained their addresses from their provider as part of an Internet connection contract, several participants expressed their opinion on this matter. The following comments illustrate the importance of ISP in encouraging the implementation.

> *"If ISP or provider can endorse the implementation of the technology, Enterprise will automatically follow it." .... [OG11]*

> *"…our own environment seems to quite enjoy the IPv4. Several times we have even coordinated with our provider, the provider of Internet services; they themselves are not really concerned about adopting IPv6" .... [OG07]*

> *"I hope the trigger is Telkom, because it has the largest network"..... [OG03]*

Participants also underline that a particular industry has to follow the standard from the industrial regulator body for technological compliance. For example, members of the banking industry are connected each other via Bank Indonesia and heavily rely on Internet technology not only to support internal banking, but also to conduct transactions among bank and third party entities (such as Visa, Maestro, or other Payment Partners). Bank Indonesia acts as a reserve bank but has not yet mandated IPv6 to its members. The importance of an industrial regulator is illustrated in the following statement:

> *"You know for banking sector, the strongest endorsement is from BI [ed. Bank Indonesia as reserve bank] …Now it has been more than 10 years, yet I haven't noticed any bank which has obviously planned to migrate to IP version 6… If it is about compliance, about standard, it is usually leaded by BI. And usually if we talk about budget, compliance, then we got a strong endorsement. Well for example, this is requested by BI, sir. We have to migrate. And that's it, management can't say a word - must follow" … .... [OG03]*

Furthermore, some participants commented on the influence of other organizations within their environment, such as parent companies or partner organizations, to justify as a separate category in this domain as indicated in the following comments:

> *First, it doesn't mean we're not aware but IPv6 is not booming. Just like 3G, now we have 4G, WiMAX. We know the advantage, but well. Even the company which is more modern than us hasn't thought about it, so why should we? Second, our group hasn't given the signal. For example, they give us alert "you have to study about the IPv6, because next year or next two years we will use it". Even it's too much to expect next year, next two years also not .... [OG05]*

> *"...There is some kind of culture among the business unit, the company member of the group. We usually share the information. So this issue is not only a responsibility for one division, but all divisions" .... [OG01]*

> *Yes, it can be. We are connected to external people. Means, if the others have used it and we don't adopt the system, we will lose the connection. So, there are no choices. We have to use it. .... [OG04]*

6.3.4 Relationships of domains overview

The final stage in the domain analysis approach as suggested by Atkinson and El-Haj (1996) is to identify relationships between sub-domains and more importantly between these and the primary domain. The following discussion thus seeks to elaborate on some of the domains and relationships pertaining to resistance to change that emerged during the three-step process of domain analysis. The relationship between the domains is derived from the participants' comments.

Firstly, the interview comments revealed that *lack of felt need* is strongly linked to *resistance to change*. The relationship between *lack of felt need* and *resistance to change* were frequently noted by study participants as shown in the following statements:

> *"If we talk about it on a macro level, the problem of IP address is obvious. We have to anticipate in term of providing policy and so on. ... Will our company adopt the IPv6? I don't think so ... Correct me if I am wrong, what is the real need for us? ... That's why we haven't found any burning platform. I don't really know where the burning platform term came from. I can imagine that if the platform is heated, like a burning, than the people will feel unsecure. However, so far it is still fine" .... [OG06]*

"Well, the company didn't see any positive contribution. If it gives benefit from the business side, absolutely the company will adopt it. So we are very flexible in this case… However, I haven't seen the benefit of IPv6 to our business." .... *[OG09]*

Secondly, results of the interview data analysis indicate that study participants stressed the *satisfaction with the current system* created some tension in relation to the resistance to change. Numerous study participants stated that the current system still could accommodate their network and they felt that the convenience of using IPv4 was a reason to preserve the status quo, as illustrated by the following remark:

"With the system, we don't have any issue … We don't have any problem with the addressing problem. Why should we use it [IPv6]" .... *[OG14]*

"We feel comfortable with the current protocol address and we can still run our business normally. We don't have any problem with IP address, so there is no reason for our company to use it" .... *[OG07]*

"…because till today our IP range is still able to cover our need, moving to IPv6 becomes not urgent…" .... *[OG03]*

Moreover, study participants also indicated the potential relationship between *satisfaction with the current* and *lack of felt need*. There was some evidence to indicate a relationship between the two domains. Based on the interview data, it appears that the need for IP addresses has been adequately met by the current system. So far, IPv4 as the common protocol in the layered network has proven to be reliable and well able to support the operational business of organizations. Although early in the implementation of IPv4 there were several shortcomings, and IP address space has been declared exhausted at the global level, the deployment of IPv4 remains dominant on the Internet. The private address model and supplemental technologies are considered adequate to overcome the problem. As a result, the more advanced features of the IPv6 were perceived to be less important in the current situation.

"We mainly provide internal services. Yes, we have Internet, but it is not really dominant. Intranet, our WAN internal, is more dominant one and it can be covered by the current technology"... *[OG09]*

> *"So far we don't find it. Also, our own environment seems quite enjoy with IPv4. Even several times we have coordination with our provider, the provider of Internet services, they themselves are not really concern for adopting IPv6" .... [OG07]*

Thirdly, considerable analysis of results from previous steps indicated that *switching cost* was not considered to have a significant impact on *resistance to change*. This finding is surprisingly different from findings in previous studies which suggested that the cost of switching is a relevant issue that is considered by organizations when they want to move to a certain technology (Bohlin & Lindmark, 2002; Hovav & Kim, 2006; Iacovou *et al.*, 1995; Venkatesh & Bala, 2012).

> *"It's about how much money we spend to change the entire system. Further, the cost could also come from the effort to implement it…Surely. But it is not a barrier" .... [OG07]*

Fourthly, the previous analysis processes also gave some indications that *perceived threat* was identified as one domain that contributed to organizational *resistance to change*. Some participants then highlighted the upgrading effort, showed their misgivings about the negative impact of switching technology and raised the issue of compatibility with the current technology and their current practice which would be significant since most of their networks rely on IPv4.

> *"There are no plans, as yet no advantage for us … And we also don't think we will need such huge addresses. Besides, we need the infrastructure, for example DSN… also the routers [and] DHCP… they have to be IPv6 capable. Moreover all the system such as windows, Linux, whatever applications we used, should support IPv6. So the effort will be remarkable… Yes, extraordinary. So we tend to postpone it" .... [OG02]*

> *"IT department is only a supporting division. What the end users want to know is whether they can smoothly use the network or not. Don't you think so? And when it's down, the users will feel that there is something that has declined and they feel uncomfortable. It is a special challenge for us. The effect is in there, not just because of migration. What I mean is that the downtime is more about the unpredictable things in a short period or long period of time. Also it has a big impact on KPI (key performance indicator). So the effect in my opinion will be much higher (than benefit)" .... [OG7]*

Finally, the data analysis provided some indications that organizational resistance to change is due to no pressure from government, regulator, industrial regulator or other parties to encourage or even give them some pressure to implement IPv6 addressing schema.

> *"Well, till recently there has been no pressure from the government. Could you tell me whether or not the government's policies exist to encourage us to adopt the technology?"*... *[OG01]*

> *"Well, the problem is that there is no regulation to force us to move and implement IPv6"* .... *[OG16]*

> *"If ISP or provider can endorse the implementation of the technology, Enterprise will automatically follow it. Also what I see, people fell that there is no urgency to use IPv6, despite run out of IPv4 addresses"* .... *[OG11]*

6.4 Chapter Summary

The recent discussion has presented key findings from the qualitative phase which explore the factors driving or inhibiting organisations from changing to a new technology. The data was collected through interviews with participants from 17 organizations. From the data analysis, six domains were identified from this qualitative phase. A number of relationships between the six distinctive domains were identified and are illustrated diagrammatically in Figure 6.2.

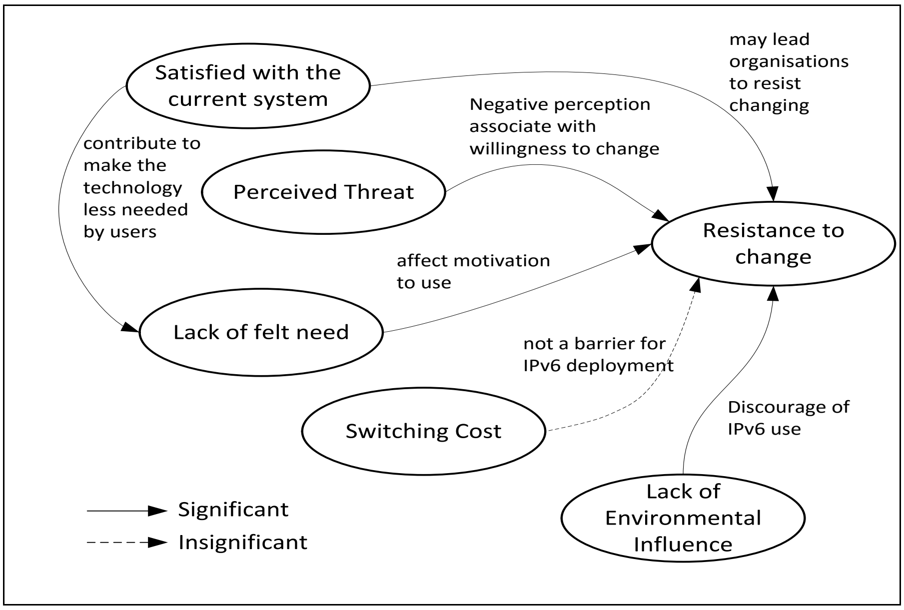

Figure 6.2. The Domain Relationship

The relationship findings were derived from the comments made by the interviewees. These are summarized in the following table.

Table 6.4. Summary of qualitative findings

Relationship	**Informant support**
R1: Lack of felt need is associated with increased resistance to change	- Do not have any problem with IP address - Lack of positive contribution to organisation - Lack of real benefit to organisation - Lack of business need - No business justification
R2: Satisfaction with the current system is associated with increased resistance to change	- Convenience with the current system - Do not have addressing issues - Prefer to stay with the current system - IPv4 has been proven
R3: Satisfaction with the current system is associated with increased lack of felt need	- Supplemental technology can solve IP addressing problem - There are many public IP address still available - Private addressing more dominant - Some feature or supplemental technologies of IPv4 can reduce the need of public address
R4: Switching cost is not strongly associated with increased resistance to change	- Most of recent network devices are ready for IPv6 anyway - Cost is not barrier to use a technology when there is business benefit

	- Business pressure could ignore adoption cost, such as Y2K case
R5: Perceived threat is associated to increased resistance to change	- Requires a lot of work - An extraordinary effort will be required - Performance loss - Concerns about compatibility - Existing technology (especially applications) might not work well
R6: Lack of Environmental influence is associated with increased resistance to change	- There is no regulation to force organizations to implement IPv6 - The government has not encouraged organizations to adopt IPv6 - ISPs or providers do not endorse the implementation of IPv6

It should be noted that the relationship between identified domains was used to develop a series of research hypotheses to be empirically tested in the quantitative phase. The next chapter presents a detailed discussion of the quantitative phase of this study.

Chapter 7. Quantitative Phase

7.1 Introduction

The previous chapter described phase one (qualitative study) of the mixed-methods study which examined the reasons why organization want to preserve the status quo and resist changing to IPv6. The empirical findings indicated that four domains strongly contribute to making participants resistant to change. Conversely, although there is substantial evidence to the contrary in previous studies, a review of switching cost factors indicated no strong support for the relationship between this factor and organizations' desire to maintain the status quo.

This chapter will describe the quantitative phase process, which is the second phase of the mixed-methods approach adopted for this study. Section 7.2 reports the research model and hypothesis development. The research model is developed based on the findings, from the previous stage, pertaining to relationships. Section 7.3 explains the instrument development; this is followed by a discussion of the sample design (Section 7.4) and data preparation (Section 7.5). Section 7.6 presents the results of the data collection. In Section 7.7, the data analysis is conducted to ensure the rigorousness of the measurement model and to test research hypotheses by deploying structural model validity (Chin, 2010; Hair *et al.*, 2010; Straub *et al.*, 2004). The chapter is summarized in Section 7.8.

7.2 Research Model and Hypotheses Development

Based on the domain relationship from the qualitative study (Figure 6.2), the model for the second phase – quantitative – is developed and presented in Figure 7.1. The figure shows the constructs that were directly derived from the domains and ideas that emerged from the qualitative phase.

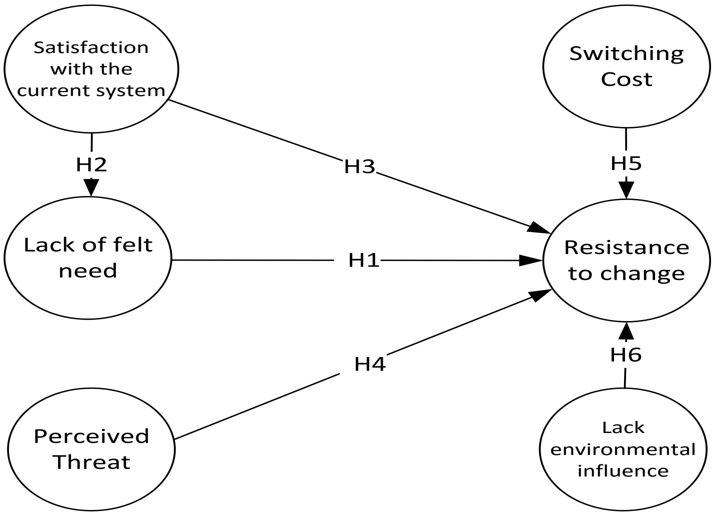

Figure 7.1. IPv6 Resistance Model

Spradley (1979) states that the relationships emerging from the qualitative data analysis lead to a set of hypotheses. These need to be tested to increase confidence in the accuracy of both the qualitative and quantitative findings. The hypotheses were developed based on the findings from the first phase and supplemented by findings from previous relevant literature. This approach is supported by Boyatzis (1998) who argued that both sources – the literatures and the interview data – are appropriate in a situation where the study has a single unit analysis. A wide range of organizations that use the Internet or, more specifically, IP addresses, are the participants in this study. The following discussion outlines in more detail the hypotheses used to guide the development of the survey questionnaire.

7.2.1 Lack of felt need

As discussed in the previous chapter, the lack of felt need is frequently mentioned by participants as a reason for maintaining the status quo. The data analysis from phase one indicated that lack of motivation, no perceived replacement benefits and lack of need for IPv6 features are the common reasons for resistance to changing to IPv6.

Maslow's hierarchy of needs is used to understand the level of need. This theory is commonly used to understand what motivates people to achieve certain needs

(Maslow, 1943). Although the hierarchy of needs theory was originally applied in the human as individual context, it is also applicable to organisational settings (Greenberg & Baron, 2003). Numerous studies have applied Marlow's hierarchy of needs theory in organizational context, in terms of IT value hierarchy (Urwiler & Frolick, 2008), online community (Bishop, 2007) and IT strategy (Singh & Holmström, 2015). According to the hierarchy, the needs are classified into five levels: (1) physiological needs are the very basic need which organizations must have before thinking about higher order needs, (2) safety needs are related to security or protection from organizational operation problems, (3) social needs refer to the relationship with others as part of a social community, (4) esteem needs include the need for things that reflect on self-esteem, social recognition and accomplishment, and (5) self-actualizing needs are the highest level of need when people are concern with their growth and want to show their potential.

Previous studies indicate that perception of need is one salient factor of adoption theory as an important reason for adopting or accepting an innovation. Therefore, many adoption theories include a similar factor in their models, such as perceived usefulness (TAM) (Davis, 1989), relative advantage (DOI) (Roger, 1995), and performance expectancy (UTAUT) (Venkatesh *et al.*, 2003). Robey *et al.* (2008) state that perceived need refers to the potential direct and indirect advantages of adopting a technology. Roger (1995) emphasized the importance of the relative advantage as a major factor in the success of adoption technology. Perceived usefulness is a key factor in the TAM model and is consistent as a predictor in innovation technology studies (Iacovou *et al.*, 1995; Venkatesh *et al.*, 2003). An organization will evaluate the benefits of the innovation based on their business needs and whether the technology will benefit the business (Reid & Bojanic, 2009) and how much the innovation contributes to business growth (Patterson, 1998). Premkumar and Ramamurthy (1995) argue that an organization would be willing to adopt an innovation if there is a genuine internal need.

Interestingly, this factor is also recognised in resistance studies. Although Gatignon and Robertson (1989) suggest that the resistance factor is not a mirror image of the adoption factor, numerous authors have a different opinion. For example, Hirschheim and Newman (1988) suggest the factor of lack of felt need in resistance studies. In order to change, potential users have to be convinced of the advantages of changes (Blin & Munro, 2008). Kim and Kankahalli (2009) use a similar factor, perceived value, to investigate user resistance to information systems implementation. In the model, they integrate the technology acceptance (TPB) and resistance theory (Lapointe & Rivard, 2005) with the status quo bias perspective (Samuelson & Zeckhauser, 1988) in a survey of 375 organizations prior to the implementation of a new IS (ERP). They found that perceived value could significantly reduce user resistance. When the perceived value is low, potential users tend to have greater resistance to change. On the other hand, if the perceived value is high, the level of user resistance is likely to be lower. Kim's finding is consistent with that of Venkatesh and Brown (2001) which indicates that the lack of perceived need can motivate potential users to reject the innovation. Spil *et al.* (2004) introduced a Use IT model which includes two dimensions of need: relevance of the system to users' need and requirement to which the system meets user need. They found that these two dimensions were important predictors of user resistance. In relation to this issue, Hagen (2011) points out the lack of business case for the context of IPv6 resistance is the most frequent reason to avoid integrating IPv6 into an organization's network. Business case is related to the business need to adopt a certain technology that is expected to provide business benefit. Therefore, it was hypothesized that:

> ***H1: Greater lack of felt needs is associated with an increased likelihood that an organization will resist changing.***

7.2.2 Satisfied with the current system

The findings from the qualitative phase suggest that satisfaction with the current system is associated with reduced need for IPv6 and increased resistance to change. All interview participants mentioned that the current system works well and adequately supports the organizations' activities. Although the IP addressing problem was identified some years ago, it does not immediately affect their network. Public IP addresses are deployed minimally, just for the servers which connect to the Internet and provide a means by which the devices within the local network can access the

Internet. The private IP addressing was the most common scenario deployed in their network. Hence, participants feel that it is convenient and easy to implement current network policy. Due to the fact that the current system has served organization for a long time, it explains the aversion of organizations to adopting IPv6.

In order to change, organizations should have a strong motivation (Swanson, 1994). While organizations feel positive about existing technology, they will increase resistance and this reduces the probability that they will adopt a new system (Ellen *et al.*, 1991). As the result, the organizations tend to use familiar routines (Arthur, 1989) and this lead to technological lock-in (del Río González, 2005) to the current system. Similarly, according to prospect theory (Kahneman & Tversky, 1979), users avoid moving when they believe the current system or situation to be positive.

Earlier studies on adoption of or resistance to change also emphasize the current technology as an important reason for the resistance to a new technology (Cenfetelli & Schwarz, 2011; Chau & Tam, 1997; Iacovou *et al.*, 1995). Chau and Tam (1997) stressed that the satisfaction with existing systems influences the adoption decision. In particular, when users are satisfied with the current technology, it is more likely that they will resist implementing the alternative (Ellen *et al.*, 1991). This satisfaction could discourage users from adopting the new technology. Before adopting a new technology, organizations need to carefully consider the move since the decision to adopt requires them to change their system operations (DeNardis, 2009). Potential users will make a rational decision about whether to stay with the status quo or switch to a new system (Polites & Karahanna, 2012)

Ellen *et al.* (1991) argue that organizations tended to stay with the incumbent or preserve a status quo, unless the alternative was either extremely attractive or very pressuring. Organizations which were already satisfied with the current system and were locked-in to it tend to resist (Polites & Karahanna, 2012).

Therefore, based on the previous explanation, the hypotheses below are developed:

H2: Satisfaction with the current system is positively associated with lack of felt need

H3: Greater satisfaction with the current system is associated with an increased likelihood that organizations will resist change

7.2.3 Perceived threat

Based on participants' comments, the one notable factor causing resistance was perceived threat. Participants highlighted several threatening conditions which they could face if they decide to switch to IPv6, such as extraordinary upgrading effort being required, feeling worried, and system compatibility. Participants indicated that information technology has greatly supported the smooth operation of their organizations, and is an integral part of their business processes. Any problem with it would worry organizations because the problem could possibly affect their entire business operation. For example, since IPv6 is not directly compatible with IPv4, existing devices or some applications might not work well or may even not work at all. Also, they are afraid of working without NAT since the current network significantly relies on the technology. Hence, the adoption would be a difficult task and would require a massive effort. The decision to adopt IPv6 has to be carefully planned and requires a comprehensive evaluation of devices and many other resources. On the other hand, some participants stated that there was a struggle with other IT projects. Therefore, the findings from the qualitative phase indicate that perceived threat is positively correlated with resistance to change

Numerous prior studies have found that perceived threat is an important determinant of either adoption or resistance. Some perceived threats may include loss of power (Markus, 1983), loss of control (Lapointe & Rivard, 2005), reorganization of work (Bhattacherjee & Hikmet, 2007), loss of status (Lapointe & Rivard, 2005), inequity (Joshi, 1991) and performance loss (Kim & Kankahalli, 2009). Moving to a new technology may require many other changes to an organization, such as net equity change (Joshi, 1991), changes in power (Markus, 1983) and risk (Pavlou, 2003). Beatty *et al.* (2001) argue that the incompatibility of new technology in terms of the organizational and technical dimensions could cause the potential user to maintain the status quo.

In their empirical study, Bhattacherjee and Hikmet (2007) conclude that perceived threat has the most significant effect on resistance to change. They introduced a resistance model by integrating the technology acceptance (Davis, 1989) and a dual-factor model of technology usage (Cenfetelli, 2004a). In their study summary, they stress the importance of incorporating user resistance with technology acceptance which fosters a better understanding of the reasons for resistance. Perceived threat was also discussed by other authors (Kim & Kankahalli, 2009; Lapointe & Rivard, 2005). At the organizational level, the potential adopters will rationally consider whether the innovation will benefit their business. Certainly, the activity of an organization will be affected when adapting becoming familiar with the innovation, especially upon the introduction of innovation (Roger, 2003). Hence, it was hypothesised that:

> ***H4: Greater perceived threat is associated with an increased likelihood that organisations will be resistant to change.***

7.2.4 Switching cost

The findings from the qualitative phase indicated that the cost of switching did not play a significant role in making participants resistant to change. Although prior studies strongly suggest that costs have to be considered when switching technology, the majority of interview participants mentioned that their network devices were IPv6-ready and regardless of whether or not they move to IPv6, they have to replace their network devices regularly anyway. Technology needed to be regularly refreshed to meet more recent business process requirements and to obtain competitive advantage. Hence, the switching cost was not the main reason for preserving the status quo. Participants explained that business pressure sometimes makes switching cost less important by providing the example of the Y2K case. At that time, organizations spent a lot of money just to ensure that their system could work well in the new century. Further, participants explained that the uncertainty cost could be reduced by establishing a good strategy.

Cost has been repeatedly investigated as an important factor in both adoption and resistance studies (Carroll *et al.*, 2002; Kim & Kankahalli, 2009; Min *et al.*, 2008; Polites & Karahanna, 2012; Venkatesh & Brown, 2001). Cost is involved in most processes where there is a transition to a new technology. Jones *et al.* (2002) identify six distinct costs that can be incurred when organizations switch to a new technology: lost performance cost, uncertainty cost, pre-switching search and evaluation cost, post-switching behavioural and cognitive costs, set-up costs and sunk costs. They therefore define switching cost as "*the perceived economic and psychological costs associated with changing from one alternative to others*" (p. 441). While Venkatesh and Brown (2001) found high cost was a critical obstacle to PC adoption, Carroll *et al.* (2002) believe that excessive cost plays an important role in resistance to change. The study of Kuan and Chau (2001) also found that the perceived financial cost could become an obstacle to the transition to a new technology. Arthur (1989) argue that the economy might become locked-in by historical events. Despite the benefits of a new technology, the switching cost was found to be the reason why organizations resist adopting a new technology, and consequently, it is logical that organizations will maximize the existing technology.

Furthermore, Kim and Kankahalli (2009) examined the impact of switching cost on resistance to a new technology and reported that switching cost significantly affects user resistance. The authors state that switching cost includes transition cost, uncertainty cost and sunk cost. Firstly, transition cost is related to any cost incurred when adapting a new technology (Kim, 2011). According to Fichman (2004), transition costs could be incurred by training, hiring experienced employees and consultants, deploying new policies and procedures, establishing a supporting infrastructure and absorbing losses in productivity. Secondly, moving to a new technology potentially creates an atmosphere of uncertainty (Hirschheim & Newman, 1988; Jiang *et al.*, 2000), therefore the cost of uncertainty is involved (Pavlou, 2003). Finally, sunk cost refers to previous commitments including investment of time and effort which have been spent on mastering the previous technology or system – time and effort that may be wasted due to switching technology. Furneaux & Wade (2011) suggest that a considerable investment in IT may become a huge consideration when an organization is deciding whether to discontinue the use of the technology. Given the massive amount of already-installed equipment based on the IPv4 technology (Hovav *et al.*, 2004), the cost of moving to IPv6 becomes a major barrier to adoption if organizations consider converting their networks to the IPv6 network. While IPv6 is not backward-compatible, the cost is even higher when the user which has heavily invested in the IPv4 infrastructure is required to upgrade it. Bohlin and Lindmark (2002) underlined the important of incentives to reduce the cost of moving to IPv6. Since there is a lot of support in previous studies, in the quantitative phase, this study undertook to measure the relationship between switching cost and resistance to change. It was therefore hypothesized that:

> ***H5: Switching cost is associated with positively increased resistance to change***

7.2.5 Lack of environmental influence

Tornatzky and Fleischer (1990) describe that the environmental context is the arena in which an organization conducts its business, and includes its industry, competitors, the government and other external parties. Some literatures suggest the role of environmental influence in the success or failure of technology adoption (Cenfetelli & Schwarz, 2011; Kim & Kankahalli, 2009; Rivard & Lapointe, 2012). Venkatesh *et al.* (2003) introduced the factor of *social influence* to explain how environment affects behaviour intention. Social influence is related to others' beliefs regarding the new technology. At the level of organization adoption, it may come from the regulator, business partner(s), or customers (Tornatzky & Fleischer, 1990).

The lack of environmental influence was identified by interview participants as contributing to increased IPv6 resistance. Discussion of this topic revealed numerous stakeholders that might influence organizations to adopt a certain technological standard, such as government, regulators (such as APNIC or IDNIC), ISPs, companies within same group or other organizations. Two participants mentioned that their organization also had to comply with the industrial regulator's technology standards (OG03 & OG10). However, the majority of participants provided some indications that there was a lack of external parties to encourage, influence or force them to move on. This was interpreted as a not impressive message from their environment to adopt IPv6.

Although the Internet is a self-regulated industry (DeNardis, 2009), since government has a significant political position, it could influence organizations to adopt a technology even if the decision to adopt does not make sense (Pereira, 2002). For example, at the beginning, the U.S. which accounted for almost half of the available public IP addresses seemed to be reluctant to implement IPv6. However, in 2008, the U.S. government mandated government agencies to have IPv6-ready equipment to enable their network. Then in 2012, the US government introduced a new mandate to allow the agencies to be reached from the IPv6 network. As a result, the U.S. currently has the largest base of IPv6 users in the world.[24]

The contribution of environmental influences has been identified by prior adoption or resistance studies. For example, a standard regulator or government can influence users by promoting the innovation and providing adequate support to facilitate it (Tornatzky & Fleischer, 1990). Venkatesh *et al.* (2003) include social influence and facilitating condition as salient factors in UTAUT theory. In their organizational study, Zhu *et al.* (2006) pointed out the critical position of the regulator in encouraging and facilitating the implementation of an innovation. In this case, the authors suggested the government involvement in the early stages of open standard diffusion. While Kuan and Chau (2001) considered the government pressure factor, Pan and Jang (2008) named the regulatory policy of the regulator as an important factor in adoption or resistance studies.

Previous leading literatures on adoption and resistance technology also suggest the factor of normative pressures as part of environment influence (Iacovou et al., 1995; Kim & Kankahalli, 2009; Yoon & George, 2013). In their study, Yoon and George (2013) reported that normative pressure was found to be the strongest influence on the adoption of a virtual world. Kim and Kankahalli (2009) argue that colleagues' opinion could affect user perception of a new technology. Chwelos et al. (2001) suggest that trading partner pressure has a great influence on user intention to adopt or reject a technology. The network can only operate and communicate with other networks under the same standard. So partners are becoming very important to encourage an organization to adopt similar technology. Normative pressure can come from a variety

[24] U.S. Government paves the way to IPv6 with mandated compliance, accessed on 12/02/2015 from http://www.enterprisenetworkingplanet.com/

of sources such as media, trade partners, and business and professional associations (Deephouse, 1996).

However, while there is not enough evidence from the first phase to develop a hypothesis based on normative pressure, a significant number of participants commented on the absence of government pressure and the lack of a regulator as a factor in IPv6 resistance. Because the adoption of an Internet protocol requires the participation of and coordination among other external parties, the relationship between organizations is extremely important and should be assessed. Therefore, based on significant insights from the qualitative phase and the literature review, the researcher intended to test the impact of government and regulator on organizations' resistance to changing to IPv6 by hypothesising that:

> ***H6: Lack of environmental influence is positively associated with an increased likelihood that organizations will resist change.***

7.2.6 Resistance to change

As consumers, Internet users have the choice of determining which technologies meet their wide diversity of needs. Much evidence from the first phase study indicated that participants have not implemented IPv6 for several reasons. IPv6 does not immediately benefit the user who adopts it and does not appear to provide any competitive advantage over those who do not have it (Huston, 2013). As previously discussed in Section 3.5, the implementation of IPv6 by Internet users is very rare, although it was introduced as the only *de facto* standard (DeNardis, 2009) to replace IPv4 as the common IP standard to provide Internet connection. The first phase of mixed-method also demonstrates a strong support for the notion that organizations are resisting the change to IPv6. Therefore, resistance to change is used as the key dependent variable.

7.3 Instrument Development

The concepts in the research model in Figure 7.1 need to be operationalised in a manner that can be measured and quantified. Sethi and King (1991) suggest establishing clear construct definitions as an important first step. By providing a clear meaning and definition, this could facilitate the development of measurement items and help to ensure that the construct flows from it (Lewis *et al.*, 2005). Burton and Mazerolle (2011) suggest beginning with a thorough exploration of relevant literature related to the constructs. Since all of the constructs were derived from qualitative phase findings, the definitions were developed by considering findings from both the previous phase and relevant construct definition from previous studies (Hinkin, 1995). Table 7.1 provides definitions for the constructs.

Table 7.1. Constructs and Definitions

Construct	Definition	Literature sources
Resistance to change	Any conduct that serves to maintain the status quo in the face of pressure to alter the status quo	(Bhattacherjee & Hikmet, 2007; Klaus & Blanton, 2010; Markus, 1983)
Lack of felt need	The extent to which an organisation is not convinced of the merits of the change	Hirschheim and Newman (1988); (Robey *et al.*, 2008; Roger, 1995)
Satisfaction with the current system	The extent to which an organization is satisfied with the current or existing system	(Ellen et al., 1991), (Cenfetelli & Schwarz, 2011)
Perceived threat	Potential negative consequences that associate with the implementation of new system	(Bhattacherjee & Hikmet, 2007; Lapointe & Rivard, 2005; Rivard & Lapointe, 2012)
Switching cost	The perceived economic and non-economic costs associated with changing from one alternative to others	(Jones *et al.*, 2002; Kim *et al.*, 2007; Polites & Karahanna, 2012)
Lack of environmental influence	The lack of external influence , such as the government, regulators or business partners contribute to influence an organization to change from one alternative to another	(Chau & Tam, 1997; Pan & Jang, 2008; Pereira, 2002)

An extensive review of the literature on information systems in terms of the adoption and resistance theories was conducted to determine relevant constructs and their relationship. The current study adapted the measurement items from a previous information systems study and rephrased them for the context of IPv6 study. The insight obtained from the first phase and discussions with the supervisor also enriched the study instrument. The measurement items are presented in Table 7.2.

Table 7.2. Survey Measurement Items

Coding	Item	Sources
Lack of Felt Need		
LN1	There is no business case justification for our company to adopt IPv6	(Hirschheim & Newman, 1988) (Kim & Kankahalli, 2009) (Venkatesh *et al.*, 2003), Qualitative findings
LN2	IPv6 will not give any benefit to our organization	
LN3	Our organization does not need additional public IP addresses	
LN4	IPv6 is unproven	
Satisfied with the current system		
SS1	The current system (IPv4) works fine and can accommodate our organization's needs	(Chau & Tam, 1997), (Ellen *et al.*, 1991), (Robey, 1979), (Cenfetelli & Schwarz, 2011), (Kleijnen *et al.*, 2009), Qualitative findings
SS2	Our organization doesn't see any problem with the size of the IPv4 address space it can use	
SS3	Our organization doesn't have any issue with NAT (Network Address Translation)	
SS4	IPv4 is a proven technology	
Resistance to Change		
RC1	Our organization does not agree with the change to the new way of working with IPv6	(Kim & Kankahalli, 2009), Qualitative findings
RC2	Our organization will not comply with the change to the new way of working with IPv6	
RC3	Our organization will not change our current protocol (IPv4) to IPv6	
RC4	Our organisation likes to stay with the way we are (IPv4)	
Environmental Influence		
RP1	There is no pressure on our organization to adopt IPv6 from the Indonesian government.	(Cenfetelli & Schwarz, 2011; Tornatzky &

RP2	There is no pressure on our organization to adopt IPv6 from Internet / IP regulators, such as APNIC, IDNIC, APJII or providers	Fleischer, 1990) (Pan *et al.*, 2008), Qualitative findings
RP3	The Indonesian government doesn't facilitate the implementation of IPv6	
RP4	Internet regulators such as APNIC, IDNIC, APJII, or providers do not facilitate the implementation of IPv6	
Perceived Threat		
PT1	Our organization worries that most of our network devices may need to be replaced under IPv6.	(Bhattacherjee & Hikmet, 2007), (Joshi, 1991), (Jiang *et al.*, 2000; Lapointe & Rivard, 2005), Qualitative findings
PT2	Switching to IPv6 could result in unexpected hassles to our company's operation	
PT3	Our organization worries that IPv6 would make it difficult to control network security by removing NAT	
PT4	Our organization worries that IPv6 would make it more difficult to apply network security policies	
Switching Cost		
SC1	Our organization has spent a lot of time, effort and money on IPv4	(Kim & Kankahalli, 2009), (Kim, 2011), (Polites & Karahanna, 2012),
SC2	The cost of implementing IPv6 in our organization would be large	
SC3	Implementing IPv6 in our organization would require much money, time and effort.	
IT sophistication		
CB	Indonesian organizations/companies are more advanced in IT than companies from other countries	(Chwelos *et al.*, 2001)

An extensive discussion with the thesis supervisor was conducted to ensure that all items were reviewed in order to revise or eliminate redundant items or ambiguous items and also remove the items that didn't meet the construct definition (Moore & Benbasat, 1991). A measurement instrument was produced with each of the constructs being represented by three or four items. Two levels of assessment were performed to ensure the validity of the instrument: face validity and content validity. The purpose of face validity is to establish an instrument's ease of use, clarity and readability (Burton & Mazerolle, 2011). Two fellow PhD students were asked to assess the face validity. Minor revisions were made based on their input and cross-checked to the informants to ensure all changes.

Straub *et al.* (2004) recommended four techniques to ensure content validity, including literature review, expert panel, content validity ratio and q-sorting. Since the measurement items were adapted from prior literatures, as noted by Boudreau *et al.* (2001) it helps to increase the content validity. To further strengthen the survey instrument's content validity, the instrument was evaluated via pretesting. The test was undertaken with those who were considered to be familiar with and knowledgeable about the topic (Lewis *et al.*, 2005). Initially, potential respondents were asked to evaluate and provide feedback based on the pre-testing questionnaire. Once they agreed, they were sent a link to pre-testing instruments. The test involved four individuals who provided feedback which is summarized is Table 7.3.

Table 7.3. Instrument Pre-testing Feedback

Participants	**Feedback Mechanism**	**Summary of feed back**
CIO	Telephone conversation	• Research purpose is clear • Have to be clearly stated who the intended person is to become target respondent • Re-order some questions • Reducing points scale number may help to increase response rates
Network Admin	Online chatting	• Easy to understand • Rewording 'business case' • Need some technical knowledge to answer some questions • 10 scale is too much • Suggest to provide Indonesian version • about 10 minutes to complete
IT Director	Telephone conversation	• Need to ensure the target respondent has sufficient knowledge of the topic • Reduce repetitiveness, since some questions look similar

		• Re-order questions to avoid potential false responses
MIS faculty	Messenger	• Suggestion to use active voice • The questions were easily understood • Since the target participants are Indonesia, better to use Indonesian language. • Use 5- or 7-point Likert scale, rather than scale of 0-10

Based on the feedback from pre-testing respondents, a number of revisions were made. The significant change was the survey item scale. The pre-testing questionnaire was based on a 10-point scale ranging from totally disagree to totally agree. The use of a consistent scale for all items was intended to minimise the effort needed to complete the survey (Dillman, 2011). In a natural conversation, this scale is very common when people are asked to rate something. A 10-points scale also provides some benefits: it offers more variance, a higher degree of measurement precision, and provides opportunity to detect changes (Wittink & Bayer, 1994). However, a 10-points scale tends to produce lower statistically different results compared with, for example, 5-point or 7-point scales (Dawes, 2008) and can increase non-response bias and respondent fatigue (Lehmann & Hulbert, 1972). Moreover, survey participants often spend a considerable amount of time responding to just one question (Wittink & Bayer, 1994). Therefore, the scale was reduced to a 7-point scale which was preferred by respondents. Other revisions included arranging measurement items in random order and providing both English and Indonesian versions of the questionnaire in order to increase response rates. Sekaran (2006) stresses the importance of providing a translation of the instrument to the local language which is equivalent to the original language in which the instrument was developed. Once all revisions had been made, including minor revisions to address feedback from pre-test participants, the revisions were reviewed, including those to the Indonesian version, by two bilingual lecturers from a reputable university to ensure that both versions had been accurately translated and the changes did not introduce any errors.

Pilot testing was conducted to obtain feedback on the clarity and contextual appropriateness of the survey. Another objective of pilot testing is to estimate the amount of time that it will take main study participants to complete the survey. The pilot study questionnaire was distributed to five respondents drawn from a sample frame from the main study survey. Once they had completed the survey, a short interview was conducted to assess the feasibility of the instruments from the respondent's point of view. They were asked to comment on the clarity of the questions and any possible difficulties in answering the questions. Subsequently, it was decided that no further revisions would be made since all respondents stated that the instructions were clearly stated and they understood all the questions well. Appendix G provides the main survey questionnaire.

7.4 Sample Design

It was stated in Section 4.5.3.1 that the sample frame for this study was the organizations in Indonesia which used the Internet or Internet technology to support their operations. The target samples ranged from medium to large-sized organizations. It is argued that the response rate from people in top managerial positions in organizations is typically lower than for other groups (Baruch, 1999). As this study tried to understand the reasons for resistance to change to IPv6, it was expected that the key persons within the organizations who were responsible for developing IT policy or managing the network of the organization could be valuable informants, such as the CIO, network manager, network administrator or other position who work closely with Internet/networking technology within an organization. Based on their positions, they were considered as persons who would be the most informed regarding the research topic.

A convenience sample was obtained from the list of respondents from the companies listed in the Indonesian Stock Exchange, educational institutions and government agencies and those through personal recommendation. Anticipating a significant problem in this phase which was the possibility of lower response rates, the sample frame was supplemented by targeting potential respondents identified from social networking (LinkedIn). The rapid growth of social networking and media has been extensively used by organizations to maintain positive relationships with their costumers (Kim *et al.*, 2014). The most essential feature of LinkedIn is that it provides personal or organizational branding. This allows the researcher to filter specific information based on various categories such as position, industry, company size, specific group and many others. Several members from IT professional groups were selected as prospective respondents.

Initial contacts were made via official university email or messenger facilities in order to maximise response rates (Dillman, 2011). The initial communication was an informal introduction to the researcher who then briefly described the research purposes and invited people to participate in the main survey or to recommend a suitable person within his/her organization. The survey was sent via email or messenger to respondents. The invitation communication contained invitation purposes, request to participate, survey address link, and a brief overview of the purposes of the survey. An expression of thanks and appreciation was delivered to those respondents who had taken the time to complete the survey. The researcher sent a kindly remainder to those who hadn't returned a completed survey and also emphasized the importance of their response in ensuring the rigor of the result and the value of this research. The final remainder was intended to encourage those who had not responded after the first remainder.

It was difficult to increase response rates even after the second reminders were sent. The first reminder was sent about six days after the invitation was successfully sent. However, there was no significant difference in response rate before and after the reminder had been sent. The reminder did not yield any additional responses. From the 516 invitations that were sent, this phase only received 80 responses (15.5% response rates). One month after the initial survey had been distributed, the researcher contacted ten non-respondents by telephone or messenger to discuss their reasons for not participating in the survey. The reasons for the reluctance of respondents to complete the survey varied and included: policy against completing a survey (2 respondents, 22.2%), time constraints (3 respondents, 33.3%), no longer at the organization (2 respondents, 22.2%), not relevant to their current position (1 respondent, 11.1%) or not interested in the topic (2 respondents, 22.2%). Compared with a prior study (Baruch, 1999), the reasons for not responding were: too busy (28%), not relevant (14%), policy against completing survey (22%). Another researcher (Ravichandran & Rai, 1999) reported that non-response was because of the large number of surveys received by them (53.3%), company policy not to respond to surveys (13.1%), lack of interest (8.3%), and lack of time (8.3%). The results of non-response assessment indicated that the reasons were not specific to the current study but it represented a common trend in the data collection method of using the survey. Therefore, it appeared reasonable to conclude that there is absence of non-response bias based on feedback from non-responding participants.

To increase the number of responses, the researcher combined the previous method with a hand-delivered, paper-based survey. The paper-based invitations and survey questionnaires were sent directly to potential respondents, with one organization filling only the survey questionnaire. The survey (50 questionnaires) was distributed with the help of two local research collaborators. This method successfully received 23 valid responses. Therefore, the combination of data collection methods produced 103 valid responses (18.19% response rate). The sample description is presented in the next section.

7.5 Data Preparation

The data needs to be prepared, checked and explored before conducting further statistical data analysis (Straub *et al.*, 2004). This step involves data entry and data screening (Section 7.5.1), testing for data normality (Section 7.5.2), examining data adequacy (Section 7.5.3) and examining common method bias (Section 7.5.4).

7.5.1 Data entry and data screening

The data entry process was undertaken by combining two sources of data into a single file using Microsoft Excel. In order to make the discussion more convenient in the next sections, the research abbreviated the names of the variables as follows: *Satisfaction* (Satisfaction with the current system), *Need* (Lack of felt need), *Threat* (Perceived threat), *Cost* (Switching cost), *Environment* (Lack of environmental influence) and *Resistance* (Resistance to change).

The data were collected from a wide range of organizations in Indonesia using mainly web-based survey (516 invitations) and supplemented by a hand-delivered paper-based survey (50 invitations). The web-based application (qualtrics.com) which was used to conduct the online survey provided a convenient feature which allowed the results to be downloaded in the form of a CSV (comma separated value) file. Based on the file, the data from the paper-based survey was manually entered into it. Every effort was made to avoid data entry errors by utilizing Excel's features and maintaining compatibility of the file with an SPSS application including values and labels for variables.

A series of assessment procedures were performed before hypothesis testing. This step is called data screening to ensure the data is useful and valid for further analysis (Hair *et al.,* 2010; Tabachnick & Fidell, 2001). The screening process commenced by performing missing data analysis. Hair *et al.* (2010) explain that missing data occurs when the valid values on one or more variables are not available for analysis. Furthermore, Hair *et al.* (2010) argue that it is important to check missing data to prevent the issue of the generalizability of the result. Any missing data over 5% has to be eliminated from the final analysis (Tabachnick & Fidell, 2001). The analysis indicated that 14 responses had some missing data. However after the analysis, two cases were considered valid because there was less than 5% missing data (Hair *et al.*, 2010), giving 91 valid responses.

The next data preparation step was to check unengaged responses. Unengaged responses occur if someone responds with exactly the same value for every single question. The data is considered as useless and has to be removed. For this purpose, Meyers *et al.* (2006) suggests calculating the standard deviation of the dataset. If the value is zero or close to zero, the data is useless because of non-variance responses. The result indicated that all scores were 0.5 or greater, which meant that no response needed to be deleted since the respondents were engaged with the questions.

7.5.2 Test for normality

Normality refers to the shape of the data distribution and the characteristics of its statistics for a single individual metric variable that meet the normal distribution (Hair *et al.*, 2010). The normal distribution is in the form of a bell-shaped curve and it is influenced by the distribution and the sample size (Goodhue *et al.*, 2012).

Tabachnick and Fidell (2001) suggest that skewness and kurtosis are two mechanisms that can be used to check whether or not the data is normally distributed. While skewness is used to describe the balance of the distribution, kurtosis is used to examine the flatness of the distribution (Hair *et al.*, 2010). The skewness and kurtosis of a normal curve have a value of zero; any skewness or kurtosis value above or below zero indicates departure from normality. The researcher found many variations of acceptable values among scholars. For example, George and Mallery (2010) suggest the most acceptable value for the two statistics is between -2 and +2. Kline (2010) recommends a value between -3 and +3 for skewness to be categorised as a normal distribution. Moreover, Kline states those absolute values higher than 8.0 for kurtosis suggest a problem. Bulmer (2012) rule of thumb suggests an absolute value of 1 for skewness. Table 8.3 presents the results of the normality testing.

Table 7.4. Normality testing

Indicators	Mean	Std. Deviation	Skewness	Kurtosis
CB	3.34	2.531	-0.158	**-1.362**
LN1	3.87	1.721	-0.153	-0.175
LN2	3.31	1.575	-0.055	-0.104
LN3	3.91	1.811	-0.004	-0.727
LN4	3.78	1.533	-0.547	0.485
PT1	4.67	1.726	-0.653	0.126
PT2	4.34	1.681	-0.513	0.118
PT3	3.89	1.65	-0.55	0.19
PT4	3.78	1.548	-0.34	0.175
RC1	3.77	1.491	-0.457	0.974
RC2	3.36	1.395	-0.376	0.243
RC3	3.65	1.622	-0.208	-0.08
RC4	4.13	1.376	-0.216	0.476
RP1	3.65	1.911	-0.37	-0.28
RP2	3.29	1.784	-0.347	-0.357
RP3	3.55	1.869	-0.277	-0.214
RP4	3.76	1.923	-0.415	-0.062
SC1	5.26	1.75	**-1.254**	**1.575**
SC2	4.46	1.797	-0.723	0.525
SC3	4.99	1.786	**-1.108**	**1.1**
SS1	6.18	0.995	**-1.192**	0.722
SS2	5.95	1.233	**-1.313**	**1.606**
SS3	5.75	1.561	**-1.899**	**4.351**
SS4	6.18	0.914	-0.895	-0.069

As shown in the table above, some measures fell outside of the desired range plus minus 1 which indicated that the values were not entirely normal (Meyers *et al.*, 2006). There are some options for dealing with non-normal data distribution. The first option is to conduct a parametric test with non-normal data with the assumption of normality. Hair *et al.* (2010) argue that slight deviations from normality may result in slight inaccuracies in parametric tests. The second option is to perform non-parametric tests for non-normal data. Non-parametric tests do not assume a specific distribution for the data, even though the test can be less powerful compared with the parametric test (Corrado, 1989). The third option is to deploy data transformation as a remedy to convert the data to obtain a normal distribution (Hair *et al.*, 2010). In this option, transformation processes use many mathematical functions (such as square root, logarithm or archine) to obtain a normal distribution data. The fourth option is to apply variance-based structural equation modelling such as PLS (Chin *et al.*, 2003). Unlike AMOS or LISREL, PLS does not require normally distributed data (Esposito Vinzi *et al.*, 2010) in order to provide a salient recommendation (Chin, 2010). Section 7.7 will present more details about the application of PLS as the analytical tool for the current study.

7.5.3 Adequacy

Sample adequacy is the amount of sample that is large enough to provide the required precision of the test results and to support the generalizability. The most common argument for deploying PLS is the use of a small sample size (Ringle *et al.*, 2012). Based on Barclay's rule of thumb, the sample size must be more than ten times the number of items in the most complex constructs (Barclay *et al.*, 1995). Given that the research model consists of six constructs, this rule suggests a minimum sample size of 60 for the current context. Since the study has 91 valid responses, the sample size exceeds the ten-time rule.

However, this study also follows Hair *et al.* (2010) who suggest testing adequacy of size using the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMOMSA) and Bartlett's Test of Sphericity (BToS) to check the appropriateness of the data. In addition, they state that a KMO between 0.5 – 1 is acceptable. Based on the value, they categorize the sizes as marvellous (.90s), meritorious (.80s), middling (.70s), mediocre (.60s) and miserable (.50s). If the BToS is less than 0.05, the sample adequacy is significant. The test indicated that the value of KMOMSA and BToS is 0.792 and .000 respectively. Therefore, the sample size was considered sufficiently large to achieve adequate power for the observed effects.

7.5.4 Common Method Bias (CMB)

CMB is related to a bias in collecting data via a single method (Straub *et al.*, 2004). CMB could cause a systematic measurement error, either inflating or deflating responses (Podsakoff *et al.*, 2003). Therefore, it is recommended to conduct CMB testing to make sure that there is no systematic bias that can influence the data (Tabachnick & Fidell, 2001). There are various ways to assess CMB (Podsakoff *et al.*, 2003) which are Harman's one-factor, partial correlation, marker variable and examine correlation matrix. However, Podsakoff *et al.* (2003) argue that none of these methods is considered perfect. Hence, the current study tested CMB using Harman's one factor and marker variable.

The first test deployed the Harman's Single-factor Method (Hair et al., 2010) which suggests that CMB exist if the factor extracted explains more than 50% of variance. SPSS was used to conduct the testing (single variance – not based on eigenvalues, no rotation). The result indicates that a single factor for only 24.435% of variance of the model. This suggests that there was no significant bias in the dataset.

Since the merit of the Harman's Single-factor has been questioned (Podsakoff *et al.*, 2003), the current study corroborated the first test by conducting a marker variable testing to control for common method bias (Lindell & Whitney, 2001). For this purpose, a marker variable which should be uncorrelated with the indicators of the study variables needs to be included in the model (Rönkkö & Ylitalo, 2011). If the correlation value is close to zero, it is unlikely that there is issue with the data. Podsakoff *et al.* (2003) argue that a correlation value more than 0.263 or 26.3% variance can be attributed to common method variance (CMV). Hence, the researcher added another variable, *IT Sophistication*, which is theoretically different from the other variables in the model. The test results (Table 7.5) indicated that no correlation was more than the threshold which indicates the likelihood that CMB is low.

Table 7.5. Test for CMB based on Marker Variable

	Cost	Need	Threat	Regulator	Resistance	Satisfaction	Marker
Cost	1						
Need	0.181	1					
Threat	0.330	0.444	1				
Environment	0.203	-0.021	0.049	1			
Resistance	0.218	0.342	0.414	0.038	1		
Satisfaction	0.336	0.023	0.060	0.114	0.080	1	
Marker	**0.046**	**0.147**	**-0.126**	**0.139**	**-0.143**	**-0.109**	1

7.6 Sample Descriptions

For sample descriptions, the researchers conducted a descriptive analysis to obtain a picture of the respondents' profiles. This section describes the profiles of the respondents, including the types of the organizations, each respondent's position and the number of computer users within each organization.

As shown in the table, the combination of organizations in Information Media and Telecommunication with Education and Training categories dominated up to about 39.6% of the total respondents. In terms of position of respondents, IT managers account for 30.8% and followed by other positions and network administrators account for 25.3% and 18.7% respectively. Table 7.6 also indicates that the organizations which have less than or equal to 1000 users accounted for 70.3% of respondents.

Table 7.6. Descriptive analysis of respondents' profiles

Organization			Position			Number of Users		
	Freq	%		Freq	%		Freq	%
Agriculture, forestry and fishing	1	1.1	CIO	8	8.8	< 100	16	17.6
Mining	8	8.8	IT Manager	28	30.8	101 - 500	21	23.1
Manufacturing	9	9.9	Network Administrator	17	18.7	501 - 1.000	27	29.7
Electricity, gas and water supply	2	2.2	System Developer	7	7.7	1.001 - 5.000	5	5.5
Construction	2	2.2	Database administrator	8	8.8	5.001 - 10.000	7	7.7
Wholesale trade, Retail trade	4	4.4	Other IT professional position	23	25.3	> 10.000	15	16.5
Transportation, storage	1	1.1	**Total**	91	100	**Total**	91	100
Information Media and telecommunication	21	23.1						
Finance and insurance	5	5.5						
Rental, hiring and real estate services	3	3.3						
Public administration and safety	1	1.1						
Education and training	15	16.5						
Health care and social assistance	6	6.6						
Other services	13	14.3						
Total	91	100						

7.7 Data Analysis

The objective of this section is to continue with the data analysis. The section presents the data analysis using structural equation modelling (SEM), more specifically, using Partial Least Squares (PLS) to evaluate the proposed model. There are two steps to the validity and reliability test for building a model in SEM using PLS (Gefen & Straub, 2005; Hair *et al.*, 2014). First, the current study conducted measurement model validity to assess the relationship between the empirically dependent and independent variables. Second, the structural model which comprised the relationship between the latent variables was conducted to build and test structural model validity (Hair *et al.*, 2010). The following two sections present more details of the two phases of the model building through (1) measurement model validity and (2) structural model validation.

7.7.1 Measurement model validity

This section discusses the first phase of the two steps of model building, measurement model validity. Hair *et al.* (2010) argue that the research model cannot be tested unless the measurement properties of its constructs are reliable and meet the minimum requirements. Measurement models provide empirical measures of the relationships between the indicators and the constructs (Hair *et al.*, 2014). Two important dimensions of the measurement model need to be assessed: validity and reliability. Straub *et al.* (2004) explain that validity is related to measurement between constructs and reliability is related to measurement within a construct. Both of them need to be evaluated to ensure that the measurement model is reliable.

The measurement model validity assessments involve (1) indicator reliability, (2) internal consistency reliability and (3) construct validity. Straub *et al.* (2004) suggest convergent validity and discriminant validity to assess construct validity. For this purpose, the current study mainly deployed SmartPLS (Ringle *et al.*, 2005) and combined this with SPSS and Excel when necessary.

7.7.1.1 Indicator reliability

Although the item measurements have been clearly and carefully defined during the development and preparation process, reliability testing is recommended to increase the accuracy of measurement and to ensure that the data can be trusted (Straub *et al.*, 2004). In addition, Hair *et al.* (2010) argue that the goal of indicator reliability is to provide a clear pattern matrix where all indicators' outer loadings are statistically significant.

Hair *et al.* (2010) suggest selecting a threshold level that improves the correlation and reliability. According to Hair *et al.* (2014) all indicators' outer loadings below 0.4 have to be dropped and those between 0.4 and 0.7 should be carefully examined because of the effect of item removal on composite reliability and constructs validity. Some authors (Chin, 2010; Henseler *et al.*, 2009; Straub *et al.*, 2004) recommend a value of 0.70 or greater is acceptable to achieve satisfaction level. However, a value higher than 0.95 is questionable since it indicates multicollinearity and the possibility that the respondents have not answered objectively (Tabachnick & Fidell, 2001). The results of analysis are presented in Table 7.7 which also reveals that some indicators are below the desired value of 0.7.

Table 7.7. Cross loading assessment

Indica-tor	Constructs						Distance to the closest loading	Remark
	Need	Threat	Resis-tance	Environ-ment	Switching	Satis-faction		
LN1	**0.758**	0.261	0.337	0.079	0.101	0.044	0.421	
LN2	**0.880**	0.488	0.502	-0.001	0.085	0.150	0.378	
LN3	**0.660**	0.186	0.309	-0.042	0.060	0.136	0.351	
LN4	**0.709**	**0.656**	0.505	0.058	0.456	0.049	**0.053**	Cross loading
PT1	0.268	**0.605**	0.306	-0.002	**0.490**	0.053	**0.116**	Cross loading
PT2	0.486	**0.786**	0.463	0.029	0.487	0.235	0.323	
PT3	0.470	**0.873**	0.544	0.156	0.239	0.074	0.329	
PT4	0.534	**0.870**	0.527	0.056	0.212	0.080	0.337	
RC1	0.396	0.469	**0.854**	0.479	0.396	0.113	0.375	
RC2	0.531	**0.607**	**0.878**	0.301	0.357	0.020	0.271	
RC3	0.501	0.440	**0.824**	0.165	0.156	0.068	0.323	
RC4	0.469	0.447	**0.775**	0.142	0.263	0.219	0.305	
RP1	0.027	0.007	0.242	**0.897**	0.187	0.034	0.655	
RP2	-0.017	0.041	0.271	**0.884**	0.159	-0.070	0.614	
RP3	0.074	0.108	0.317	**0.905**	0.195	0.034	0.587	
RP4	0.025	0.124	0.360	**0.899**	0.283	0.039	0.616	
SC1	0.176	0.148	0.144	0.170	**0.586**	0.299	0.287	> 0.7
SC2	0.243	0.360	0.326	0.181	**0.903**	0.250	0.576	
SC3	0.206	0.431	0.354	0.231	**0.906**	0.362	0.544	
SS1	-0.021	0.061	-0.022	0.027	0.303	**0.706**	0.403	
SS2	0.092	0.091	0.098	-0.032	0.305	**0.866**	0.561	
SS3	0.113	0.149	0.088	0.055	0.332	**0.893**	0.561	
SS4	-0.026	0.026	0.045	0.016	0.310	**0.571**	0.261	> 0.7

For further analysis, the current study examined major cross loadings to obtain a clear factor structure (Henseler *et al.*, 2009). Major cross loading occurs if a loading factor is less than 0.2 away from the primary factor (Henseler *et al.*, 2009) and they have to be discarded when this occurs. Table 7.7 shows the result of cross-loading assessment which indicates loading issues at some indicators.

Table 7.8 provides a summary of dropped items and the reason that they have been dropped. Four indicators were removed as they have one or more of the factorial criteria issues - either cross-loading (PT1 and LN4) or the value below the expected loading values (SC1 and SS4) (Hair *et al.*, 2014). As the result, some indicators' loadings increased as shown in Table 7.9 .

Table 7.8. Summary of Exploratory Factor Analysis

Constructs	Drop Items	Reason to drop
Cost	SC1 - Our organization has spent a lot of time and money on IPv4	Loading < 0.7
Threat	PT1 - Our organization is worried that most of our network devices may need to be replaced under IPv6.	• Other factors: Loading improve • Cross loading > .2 - Switching Cost (0.468) - Perceived Threat (0.620)
Need	LN4 - IPv6 is unproven	• Other factors: Loading improve • Cross loading >.2 • Need (0.630) • Threat (0.658)
Satisfaction	SS4 – IPv4 is a proven technology	Loading < 0.7

7.7.1.2 Internal consistency reliability

Hair *et al.* (2010) explain that internal consistency is a reliability requirement in reflective constructs. Straub *et al.* (2004) argue that this reliability is to ensure that the data can be trusted. Internal consistency measures a construct through a variety of indictors within the same instrumentation (Straub *et al.*, 2004). Furthermore, Hair *et al.* (2014) suggest using composite reliability to replace traditional Cronbach's alpha to determine the internal consistency reliability. Some studies as reported by Hair *et al.* (2012), combine both of them to ensure a high level of validity. For acceptable values, Straub *et al.* (2004) argue that Cronbach's alpha can be accept if it is 0.6 or higher, while Hair *et al.* (2010) recommend 0.5 or higher to allow Composite reliability to be accepted. Table 7.9 shows that both Composite reliability and Cronbach's Alpha for all constructs are satisfactory and above the recommended thresholds. The high levels of internal consistency reliability have been shown by all the constructs which indicate that each item has strong internal consistency with other items of the construct.

Table 7.9. Summary for Reflective Outer Models

Construct	Indicator	Factor Loadings	Indicator Reliability (loading^2, min 0.4 preferred >0.7)	Composite Reliability (>0.7)	Cronbach's Alpha	AVE (>0.5)
Need	LN1	0.811	0.658	0.867	0.772	0.685
	LN2	0.909	0.826			
	LN3	0.756	0.571			
Threat	PT2	0.750	0.562	0.893	0.818	0.737
	PT3	0.915	0.836			
	PT4	0.902	0.813			
Resistance	RC1	0.853	0.728	0.901	0.854	0.695
	RC2	0.875	0.765			
	RC3	0.827	0.685			
	RC4	0.777	0.603			
Environment	RP1	0.897	0.804	0.942	0.919	0.803
	RP2	0.884	0.782			
	RP3	0.905	0.818			
	RP4	0.899	0.808			
Cost	SC2	0.913	0.834	0.917	0.820	0.847
	SC3	0.927	0.860			
Satisfaction	SS1	0.691	0.477	0.860	0.839	0.674
	SS2	0.854	0.729			
	SS3	0.902	0.814			

7.7.1.3 Construct Validity

Construct validity is concerned with the instrument items for the study - whether it fits together to measure the concept it is intended to measure (Straub *et al.*, 2004). In this study, it was tested with convergent and discriminant validity (Hair *et al.*, 2012; Henseler *et al.*, 2009; Straub *et al.*, 2004).

7.7.1.3.1 Convergent validity

Convergence validity assessed whether the indicators of a specific construct converge or have a high proportion of variance in common (Hair *et al.*, 2010; Straub *et al.*, 2004). In order to check convergent validity, Average Variance Extracted (AVE) for each of construct is commonly used. Convergent validity is confirmed if AVE is 0.5 or more. Table 7.9 indicates that all of the AVE values are greater than the acceptable threshold of 0.5, confirming the convergent validity.

7.7.1.3.2 Discriminant validity

Discriminant validity is used to examine whether each factor is related to other factors (Hair *et al.*, 2010). Gefen and Straub (2005) explain that two procedures are used to check the validity: (1) checking cross-loading and (2) assessing the squared root of the AVE for conducting Forner-Larker Criterion Analysis (Wong, 2013).

The first step to check discriminant validity at item level is by examining the item loadings to construct correlation (Gefen & Straub, 2005). Table 7.7 indicated that some cross loading occurred and has been removed. As the cross-loading was removed, the loading of other factors increased as shown in Table 7.9.

The second procedure to check discriminant validity at construct level is by conducting Forner-Larker Criterion analysis. This procedure suggests that the ratio of the square root of the AVE of each construct to the correlation of the construct to all the other constructs can be used to establish discriminant validity (Gefen & Straub, 2005). The square root of the AVE value has to be greater than the correlation with any other constructs (Hair *et al.*, 2014; Urbach & Ahlemann, 2010). The results in Table 7.10 indicate that discriminant validity is well-established for all the constructs. Therefore, it was concluded that the measurement model validity process exhibited a substantial degree of convergent and discriminant validity that justified proceeding with structural model validity and hypotheses testing.

Table 7.10. Fornell-Larcker Criterion Analysis

	Cost	Environment	Need	Resistance	Satisfaction	Threat
Cost	**0.920**					
Environment	0.225	**0.896**				
Need	0.088	0.012	**0.828**			
Resistance	0.369	0.339	0.479	**0.834**		
Satisfaction	0.331	0.012	0.145	0.120	**0.821**	
Threat	0.372	0.097	0.431	0.596	0.148	**0.859**

7.7.2 Structural model validity

The measurement model has been validated through a systematically rigorous process in the previous section. The result indicates that all properties of reliability and validity assessment are within the acceptable range of error. The result of the normality test also indicates that there is some issue with normality. Chin (2010) recommended the PLS estimation to the case of non-normal variable distribution. The structural model was assessed to determine the explanatory power of the model as well as to test research hypotheses. The current study adapted Hair *et al.* (2014) to assess the structural model validity.

7.7.2.1 Collinearity assessment

Collinearity exists when two or more indicators are highly correlated (Hair et al., 2010). Collinearity can cause both logical and statistical problems and therefore it will affect the result. When collinearity occurs, the corresponding indicator(s) need to be removed. Hair et al. (2014) suggest using the Variance Inflation Factor (VIF) and tolerance value for collinearity checking. A tolerance refers to the percentage of variance in the independent variable that is not accounted for in the other independent variable(s). VIF indicates the degree to which the standard errors are inflated due to the levels of collinearity. A tolerance value of 0.20 or lower and a VIF value of 5 or higher respectively indicate a potential collinearity problem (Hair et al., 2014). Based on the model in Figure 7.1, two dependent variables need to be checked which *Satisfaction* is acting as the predictor of *Need* and five independent variables (*Need, Satisfaction, Threat, Cost* and *Environment*) jointly explain *Resistance.*

Since SmartPLS does not provide features to check the collinearity, the current study uses SPSS as suggested by Hair *et al.* (2014). Table 7.11 indicates that the values of Tolerance and VIF for all predictor constructs are beyond the threshold value indicate no collinearity issues.

Table 7.11. Collenearity Assesments

Dependent	Predictor(s)	Collinearity Statistics	
		Tolerance	VIF
Need	Satisfaction	1	1
Resistance	Satisfaction	0.788	1.270
	Need	0.802	1.247
	Regulator	0.923	1.083
	Switching	0.668	1.497
	Threat	0.720	1.390

7.7.2.2 Assessing for the path coefficients

The path coefficient represents the strength, direction (Hair *et al.*, 2010) and significance of the hypothesized relationships (Hair *et al.*, 2014) among constructs. The higher the path coefficient, the stronger is the effect of an independent latent variable on the dependent variable (Hair *et al.*, 2014). The model has meaningful predictive power at the value of 0.20 or greater (Lowry & Gaskin, 2014).

The current study also calculated the significance of t-value for the path coefficient and p-value for measuring the level of significance. As suggested by Hair *et al.* (2014), the common requirement values are 1.65, 1.96 and 2.57 of t-test value at the significant p-value level of 0.10, 0.05 and 0.01 respectively. The statistical significance of path coefficients was established using bootstrap (Sign Changes = No Sign Changes, Cases = 91, Sample = 1000). Entertaining

The result of hypotheses testing is summarized in Table 7.12 which indicates that the path coefficient of *Threat* (0.392) has the biggest impact on *Resistance*, and it was followed by *Need* (0.299) and *Environment* (0.264) respectively. On the contrary, both *Satisfaction* (-0.033) and *Cost* (0.148) are below the threshold value (below 0.20) and therefore they do not statistically contribute to explain *Resistance* (Lowry & Gaskin, 2014). Consistent with path coefficient test, Table 7.12 also indicates that the t-test values of three independent variables (*Threat*, *Need* and *Environment*) have a significant effect on the dependent variable, *Resistance.* The test also suggests that the path coefficient of *Satisfaction* in relation to *Need* does not indicate a meaningful effect (0.145).

Table 7.12. Significance Testing of the Structural Model Path Coefficient

Hypotheses	Path Coefficient	t Values	Significant Levels	Inference
H1. Need -> Resistance	0.299	3.452	***	Supported
H2. Satisfaction -> Need	0.145	0.789	NS	Not Supported
H3. Satisfaction -> Resistance	-0.033	0.400	NS	Not Supported
H4. Threat -> Resistance	0.392	4.412	***	Supported
H5. Cost -> Resistance	0.148	1.603	NS	Not Supported
H6. Regulator -> Resistance	0.264	3.199	***	Supported

7.7.2.3 Assessing the level of R^2

Unlike CB-SEM, the structural model in PLS-SEM is determined by assessing the explanatory power of the structural model (Gefen *et al.*, 2000; Hair *et al.*, 2006) and the path coefficient (Hair *et al.*, 2010; Henseler *et al.*, 2009; Tabachnick & Fidell, 2001). The prior path testing showed that three independent variables *(Need*, *Threat* and *Environment*) were highly correlated to the dependent variable, while the other two (*Satisfaction* and *Cost*) were not. As suggested by Hair *et al.* (2014), the current study assessed the explanatory power of the model by calculating the squared multiple correlation (R^2).

According to Hair *et al.* (2010), the level of R^2 is important in evaluating the structural model. Chin (2010) recommends that R^2 values of 0.67, 0.33 or 0.19 for endogenous latent variable in the inner part model are described as substantial, moderate or weak respectively. The result indicates that R^2 for resistance to change is 0.517. This means that the latent variables satisfactorily explain 51.7% of the variance in *Resistance*. Conversely, *Satisfaction* contributed only 0.021 of the variance in *Need* which means that it has no effect on the dependent variable. The final model and summary of the hypotheses testing are presented in the following:

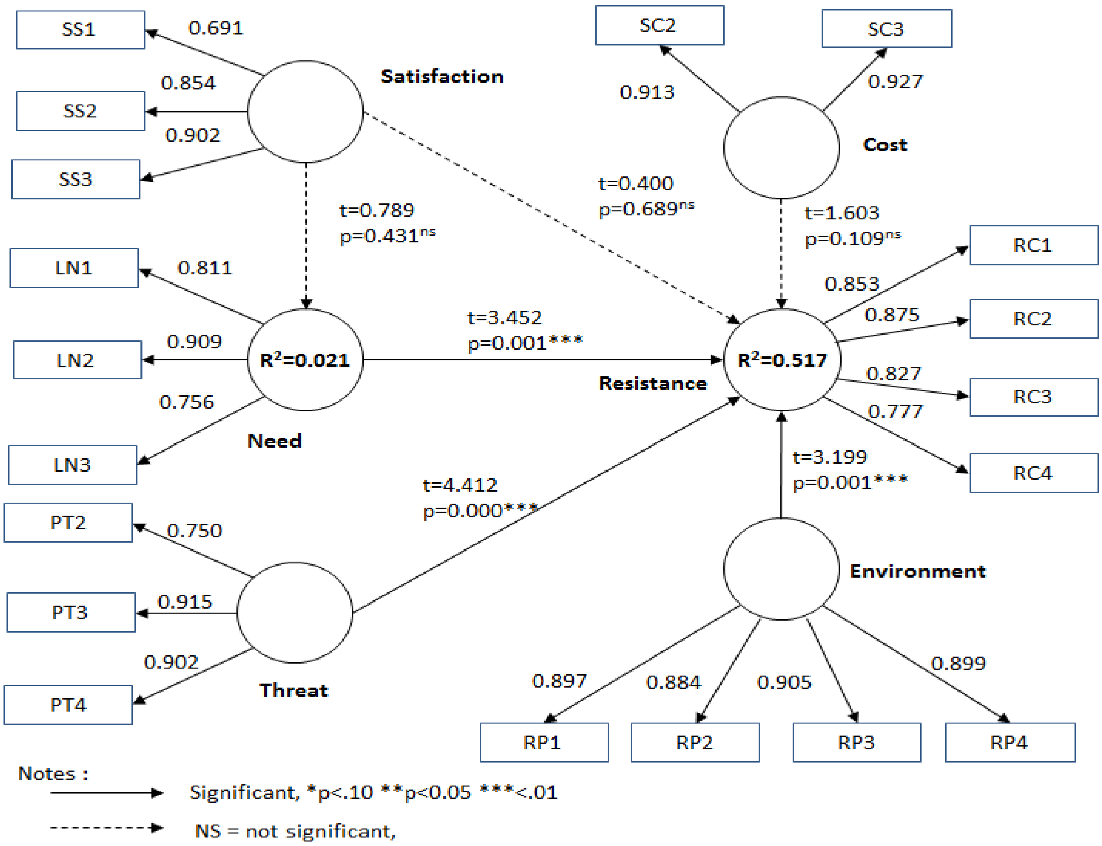

Figure 7.2. Path Model Results

7.8 Chapter Summary

This chapter has presented the sequential process of the quantitative phase including the research model which was derived from phase one and hypotheses development (7.2), instrument development (7.3), sample design (7.4), data preparation (7.5), sample description (7.6), and data analysis (7.7). The collected data was prepared through a rigorous process that served to establish a convenient dataset for subsequent PLS analysis. The assessment and testing of the model involved two steps, namely measurement model and structural model. While the measurement model validity was to ensure the validity and reliability of the measurement items, the structural model validity was to test the research hypotheses using PLS estimation. The results of the measurement validity indicate a satisfactory statistical level and the data analysis indicated that *Lack of felt need*, *Perceived threat* and *Lack of environmental influence*s have a significant effect on *Resistance to change* in the case of IPv6. However, the analysis provided an unexpected result that *Satisfaction with the current system* does not contribute both to organizations' resistance to change to IPv6 and lack of felt need. The analysis result validates the findings of the qualitative study that *Switching cost* is not a predictor of resistance to change. The next chapter discusses the research findings from qualitative and quantitative stages.

Chapter 8. Research Findings and Discussion

8.1 Chapter Introduction

This chapter provides a summary of the key findings of the preliminary study as well as the findings from phase one and two of the mixed-methods approach. Also, it outlines the limitations and areas for future work and provides concluding remarks. This chapter is organized into six sections. Section 8.2 provides a discussion of the core findings of the current study. Section 8.3 revisits the research objectives and summarises the achievement. Section 8.4 outlines the implications of this study for theory and practice. Section 8.5 presents the limitations of the current study. This is followed by identifying possible future research directions in Section 8.6. Finally, Section 8.7 concludes the current study.

8.2 Discussion of Findings

The objective of this section is to discuss the findings from phase two of mixed-method and when appropriate, the discussion will be elaborated and triangulated to the key research findings from preliminary study and the first phase of the mixed-methods approach, the qualitative study. The findings are discussed with reference to the variables within the model.

8.2.1 Resistance to change

The current study has proposed a theoretical model (see Figure 7.1) of IPv6 resistance at the organisational level based on insights drawn from the findings of the first phase of the main study and the prior studies on adoption or resistance technology. Because of the fact that organizations as the end-users of the technology are resistant to implementing IPv6, the central focus of the model is resistance to change. This argument was supported by the findings of the preliminary study which indicated that most of the participants have not made any preparation to implement IPv6 within their networks. These findings extend the findings from prior research studies on IPv6 readiness (Dell, 2011; Pickard *et al.*, 2015).

Based on the analysis of the results from qualitative study, the model links the resistance to change as the dependent variable which is influenced by five independent variables (*lack of felt need, satisfaction with the current system, perceived threat, lack of environmental influence* and *switching cost*). The model was tested through a survey of 91 organizations in Indonesia.

The structural model analysis indicated that the five independent variables satisfactory explain 51.7% of the variance in resistance to change. Among them, *lack of felt need*, *perceived threat* and *regulator pressure* were identified as the most salient factors causing organizations to preserve the status quo. In contrast, surprisingly, although there is much support from previous studies and the empirical findings from the qualitative phase, *satisfaction with the current system* did not seem to significantly impact on the emergence of *resistance to change* and increase *lack of felt need* to adopt IPv6. Furthermore, *switching cost* again has no significant effect on organisational resistance to changing to IPv6. The empirical findings of the quantitative phase also validated the findings from first phase related to the impact of *switching cost* on resistance to IPv6. The next section presents, discusses and interprets the findings in terms of the independent variables.

8.2.2 Lack of felt need

Lack of felt need was measured using three measurement indicators: need of additional address (loading 0.756), business case (loading 0.811) and benefit issue (loading 0.909). The statistical model measurement analysis indicates a significant influence the factor to the dependent variable ($t=3.452$, $p=0.001$). Therefore, hypothesis 1 *(Greater lacking of felt needs is associated with an increased likelihood that an organization will resist changing)* was supported at a 99 percent level of confidence.

This finding confirms the reports from previous observations about IPv6 implementation which described the absence of specific business-case drivers (Botterman, 2009; Roberts, 2009) and the difficulty of measuring the benefits to be derived from the adoption (Gallaher & Rowe, 2006). It also extends the conceptual argument of prior IS implementation literatures on the role of lack of felt need in IT implementation (Agarwal & Prasad, 1998; Hirschheim & Newman, 1988; Premkumar & Ramamurthy, 1995; Riley & Smith, 1997).

Based on comments from interview participants, the findings indicated that the lack of felt need can be categorized into the first three levels of Maslow's hierarchy of needs (see 7.2.1). Firstly, physiological need relates to the finding that lack of motivation and justifications from the business perspective are the common reasons according to interview participants. Based on the interview comments, participants stated that they did not need the IPv6 because there was no business pressure to implement it.

> *"The pressure has to come from business side ...Why should we think it? We have many things that we have to follow up immediately. Not this is one"……. .... [OG5]*

The interview results extend the findings from the preliminary study in which organizations believe in the importance of IPv6. However, the implementation of IPv6 is perceived to be less urgent as shown by the following comment:

> *"Yes, this is about priority. IPv6 is not our priority. We have a lot of things, which have been burning. The platforms have been on fire." .... [OG6]*

Secondly, it is related to safety need. The Internet users have a wide diversity of need and the providers who provide IPv6 do not appear to have any competitive advantage as compared to those that don't (Huston, 2013). On the other hand, from the technology perspective, NAT provides a more convenient solution which allows multiple devices to share the same IP address and is less painful than redesigning and modifying the addresses schema. The findings suggest that the participant felt safe with the current situation. Although IPv6 offers more advanced features than the previous version, the majority of interview participants indicated that their organizations did not see the features as a drawcard to make them use IPv6.

> *"We see this issue as a corporation a bit different. If we talk about it on a macro level, the problem of IP address is obvious. We have to anticipate in terms of providing policy and so on. We currently deploy NAT for our network. We can implement our own policy according the need of our company. So we fully control our network. Will our company adopt IPv6? I don't think so." .... [OG06]*

Finally, it is related to social need. At present, most of the world is capable of running IPv6,[25] although the IPv6 is still insignificantly adopted by about only 4.5 percent[26] of the entire Internet connection. Despite many efforts, numerous warnings, and some incentives provided to encourage the adoption of IPv6, Internet users are still reluctant to implement it on their networks. OG07 mentioned that there was no benefit in adopting IPv6 when today's Internet is still dominated by IPv4.

> *"Well, we will not hesitate to invest to particular technology as long as it gives values to our business. However, I haven't seen the benefit of IPv6 to our business where most of Internet connections still massively rely on IPv4"* .....

The internet users still have to communicate with the rest of the world; therefore, those who adopt IPv6 have to rely on transition technology, such as dual-stack technology or protocol translation which not only increase cost and management of adoption, but also reduce the performance and security of networks.

The findings clearly indicate that IPv6 is not required by organizations in order to sustain a business (Singh & Holmström, 2015). The analysis results show that organizations are concerned by very basic physiological needs and this is followed by safety and social needs. However, it must be noted that Maslow's hierarchy of needs is used to discuss the absence of need for IPv6 based on participants' comments. Therefore, further investigation is required to determine the correlation between resistance and level of need.

8.2.3 Perceived threat

Perceived threat was measured by four items. However, since PT1 (worried most of devices have to be replaced) had low loading and a major cross loading with Switching Cost, the item was not included for further analysis. Hence, the variable was measured using three items: performance loss (loading 0.758), NAT issue (loading 0.892) and security policy issue (loading 0.876). The findings indicate a strong relationship

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[25] Geoff Huston (2013) presentation on the Linux.conf.au reported by Angus Kidman "Why hasn't everyone moved to IPv6". Report available on http://www.lifehacker.com.au/2013/01/why-hasnt-everyone-moved-to-ipv6/
[26] https://www.google.com/intl/en/ipv6/statistics.html accessed on 18/10/2014

between perceived threat and resistance to change in the case of IPv6 (t=4.412, p=0.000). Therefore, hypothesis 4 *(Greater perceived threat is associated with an increased likelihood organisation will be resistance to change)* was supported at a 99 percent level of confidence.

The current study validates the findings from previous studies (Bhattacherjee & Hikmet, 2007; Kim & Kankahalli, 2009; Lapointe & Rivard, 2005; Markus, 1983) - that users are likely to preserve the status quo and tend to resist change when perceived threat is high. The findings from both the qualitative and quantitative phases of this study imply that perceived threat has a significant effect on IPv6 resistance.

Results from the first phase of the study indicated that perceived threat could be classified into three categories. First, the organizations are concerned about the level of expertise within the organisation. Most of the interview participants indicate that they do not have sufficient expertise to manage an IPv6-based network. Second, the implementation of IPv6 was believed to require a massive work load because organizations have to reconfigure their networks, establish a new policy, etc. On the other hand, organizations have to deal with other things which are more important. Finally, the implementation of IPv6 potentially introduces the risk of disturbance. Currently, many organizations rely heavily on a computer network to support their operational activities and IPv4 has served them for quite a long time. As an integral part of their daily business, the any disruption to their IT may affect their entire business. Since IPv6 is not compatible with IPv4, it may even cause most of the current network resources (hardware or software) useless and organizations have reorganization their work (Bhattacherjee & Hikmet, 2007). While the technical challenge can be resolved with a technical solution, dealing with human is always not an easy task, as the comment from OG06 indicates:

> *"Yesterday, I was interviewed by the Info Komputer [one of a popular computer magazine in Indonesia]. I said to them that non-technical things always become a challenge. And more specific to technical things as said, a technical problem can always be solved by a technical solution. We are never afraid of that … In the worst scenario, we can ask to the IT community that is familiar with the problem. Or if I don't know then after you tell me, I will know… for technical problem there is always technical solution"*

In summary, the findings from both the qualitative and quantitative studies strongly indicate perceived threat as predictor of resistance. The qualitative analysis results reveal that perceived threat could stem from concern about the level of IPv6 expertise within the organization, being daunted by the amount of work required to implement IPv6, the risk of disruption to other IT operations and concern about compatibility with the current system and the current practice.

8.2.4 Lack of environmental influence

In the quantitative phase, *lack of environmental influence* was measured using four indicators and all measurement items indicated significant loadings: government encouragement (loading: 0.0897), government facilitation (0.884), other regulator support (loading: 0.905) and other regulator facilitation (loading: 0.899). The structural analysis and hypothesis testing results indicate that this factor has a significant effect on IPv6 resistance (t=3.199, p=0.001). Therefore, hypothesis 6 *(Lack of environmental influence is positively associated with an increased likelihood that organizations will resist change)* was supported with a confidence level of 99 percent.

Analysis results from the qualitative phase strongly indicate that there is an absence of environmental influence in encouraging and facilitating IPv6 implementation. The findings suggested that there was lack of active encouragement or facilitation from Indonesian government or other regulatory sources as the following comments indicate:

> *"Especially our government, they don't care about this. They are sleeping. We have to wake them up. What do you want to say? That is the actual fact, our government is sleeping. If it's late means they are aware. They're sleeping. So you have to wake them up" .... [OG05]*

> *The problem is now we're under the regulation of SKK Migas [ed. SKK migas is Oil and Gas Special Task Force] or BP Migas. All companies with category K3 [ed. Cooperative contract company], just like us, should follow all regulation from the SKK Migas… until we have new regulation, not yet. We don't need it [IPv6]. Except, there's a new rule, then we have to. For example later in if there's a regulation to connect to the SKK Migas via IPv6. What should we say, we have to." .... [OG10]*

Actually, the Indonesian government has provided and updated the IPv6 implementation road map (PP No 13-2014). The document is intended (1) to provide a guideline for Internet stakeholders to implement IPv6, (2) to provide proper direction and government strategy in implementing IPv6 nationally, and (3) to specify necessary steps for the success implementation IPv6 in Indonesia. To achieve these objectives, the government established the ID-IPv6TF (Indonesian IPv6 task force) which was responsible for coordinating IPv6 activities in Indonesia, formulating standards and strategies of IPv6 implementation, and ensuring all relevant parties obtained the benefit of its implementation. The body is comprised of the ISPs' association (APJII), representatives of telco industries and other Internet stakeholders.

Besides ID-IPv6TF, Indonesia's IPv6 Forum which is part of the IPv6 global forum has a similar role to disseminate IPv6, educate competent parties and promote the implementation of IPv6 within the region. Unlike ID-IPv6TF, the membership of this forum is open to everyone and every organization. Forum members could come from all ICT-competent parties in government departments, the telecommunication industry, universities, and other Internet communities.

However, these bodies do not seem to function properly which is likely to become a common phenomenon in other countries. There is not much information available to the public in relation to the recent IPv6 activities conducted by the two bodies. The official website (IPv6forum.or.id) is not well-maintained and inadequately provides information related the development of IPv6 in this region. There are numerous unrelated topics and postings in the discussion forum. In addition, the official website of ID-IPv6TF (IPv6tf.or.id) has been hacked for a considerable period of time. This adds up to a picture of poor support for IPv6 deployment in Indonesia.

Moreover, although it has been reported that most of Indonesian ISPs' infrastructures are ready for IPv6 (Budiono & Azmi, 2011), the interview analysis result (see 6.3.3.6) suggests that ISPs, which are an important aspect of the Internet, are not providing adequate support for the implementation. For example, OG13 stated that IPv6 traffic has to be routed to overseas first in order to reach the IPv6 pages in Indonesia. This is due to the fact that the providers do not properly configure their router to facilitate IPv6 traffic. It might be because the ISPs do not see that providing IPv6 services would give them a competitive advantage over those who do not provide IPv6 services (Huston, 2013). Another possibility is that there is no significant demand for the services from their customers, much like the egg-chicken argument – who should start the adoption (Bohlin & Lindmark, 2002; Dul, 2011; Lehr *et al.*, 2008).

This finding aligns with those of previous studies which suggest the involvement of government or competent regulatory bodies in promoting IPv6 by providing supportive policy (Dell, 2010; Mueller, 2010a) or offering encouraging strategies (Hovav *et al.*, 2011). Clearly, the findings from the qualitative and quantitative studies indicate poor support from the government and from those organizations which should actively promote the technology and strongly influence the Internet user to adopt it. While this situation continues, Internet users will undoubtedly continue to resist change.

8.2.5 Satisfaction with the current system

Prior adoption or resistance studies emphasize the current technology as an important reason for the resistance to a new technology (Cenfetelli & Schwarz, 2011; Chau & Tam, 1997; Iacovou *et al.*, 1995). Chau and Tam (1997) stated that satisfaction with existing systems will influence the adoption decision. In particular, when users are satisfied with the current technology, it is highly likely that they will resist changing to the alternative (Ellen *et al.*, 1991). This satisfaction could discourage users from adopting the new technology. An organization should undertake careful and comprehensive deliberations before adopting a new technology, since the change also forces them to change their operations (DeNardis, 2009). Similarly, Zhu *et al.* (2003) explains that the user's existing equipment can contribute to the technological resistance.

Hypothesis 2 (*Satisfaction with the current system is positively associated with lack of felt need*) and hypothesis 3 *(Greater satisfaction with the current system is associated with an increased likelihood that an organization will resist change)* were developed based on a great deal of support from prior literatures. The findings of the preliminary study and numerous testimonials made by interview participants also suggested the importance of satisfaction with the current system as an important reason for organization resisting the change to IPv6. However, this factor surprisingly fails to find support for the associated research hypothesis. The statistical test revealed an unexpected result, in contrast to the findings in the extensive body of IS literature (Ellen *et al.*, 1991; Robey, 1979) and the results from the qualitative study.

The *satisfaction with the current system* was measured using four item indicators. Three indicators indicated the statistically significant level for accommodating issues (0.691), quantity issues (0.854), and NAT issue (0.902). However, the item related to the IPv4 proven issue was dropped from further analysis because of lower loading. The measurements model reliability and validity test returned a satisfactory result, indicating that this independent variable was well-established. However, the structural model analysis showed that path coefficient to resistance to change (H3) was only -0.033, far below the recommended value of 0.20 (Lowry & Gaskin, 2014) and t-value was 0.400, indicating an insignificant predictor. Similar, the path coefficient and t-test of 0.145, 0.789 respectively show insignificant support for the predictor of *lack of felt need.*

The insignificant effect of satisfaction with the current system may have indicated that IPv4 which has served Internet user was not the critical reason for an organization to maintain its status quo. Attempt to understand the insignificant effect of satisfaction as a dependent variable could be because of two things. First, the insignificant finding is due to an insufficient sample size to detect effect of the satisfaction variable to dependent variable. Second, there is insufficient variation in independent variables to satisfactorily measure and estimate the effect of each process on the outcome. The current study cannot discount the findings from the quantitative phase. However, no conclusive evidence was found. Therefore, it can be considered for future work as described in Section 8.6.

8.2.6 Switching cost

Prior adoption or resistance studies (Jones *et al.,* 2002; Kim, 2011; Kim & Kankahalli, 2009; Polites & Karahanna, 2012) suggested the importance of switching costs. This factor contributes significantly to increasing user resistance (Kim & Kankahalli, 2009). Also, there are many studies that indicate the negative effect of switching costs

(Carroll *et al.*, 2002; Chau & Tam, 1997; Iacovou *et al.*, 1995) on technology adoption. Moreover, numerous prior works on IPv6 also emphasize cost as a major barrier to organizations adopting IPv6 (Bohlin & Lindmark, 2002; Hovav *et al.*, 2004).

Although the results of the phase one of this research indicated there was little evidence that the cost of switching was related to organizational resistance, since this factor was heavily supported in the literature, the researcher conducted phase two in an attempt to measure this relationship. Three items were used to measure the effect of switching cost using the measurement model validity and reliability test: transition cost (loading 0.913) and uncertainty cost (loading 0.927). Meanwhile sunk cost (SC1) was removed since the loading was below the threshold used in this study. Both of the measurement items indicated excellent levels of loading factor. However, the statistical testing result suggested that switching costs had a less powerful effect on the resistance to change in the case of IPv6. The PLS testing indicated the lack of a significant relationship between switching cost and resistance to change. This result extends previous findings that switching cost has no impact on user resistance (Furneaux & Wade, 2011).

Findings from the interview sessions indicated that, for several reasons, costs were considered not as a barrier to adopting IPv6. Firstly, as Kim and Kankahalli (2009) noted, if organizations see that the costs exceed the benefit, this increases resistance to change (Kim & Kankahalli, 2009). In this context, the interview participants argued that the benefit of adopting a technology was more important than costs, as the following comment shows:

> *"... The company tends to use a technology to be competitive. If the technology can facilitate the company to be competitive, we have to adopt it. No matter how much cost should be spent"* .... *[...OG09]*

Secondly, it is perceived that there is no urgency to adopt and implement IPv6. Some interview participants pointed out the Y2K phenomenon where many organizations saw that it could threaten their business organization. In anticipation, organizations spent a lot of money just to ensure that their system could operate normally at the end of any century.

Finally, IPv6 is considered as a standard feature on the recent networking devices. Therefore, interview participants believed their organizations were ready to implement

IPv6: they just need to turn the feature on when it is needed. Whether or not organizations want to implement IPv6, they have to regularly update their devices and personnel's' skills and knowledge. Hence, cost might not be a reason for resistance to change.

In summary, the findings from the qualitative and quantitative studies indicated that there was no evidence to suggest that the cost of switching is a predictor of resistance to change. These findings are in contrast to the findings from previous IPv6 studies (Bohlin & Lindmark, 2002; Dell, 2010; Pickard, 2014) which suggest the importance of cost in influencing Internet users to resist IPv6. However, the current study also complemented and extended previous IPv6 studies. For example, Hovav *et al.* (2011) found that financial factors had no influence on the adoption of IPv6 in South Korea. The finding also validated a previous study by Gallaher and Rowe (2006) and OECD (2014) which suggests that the numerous benefits to be gained from switching to IPv6 far outweigh the cost involved.

8.3 Revisiting Research Objectives & Research Questions

The current study was inspired by the fact that IPv6 has not been widely adopted although it was introduced as the de facto standard to replace IPv4. Although many advocates believed that its larger address space and better features would drive its success (Waddington & Chang, 2002), organizations still preserve the status quo and resist changing to IPv6. In this study, resistance to change is the central concern due to the fact that the rate of IPv6 adoption remains negligible although it was introduced as the only protocol standard for the future Internet. To guide the study, five objectives were identified and four research questions were carefully developed to guide the research process. A sequential mixed-methods approach, supplemented by a preliminary study, was used in order to achieve the research objectives and answer the research questions. Table 4.4 presents the relationships between research objectives, research questions and research approaches which will be discussed in the rest of this section.

8.3.1 Objective 1: To investigate Indonesia's IPv6 readiness

Objective 1 (OB1) is important as a starting point to understanding the Indonesia resistance to IPv6 resistance. Since the decision to adopt the technology is at the organisational level, R1 (*What is the current status of IPv6 readiness among organizations in Indonesia*) is intended to focus this objective. The findings arising from this research question serve to provide some guidance to the researcher and assure him that IPv6 resistance is occurring in this region.

A preliminary study was designed and conducted to obtain a comprehensive overview of the readiness of Indonesian organisations to adopt IPv6. Chapter 5 presented the steps taken to achieve this objective and answer R1. The instrument was adopted from prior IPv6 readiness studies (Dell, 2011) and the findings clearly indicated that Indonesian organizations are not prepared for the implementation of IPv6. This was not a surprising result since the phenomenon of resistance to IPv6 is also evident in other countries (such as Australia as reported on Dell (2011) and the U.S. as reported by Pickard et al., (2015)) and most Internet users still intend to continue to rely on IPv4 in the foreseeable future. Although IPv6 is more advanced than the previous protocol (Wu *et al.*, 2013), it is not a strong enough motivation for organizations to switch their technology. The results increased the researcher's confidence and led to a more in-depth investigation of the reasons for organizations in Indonesia resisting the change to IPv6.

8.3.2 Objective 2: To explore, review and synthesise relevant literature related to adoption of or resistance to technology.

This objective was met by addressing R3 (*What factors lead organizations to resist changing to IPv6*). Two literature reviews concerning (1) Internet and Internet Protocol and (2) adoption and resistance studies, were conducted to highlight the relevant issues related to Internet policy and IP standards and to identify relevant perspectives regarding the factors determining the adoption of or resistance to technology.

The Internet has developed as a deregulated (Huston, 2013) and self-regulated industry (DeNardis, 2009). Chapter 2 discussed the background of the Internet, highlighted several organizations that ensure Internet interoperability, and the political and technical challenges regarding its governances. Mueller (2010b) argued that no single institutions could force Internet user to use a certain technology, including IPv6. However, while the Internet involve many parties which have their own interest and various of technologies involved, some institutions or bodies have important roles to determine appropriate standards, provide adequate policies and manage the Internet resources to allow smooth communication among Internet entities.

Chapter 3 discussed insights and lessons from previous studies on the adoption of or resistance to new technology. Research examining resistance to change has attracted relatively less attention and less theorisation than technological adoption (Klaus & Blanton, 2010). Moreover, the focus of previous studies was on resistance to a technology being promoted by an organization to individual end-users within the organization and conceptualised group-level resistance as an aggregated individual act of resistance. As Laumer and Eckhardt (2012) state, resistance research does not provide a unified understanding of resistance to technology. This provides opportunities for future researchers to further explore this issue (Ford *et al.*, 2008) as an alternative to technology implementation. Resistance has to be understood in relation to the success of technology implementation (Lapointe & Rivard, 2005). Resistance factors are not simply the opposites of adoption factors (Gatignon & Robertson, 1989). As suggested by Cenfetelli (2004a), both enablers and inhibitors affect technology usage. As suggested by Bhattacherjee and Hikmet (2007) and Kim and Kankahalli (2009), both adoption and resistance factors should be combined into a single study in order to better understand the resistance phenomenon. The approach of the current study therefore was informed by the TOE framework for organizational technology resistance and more specifically the resistance by Indonesian organizations to IPv6. Several factors mentioned in both adoption and resistance studies were identified at this stage, which then were used as the protocol for the first phase.

8.3.3 Objective 3: To identify factors that might influence IPv6 resistance among organizations.

The R2 (Why do organizations resist changing to IPv6), R3 (*What factors lead organizations to resist changing to IPv6*) and R4 *(What is the relationship between these factors)* were addressed to achieve OB3. The findings from the literature review revealed several factors that potentially can contribute to resistance to technology. The inquiry protocol used in the qualitative phase was developed based on insights and lessons from numerous studies on adoption or resistance as well as previous IPv6 studies.

While Chapter 3 discussed the factors which theoretically influence the implementation of a new technology, Chapter 6 presented the empirical investigation of IPv6 resistance among various organizations as end-users of IPv6 technology. As suggested by prior organizational research, those who were considered have a high level of competence or expertise in the area under study were accepted as respondents for this study (Flick, 2007; Neuman, 2003; Tornatzky & Fleischer, 1990). Therefore, there were 17 organizations of various sizes and from different industries that comprised the respondents for this phase, as described in Table 6.1. The analyses results showed that in fours domains (*lack of felt need, satisfaction with the current system, perceived threat and lack of environmental influence*) there was strong evidence to indicate the importance of these domains on organizational resistance to IPv6. The findings also indicated that s*atisfaction with the current system* was associated with increasing of *lack of felt need*. However, there was no significant support for the notion that concerns about cost increased resistance to IPv6.

8.3.4 Objective 4: To develop a conceptual model based on findings from objective 3

The relationship finding from this qualitative phase (Table 6.4) served as the basis for the development of a theoretical model. This objective was addressed in research questions R3 and R4. Four identified domains in the qualitative study serve as the predictor of resistance to change.

Although there was not strong evidence regarding the cost of switching, however, as there is a great deal of support for this in previous studies, (Bohlin & Lindmark, 2002; Burnham *et al.*, 2003; Dell, 2010; Kim, 2011; Kim & Kankahalli, 2009; Polites & Karahanna, 2012; Rowe & Gallaher, 2005a; Zhu *et al.*, 2006), the researcher intended to measure the effect of switching cost on IPv6 resistance. Therefore, it was included it in the theoretical model as presented in Figure 7.1. Furthermore, based on the qualitative study findings and the literature review, six research hypotheses were established and led to research objective 5.

8.3.5 Objective 5: To validate the model in order to generalize the findings.

R5 (*To what extent do these factors contribute to make organization resistance to change?*) was developed to address objective 5. Chapter 7 discussed the effort and the findings in order to achieve this objective. A quantitative study was conducted by targeting Indonesian organizations as participants in the study to empirically test the model. The survey attracted 91 valid responses representing various organizations in Indonesia. The findings indicated that there were several significant factors that determined organizations' resistance to IPv6, including *lack of felt need, perceived threat and lack of environmental influences*. However, the model revealed three insignificant relationships. Both *satisfaction with the current system* and *switching cost* has no direct impact on *resistance to change*. The study also found *that satisfaction with the current system* had no effect on lack of felt need.

In general, the model was developed as an initial effort to identify the reasons for organizations' resistance to IPv6. The hypothesis findings represent an important contribution to explaining this resistance.

8.4 Contributions of the Study

By developing and validating the theoretical model, this study contributes to research, theory and practice in several ways. This section underlines these contributions.

8.4.1 Contributions to Research and Theory

This research offers several implication and contribution research and theory. The first contribution made by the current research is that it enriches the existing researches on organizational resistance. This study contributes by building a conceptual model, resistance to IPv6 which extended the range of existing theories on adoption of and resistance to technology. The study combined adoption and resistance theories into a single model and was tested, validated and provided empirical support for the proposed theoretical model. The study significantly improves understanding of how and why organizations resistance to IPv6.

Secondly, the development and validation of the theoretical model is also an original contribution to the adoption of and resistance to technology literatures. The IPv6 resistance model is novel as it integrates adoption and resistance to technology theories and has been tested at an organizational level. It is argued that people react faster to negative stimuli then the positive ones (Cenfetelli & Schwarz, 2011; Spil *et al.*, 2004). Therefore, the dependent variable of model is resistance to change. Furthermore, resistance to change at an organizational level has not been widely explored. By providing a theoretical lens to integrate the adoption of and resistance to technology studies could provide a better understanding on the technological resistance phenomenon.

The third contribution is that the study provides empirical evidence of the IPv6 resistance phenomenon in the context of a developing country, while prior studies (Dell, 2011; Hovav *et al.*, 2011; Pickard *et al.*, 2015) studied IPv6 adoption phenomenon on the context of developed economic. In this regard, the current study addressed an important gap on adoption of and resistance to IPv6 studies. These represent original contributions to both the IPv6 research and adoption of and resistance to technology theories in developing country.

Another way in which this study contributes to research and theory is that the study validated the relevance of previous findings of adoption of or resistance to technology studies (Bhattacherjee & Hikmet, 2007; Lapointe & Rivard, 2005). However, it also rejected the findings from IPv6 prior literatures (Bohlin & Lindmark, 2002; Dell *et al.*, 2007; Gallaher & Rowe, 2006) on the important of switching cost as the inhibitor of IPv6 adoption. Although the empirical evidence come from Indonesia, the IPv6 resistance model can be potentially applied for organizations outside Indonesia. Moreover, it is important for future theoretical work to consider not only to focus to examine positive aspect to get people to use technology but also to explore factors which contribute to make people resist to technology.

8.4.2 Contributions to Practice

Furthermore, this study also has practical implications in at least three ways. First, the study is valuable organizations who promote the implementation of IPv6. Understanding these resistance factors enables the organizations to become more successful in encouraging more people to use IPv6. Second, this study indicates to the Internet community that more work is required to counter the perceptions that IPv6 is a threat. Much work still needs to be done to overcome resistance, especially to demonstrate that in terms of future business requirements, organizations need to prepare for the implementation of IPv6. Third, the findings indicate the need for further investigation to test whether governments or regulators could play a more significant role in addressing the resistance to IPv6.

8.5 Limitations

Although the current study has yielded interesting findings, it has certain limitations, although it provides several interesting insights and useful directions for future research. Firstly, although the common method bias test indicated that there was no threat to the validity of this study, one main challenge in this study was to increase the number of respondents for the second phase of the study; also the number of respondents was not equally distributed among various industries. This may have introduced potential bias which could only be resolved by providing additional data. Secondly, the study focused specifically on organizations in Indonesia as a developing economy where resources and capabilities are relatively low. Hence, this might detract from the generalisability. Thirdly, as the result of measurement validity, some measurement items had to be dropped. Although the remaining items satisfactorily reflect the variables within the model, the construct validity might suffer. Fourthly, the quantitative phase deployed a survey which by nature measure people's opinions,. The data was obtained voluntarily from those who were responsible to the organisation’s network on behalf of their organization. Therefore, it potentially causes a possible flaw.

8.6 Future Research

Despite some limitations, the result of the two phases of the empirical mixed-methods approach provided strong evidence of the reasons why organizations resist changing to IPv6. This study proposes the following opportunities for the future research.

As noted previously, one challenge of the current study is the number of survey participants. Although the statistical tests indicated that the number of participants was sufficient, the number might potentially introduce sample bias. Therefore, future research needs to include more participants from various industries.

Moreover, the sample frame was restricted to Indonesian organisations. On the one hand, it was helpful for increasing internal validity, but it also potentially inhibits the generalizability. Therefore, it is essential to assess the generalizability of the research beyond the Indonesian context. This effort will both increase the generalisability and contribute to improving the model.

Another possibility for future research is to examine which organizations or bodies are being resistant. This question is important, not because it is necessarily difficult to answer (RIRs, government agencies, etc.) but because by considering this question, we are able to identify which bodies and/or organizations need to do more to promote IPv6. Such research is quite likely to identify those organizations that are being resistant by either not promoting effectively or because they do not actively promote IPv6 as they should be. Hence, the competent parties can provide a better strategy in order to encourage more people to use IPv6.

8.7 Conclusion

The current study was designed to extend our understanding of the problem of resistance to change among organizations as the end users of IPv6. A preliminary study was conducted to determine the readiness status of Indonesia organizations. The results of the study validated the findings from a similar prior study of the case in Australia, where most organizations have made no significant preparation for the technology. To extend our understanding of why IPv6 is not being widely adopted, a mixed methods research approach has been applied to identify the reasons for this resistance.

The first phase of the study acquired insights by conducting interviews with those who are responsible for managing IT within organizations. The interviews with personnel from 17 organizations indicated that lack of felt need, satisfaction with the current system, perceived threat and lack of environmental influence are key factors that lead organizations to resist changing to IPv6. Based on the findings from the first phase, a resistance to IPv6 model was developed and tested to generalise the findings by conducting a survey. The cost of switching over was included in the model since it was highly supported by prior adoption and resistance studies. The result of the second phase validated lack of felt need, perceived threat and lack of environmental influence as key factors which produce organizations' resistance, while satisfaction with the current system and the cost of switching were not supported. The findings revealed interesting insights for Internet community, enabling them to provide a better strategy to encourage more people to use the technology.

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Appendix A. Ethical Approval of Qualitative Study

Curtin University

Memorandum

To	Dedy Syamsuar, School of Information Systems
From	Francesca Vallini
Subject	Protocol Approval **IS_13_01**
Date	29 January 2013
Copy	Peter Dell

Office of Research and Development
Human Research Ethics Committee
Telephone 9266 2784
Facsimile 9266 3793
Email hrec@curtin.edu.au

Dear Dedy

Thank you for your "Form C Application for Approval of Research with Low Risk (Ethical Requirements)" for the project titled *"Understanding IPv6 adoption among different types of organizations in Indonesia"*. On behalf of the Human Research Ethics Committee, I am authorised to inform you that the project is approved.

Approval of this project is for a period of four years 21 January 2013 to 21 January 2017.

The approval number for your project is **IS_13_01**. *Please quote this number in any future correspondence.* If at any time during the twelve months changes/amendments occur, or if a serious or unexpected adverse event occurs, please advise me immediately.

F Vallini

Francesca Vallini
Human Research Ethics Coordinator
School of Information Systems

Please Note: The following standard statement must be included in the information sheet to participants:
This study has been approved under Curtin University's process for lower-risk Studies (Approval Number xxxx). This process complies with the National Statement on Ethical Conduct in Human Research (Chapter 5.1.7 and Chapters 5.1.18-5.1.21).
For further information on this study contact the researchers named above or the Curtin University Human Research Ethics Committee. c/- Office of Research and Development, Curtin University, GPO Box U1987, Perth 6845 or by telephoning 9266 9223 or by emailing hrec@curtin.edu.au.

Appendix B. Ethical Approval of Quantitative study

Curtin University

Memorandum

To	Dedy Syamsuar, School of Information Systems
From	Francesca Vallini
Subject	Protocol Approval **IS_14_10**
Date	3 April 2014
Copy	Prof Peter Dell

Office of Research and Development
Human Research Ethics Committee
Telephone 9266 2784
Facsimile 9266 3793
Email hrec@curtin.edu.au

Thank you for your "Form C Application for Approval of Research with Low Risk (Ethical Requirements)" for the project titled "*IPv6 Survey on organizations in Indonesia*". On behalf of the Human Research Ethics Committee, I am authorised to inform you that the project is approved.

Approval of this project is for a period of 2 years from **27.04.2014** to **27.04.2016.**

Your approval has the following conditions:

(i) Annual progress reports on the project must be submitted to the Ethics Office.

(ii) It is your responsibility, as the researcher, to meet the conditions outlined above and to retain the necessary records demonstrating that these have been completed.

The approval number for your project is **IS_14_10.** Please quote this number in any future correspondence. If at any time during the approval term changes/amendments occur, or if a serious or unexpected adverse event occurs, please advise me immediately.

F. Vallini

Francesca Vallini
Form C Ethics Co-ordinator
School of Information Systems

Please Note: The following standard statement must be included in the information sheet to participants:
This study has been approved under Curtin University's process for lower-risk Studies (Approval Number xxxx). This process complies with the National Statement on Ethical Conduct in Human Research (Chapter 5.1.7 and Chapters 5.1.18-5.1.21).
For further information on this study contact the researchers named above or the Curtin University Human Research Ethics Committee. c/- Office of Research and Development, Curtin University, GPO Box U1987, Perth 6845 or by telephoning 9266 9223 or by emailing hrec@curtin.edu.au.

Appendix C. Information Sheet

Curtin University

Information Sheet
English version

Project Title Understanding IPv6 adoption among different types of organizations in Indonesia

Researchers Dedy Syamsuar & Peter Dell

Dear Participant,

Allow me to introduce myself. My name is Dedy Syamsuar and I am a PhD student at Curtin University. Together with my supervisor, Peter Dell, we are conducting this study investigating IPv6 adoption by Indonesian organizations, and we would like to invite you to participate.

The purpose of this study is to investigate and identify factors that influence IPv6 adoption by Indonesian organizations. The current Internet Protocol (IPv4) cannot accommodate the Internet's projected rate of growth. IPv6 was introduced in 1998 to overcome these problems and offers a larger address space, along with other features such as security, routing and support for mobile devices. However, IPv6 has not yet become widely implemented, even though IPv4 has already been exhausted. This study attempts to understand the factors that influence IPv6 adoption at an organizational level.

What participation involves: We would like to invite you to participate in an interview session. The interview can be either face-to-face or online (using email, Skype or Instant Messenger) and either English or Indonesian could be used depending on your preference. The interview will be recorded and a transcript will be made. The transcripts will be approved by you in case something needs to be changed or clarified.

Benefits: This study will enrich IPv6 study literature by exploring why the technology has not become widely implemented. Additionally, from a practical point of view, this study will provide a real picture of why the IPv6 standard has been ignored and will thus be useful to policy analysts to devise strategies to increase its adoption.

Risk: If you decide to participate in this study there are no known risks for you, nor are there any costs for taking part. If you feel you have been hurt in any way then please feel free to contact either myself or my supervisor.

Withdrawal from study: Participation in this study is completely voluntary and you may withdraw your participation at any time. The decision to do so will not affect the research in any way.

Results: If you would like a copy of the report from the study, we will be happy to share it.

Confidentiality: Please be assured that confidentiality is guaranteed and no identifying information is kept on file at the completion of the research. Names and email addresses are optional and are collected so that you can be contacted, and at the completion of the study the data will be de-identified, which means that any identifying information will be permanently removed. The data will be stored in secure location electronically.

Further Information: You can contact myself (Dedy Syamsuar) on +614 5244 7644 (Dedy.Syamsuar@postgrad.curtin.edu.au) or my supervisor, Peter Dell (Peter.Dell@cbs.curtin.edu.au) at the School of Information System – Curtin University at +618 9266 7027. Please do not hesitate to contact us for further inquiry and/or assistance. Alternatively, if you have any concerns regarding this research, please do not hesitate to contact the Curtin University Human Research Ethics Committee by email on hrec@curtin.edu.au.

This study has been approved under Curtin University's process for lower-risk Studies (Approval Number IS_13_01). This process complies with the National Statement on Ethical Conduct in Human Research (Chapter 5.1.7 and Chapters 5.1.18-5.1.21). For further information on this study contact the researchers named above or the Curtin University Human Research Ethics Committee. c/- Office of Research and Development, Curtin University, GPO Box U1987, Perth 6845 or by telephoning 9266 9223 or by emailing hrec@curtin.edu.au.

Appendix D. Consent Form

Curtin University

Consent Form

Project Title: Understanding IPv6 adoption among different types of organizations in Indonesia

Principal Investigator: Dedy Syamsuar

I agree to take part in the study specified above. I have had the study explained to me, and I have read the attached information sheet. I understand that agreeing to take part means that:

1. I agree to be interviewed by researcher
2. I agree the interview to be recorded

I understand that I will be given a transcript of data concerning me for my approval before it is included in the write up of the research.

I understand that my participation is voluntary, that I may change my mind and stop at any time without being penalised or disadvantaged in any way.

I agree that research data gathered from the interview for use in report or published finding will not, under any circumstances, contain my names or identifying characteristics.

Name of Participant/Authorised Representative:

Signature:

Date:

Appendix E. Qualitative Phase : Interview Guide

Curtin University

Respondent Interview Form

English version

Organization Details			
Name/nama:			*Date of interview/tanggal:*
Type of organization	*Number of employees*		*Short description:*
		< 100	
		100 – 1000	
		1001 – 10000	
		> 100000	

Respondent Details			
Name of respondent	*Position/role*	*Email*	*Phone*

Interview Questions (English version)

Introduction

1. How does your organization use computer networks and Internet? *(to know how the Internet is used in the organization)*
   a) Does your company have website? ☐
   b) Does your company have domain, email? ☐
   c) Does your organization provide Internet access for your employees? What kind of activities usually do they do using the Internet? ☐ ☐
   d) Find whether the organization has branches, and if so whether networks at each site are interconnected or not. If yes, continue with do they use a WAN or VPN to connect multiple sites together? *(If so they might have more need for public address space, depending how it's implemented).* ☐

2. Currently IP address is completely exhausted, and IPv6 is provided to deal with the shortage, do you know that. What do you think? ☐

Readiness

3. What preparation has your organization made to IPv6? ☐
   a) If it has, continue with the question on whether they have
      - Planned to implement IPv6? Why yes/no?
      - trained your staff for gaining IPv6 expertise
      - assessed your asset
      - developed IPv6 policy (purchasing, application development)
4. If the answer is no
   a) Has planning for IPv6 been considered in your organization?
   Then if it has, continue which more details questions, when they will start preparing etc. But if they haven't even considered it, move to the next question.

Technology (Toe)

5. Is IPv4 shortage of IPv4 address to be a problem for your company? Why/How? ☐
6. Are you satisfied with IPv4? Or Dissatisfied, why and how?(Lapointe & Rivard, 2005) ☐
7. What do you think whether IPv6 is needed for you organization or not? Why? ☐
8. What do you think whether IPv6 technology is different with IPv4 technology? ☐

9. Considering the time and effort that your organization has to spend, do you think the adoption of IPv6 would be valuable?	☐
10. Considering the loss that could be incur, do you think the adoption of IPv6 is of good value?	☐
11. What are the benefits (also the loss) of adopting IPv6?	☐
Environment (toE)	
12. Will you consider to implement IPv6 if your partner, major vendor, or customer has implemented the IPv6 technology	☐
13. Tempted or forced to use it? Who?	☐
14. Is there any pressure (industry or government pressure) to move to IPv6 technology?	
15. Would an incentive (e.g. incentive from your government), encourage you to adopt IPv6? (Bohlin, 2002). *(follow-up questions about what kind of incentive, and reasons why/why not. I will also presumably dig a bit more deeply with example incentives if they don't come up with anything themselves, e.g. financial incentives (e.g. tax credits; subsidy schemes; gov't payments) or other incentives (e.g. free training; etc).)*	☐ ☐ ☐
Organization (tOe)	
16. What do you think whether IPv6 is needed for you organization or not? Why?	
17. How confident are you that your organization has a sufficient expertise to implement the IPv6 technology?	☐
18. Base on your staff's knowledge, skill and abilities, how confidents are you that moving to IPv6 would be easy for your organization?	☐
19. Does your management provide the necessary help and resource to implement the IPv6? How/Why	☐
20. In many case of switching to new technology especially IP, Do you think a lot of cost involve if you have to implement it..?	☐
21. How does the cost affect your decision to adopt IPv6?	☐

Appendix F. Readiness Survey Questionnaire

Criteria	Specific aspects
Training	Has training in IPv6 technology been provided? Has training in IPv6 deployment been provided? Has training in IPv6 security been provided? Has training in configuring IPv6 equipment been provided? Has training in configuring IPv6 in operating systems and applications been provided? Has training in developing IPv6 applications been provided?
High-level Planning	Has IPv6 planning commenced? Has an IPv6 strategy been developed? Has an IPv6 project been created?
Assessment of the current environment	Have training requirements been assessed? Have IT assets been assessed for IPv6 requirements? Has the application portfolio been assessed for IPv6 requirements?
Policy frameworks	Have purchasing policies been updated to incorporate IPv6 requirements? Have application development policies been updated to incorporate IPv6 requirements? Have security policies been updated to incorporate IPv6 requirements?
IPv6 deployment	Has the organization done IPv6 address planning? Has the organization deployed IPv6?

Source : Dell (2011)

Appendix G. Quantitative Phase : Survey Instrument

IPv6 in Organization Survey

Introduction
Internet Protocol (IP) addresses are an important part on the Internet, since every device connected to the Internet must be identified using such an address. The exponential growth of the Internet has made IPv4 unable to accommodate the demand for IP addresses. IPv6 was introduced to deal with this issue by creating a very large address range, as well as other features to accommodate the needs of the Internet in the present and the future. However, although almost two decades have passed since IPv6 was standardized, adoption of IPv6 is still very low.

The aim of this survey is to investigate attitude towards IPv6 among a wide range of organizations in Indonesia. The survey will take less than 15 minutes to complete and is intended for IT policy makers, IT staff or those who work on IT-related area within the organization.

Participation & Confidentiality
Participation in this survey is voluntary. All data obtained from participants will be kept confidential and results will be published in an aggregate format.

Questions about the Research
If you have questions regarding this study, you may contact me as the principal investigator (mobile number +62 452 744644 or email : dedy.syamsuar@postgrad.curtin.edu.au). Alternatively, you can contact my supervisor Dr. Peter Dell (email: P.T.Dell@curtin.edu.au).

Research statement
This study has been approved under Curtin University's process for lower-risk Studies (Approval Number IS_14_10). This process complies with the National Statement on Ethical Conduct in Human Research (Chapter 5.1.7 and Chapters 5.1.18-5.1.21).
For further information on this study contact the researchers named above or the Curtin University Human Research Ethics Committee. c/- Office of Research and Development, Curtin University, GPO Box U1987, Perth 6845 or by telephoning 9266 9223 or by emailing hrec@curtin.edu.au

Please selects the industries in which your organization is active

- Agriculture, forestry and fishing
- Mining
- Manufacturing
- Electricity, gas and water supply
- Construction
- Wholesale trade, Retail trade
- Accommodations, food services
- Transportation, storage
- Information Media and telecommunication
- Finance and insurance
- Rental, hiring and real estate services
- Administrative and support services
- Public administration and safety
- Education and training
- Health care and social assistance
- Other services ______

Please select your current position

- CIO
- IT Manager
- Network Administrator
- System Developer
- Database administrator
- Network security specialist
- Other IT professional position ______

How many employees are there in your organization?

- < 100
- 101 - 500
- 501 - 1.000
- 1.001 - 5.000
- 5.001 - 10.000
- > 10.000

Please rate to what extent you agree with the following statements on a scale of 1 - 7

	Totally Disagree 1	2	3	Neutral 4	5	6	Totally Agree 7
Indonesian organizations/companies are more advanced in IT than companies from other countries	○	○	○	○	○	○	○
There is no pressure on our organization to adopt IPv6 from Indonesian government.	○	○	○	○	○	○	○
The Indonesian government doesn't facilitate the implementation of IPv6	○	○	○	○	○	○	○
	Totally Disagree 1	2	3	Neutral 4	5	6	Totally Agree 7
There is no pressure on our organization to adopt IPv6 from Internet / IP regulators, such as APNIC, IDNIC, APJII or providers	○	○	○	○	○	○	○
Internet regulators such as APNIC, IDNIC, APJII, or providers do not facilitate the implementation of IPv6	○	○	○	○	○	○	○

Please rate to what extent you agree with the following statements on a scale of 1 - 7

	Totally Disagree 1	2	3	Neutral 4	5	6	Totally Agree 7
Our organization does not agree with the change to the new way of working with IPv6	○	○	○	○	○	○	○
Our organization will not comply with the change to the new way of working with IPv6	○	○	○	○	○	○	○
Our organization will not change our current protocol (IPv4) to IPv6	○	○	○	○	○	○	○
Our organization likes to stay with the way they are (IPv4)	○	○	○	○	○	○	○

We really appreciate your participation. This last question is voluntary. The objective of the question is to allow the researcher to able to communicate with you if necessary. Your email will be treated as confidential. Please enter your valid email address

Please rate to what extent you agree with the following statements on a scale of 1 - 7

	Totally Disagree 1	2	3	Neutral 4	5	6	Totally Agree 7
The current system (IPv4) works fine and can accommodate our organization needs	○	○	○	○	○	○	○
Our organization doesn't see any problem with the size of IPv4 address space it can use	○	○	○	○	○	○	○
Our organization doesn't have any issue with NAT (Network Address Translation)	○	○	○	○	○	○	○
IPv4 is a proven technology	○	○	○	○	○	○	○
There is no reason for our company to adopt IPv6	○	○	○	○	○	○	○
	Totally Disagree 1	2	3	Neutral 4	5	6	Totally Agree 7
IPv6 would not give any benefit to our organization	○	○	○	○	○	○	○
Our organization does not need additional public IP addresses	○	○	○	○	○	○	○
IPv6 is unproven	○	○	○	○	○	○	○
Our organization has spent a lot of money, time and effort on IPv4	○	○	○	○	○	○	○
The cost of implementing IPv6 in our organization would be large	○	○	○	○	○	○	○
	Totally Disagree 1	2	3	Neutral 4	5	6	Totally Agree 7
Implementing IPv6 in our organization would require much time and effort.	○	○	○	○	○	○	○
Our organization is worried that most of our network devices may need to be replaced under IPv6.	○	○	○	○	○	○	○
Switching to IPv6 could result in unexpected hassles to our company's operation	○	○	○	○	○	○	○
Our organization is worried that IPv6 would make it difficult to control network security by removing NAT	○	○	○	○	○	○	○
Our organization is worried that IPv6 would make it more difficult to apply network security policies	○	○	○	○	○	○	◉