TECHNOLOGY DIFFUSION: BARRIERS TO IPV6 ADOPTION IN INDONESIA

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Abstracts: *Cepatnya pertumbuhan penggunaan internet telah menampakkan sejumlah keterbatasan kemampuan dari Internet Protocol (IP4), yang digunakan saat ini. Keterbatasan jumlah IP menjadi masalah utamanya, disamping kelemahan lainnya seperti keamanan dan QoS. Hal ini perlu diatasi sebagai antisipasi terhadap kebutuhan sekarang dan masa depan akan IP. IPv6 diperkenalkanlah untuk mengatasi hal ini. Meskipun telah dilebih dari satu dekade diperkenalkan akan tetapi adopsinya masih sangat rendah sehingga menjadi tantangan bagi perkembangan internet. Penelitian ini dilakukan untuk menginvestigasi permasalahan adopsi IPv6 di Indonesia dengan menggunakan dua tahap awal dari Roger innovation-decision process model. Penelitian ini mencoba menggali faktor-faktor yang mempengaruhi adopsi IPv6 pada komunitas internet di Indonesia. Manfaat dari penelitian ini diharapkan memberikan masukan guna meningkatkan adopsi IPv6 itu sendiri. Dari hasil penelitian didapatkan bahwa kepedulian atas IPv6 cukup tinggi diantara praktisi TIK dan persepsi tentang kehadirannya positif, utamanya pada keuntungan relatif dari teknologi tersebut.*

Keywords: *Diffusion, Technology, IPv6.*

1. INTRODUCTION

When it was first designed during the 1970s, nobody could anticipate that the Internet would become as widespread as it is today. It has become central to many aspects of life in modern societies and many human activities now rely on this technology. Government institutions, education, business and non-profit organizations and individuals all use the technology on a daily basis. It has created new communication modes in which geographic boundaries are increasingly meaningless.

The Internet is described as a global set of interconnected networks that support communication between computers all over the world (Bradner, 1996). All

devices on the Internet are identified by a unique 32-bit number known as an IP (Internet Protocol) address, which in theory can provide for up to 4.3 billion devices, and far fewer in practice due to overheads in address allocation schemes.

However, the explosion in the Internet's popularity since the 1990s has rendered this 32-bit address space insufficient, and address shortage has become the main issue facing the IPv4 (Bohlin and Lindmark, 2002). The current projection by the Internet Assigned Numbers Authority (IANA) are that remaining address space will be exhausted at some time during 2011 (IANA, 2008), although in reality the date is likely to be sooner due to panic buying behaviours that are impossible to model (Huston, 2005). Address space consumption may also be more rapid than predicted due to the increased demand for IP connectivity from non-traditional devices such as smart appliances.

To address this weakness in IPv4, a new, enhanced version known as IPv6 was developed in the 1990s. IPv6 provides a 128-bit address space, allowing for a huge number of addresses: 3.4×10^{38} unique addresses – easily enough to cater for continued expansion of the Internet for the foreseeable future. Additionally, IPv6 also addresses other IPv4 weaknesses such as its poor security, its inability to provide Quality of Service (QoS), and complex network management requirements.

With many features offered, IPv6 is the answer to the majority of the problems and is believed as the long term solution (Bouras *et al.*, 2003). Indeed, eventual worldwide adoption of IPv6 is seen as inevitable, and early adoption may be an issue of strategic national importance (Dell *et al.*, 2008). Nevertheless, although IPv6 has been available for more than a decade and offers many advantages, its adoption has been negligible.

There are several barriers to IPv6 adoption that have been observed in other countries. The main barrier comes from the use of Network Address Translation (NAT), which was introduced in the 1990s and allows a whole network to connect to the Internet while using only a single IP address. NAT has been extremely successful in slowing the consumption of IPv4 addresses. However, NAT was never intended as a long term solution (Chown *et al.*, 2004), and it does introduce its own problems. First, it forces all traffic to pass through a NAT server, which introduces performance bottlenecks and extra network maintenance costs. Second, NAT breaks the "end-to-end" assumption of the Internet, making it difficult to deploy many services via NAT servers, and impossible in some cases.

The cost of migration to IPv6 is also a major factor in slow IPv6 adoption (Bohlin and Lindmark, 2002; Hovav *et al.*, 2004). Costs involved not only include upgrading hardware and software, but training, hiring experienced workers or consultants, deploying new poli infrastructure and absorbing possi (Fichman, 2004).

A third barrier is perceive backward compatible with IPv4, p to connect to other devices using strategies have been publicised si stacking and protocol translation, prevent ICT professionals from seri

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2. LITERATURE REVIEW

2.1 Diffusion of Innovation The

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consultants, deploying new policies and procedures, establishing supporting infrastructure and absorbing possible losses in productivity during the transition (Fichman, 2004).

A third barrier is perceived compatibility issues. Because IPv6 is not backward compatible with IPv4, problems could occur when devices with IPv4 try to connect to other devices using IPv6 and vice versa. A number of transition strategies have been publicised since the mid 1990s, including tunnelling, dual-stacking and protocol translation, but perceptions of incompatibility could still prevent ICT professionals from seriously considering IPv6.

Guided by Rogers' (1995) innovation diffusion theory, this study explores the awareness and perceptions of IPv6 in the Indonesian Internet community in order to learn more about how these barriers – and perhaps others not identified in the literature – may be inhibiting IPv6 adoption Indonesia. Thus, the paper aims to inform the Indonesian Internet community with the objective of increasing the likelihood of successful adoption in Indonesia sooner rather than later.

Rogers' theory is reviewed in the next section. This is followed by discussion of the research questions and method, and subsequent presentation of findings and analysis. The paper notes limitations of the current study and concludes with some recommendations both for practice and future research.

2. LITERATURE REVIEW

2.1 Diffusion of Innovation Theory

There have been several attempts both to extend existing theories of technology adoption and to develop new theoretical perspectives to gain a better understanding of IT adoption (Rogers, 1995; Davis, 1989, Hovav *et al*, 2004), including Theory Reasoned Action (TRA) (Fishbein and Ajzen, 1975), Technology Acceptance Model (TAM) (Davis, 1989), Diffusion of Innovation (DOI) (Rogers, 1995) and the more recent Internet Standard Adoption (ISA) (Hovav *et al*, 2004).

Rogers' Diffusion of Innovation theory is used in this study because of its comprehensive framework to address the issues affecting adoption decisions by individual decision makers. DOI theory has relevance to a wide range of industries and issues and as a consequence has been highly popular in a wide variety of academic disciplines, public agencies and private firms for many years (Hovav *et al.*, 2004). The core idea behind DOI theory is the way in which a new idea migrates from creation to use. Rogers (1995) argues that this process is not

instantaneous; it takes time as the potential adopter must first discover an innovation, be persuaded of its benefits, decide to adopt the idea and eventually implement that decision. Rogers labels this process the innovation decision process, illustrated in Figure 1.

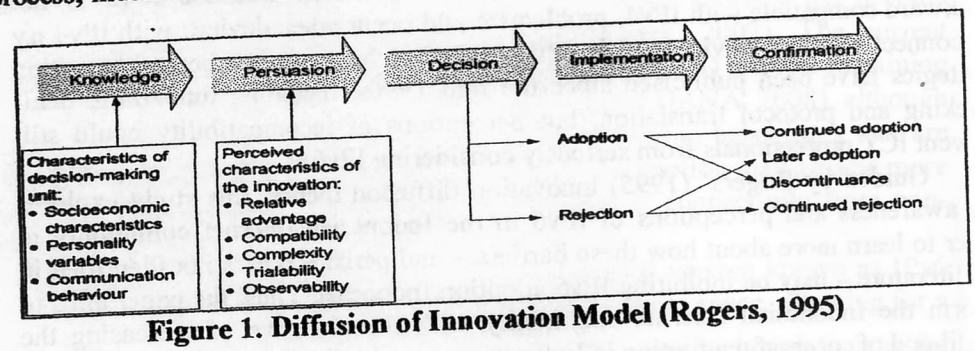

Figure 1. Diffusion of Innovation Model (Rogers, 1995)

Given the lack of IPv6 deployed world-wide, the technology clearly has no yet reached the decision stage of Rogers' model. The focus in this study is thu primarily concerned with the knowledge and persuasion stages. The knowledg stage refers to the ways in which people become aware of new technologica innovations, and focuses on socio-economic, personality and communicatio characteristics of the decision-maker.

In cases where individual organisations proceed beyond the knowledg stage, they must be persuaded that IPv6 is desirable if they are to eventually ado it. The persuasion stage refers to ways in which a favourable or unfavourab attitude toward the innovation is formed and during this stage, individuals becom more involved with the innovation and actively seek more detailed informatio about it in order to reduce uncertainty. Persuasion to adopt an innovation affected by five factors (Rogers, 1995): 1) Relative advantage – whether th innovation will give the adopter an advantage – can be measured in econom terms, social prestige factors, or convenience and satisfaction. Previous empiric studies suggest that relative advantage plays a particularly important role determine the level of diffusion a new idea or technology (Teo *et al.*, 1999, Mo and Kim, 2001; Achjari, 2003), 2) Compatibility – whether the innovation compatible with the adopter's organization – includes compatibility with existi work practices, preferred work style, prior experience and values (Agarwal a Karahanna, 1998). Increased compatibility results in lower switching costs, Complexity – the difficulty involved in implementing the innovation. Those w believe that a new system is too complex and beyond their ability to implem

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2 The Problem of IPv6 Adopt

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will be reluctant to adopt it (Igbaria and Iivari, 1995, cited in Achjari, 2003), 4) Trialability – the possibility of trialling an innovation before committing to it. When users consider adopting an innovation they face uncertainty as to whether it will yield a benefit or a detriment. The possibility to conduct an experiment or trial reduces risk (Rogers, 1995), and there is a significant link between early adopters and trialability (Hovav and Schuff, 2005). However, to provide this capability often requires significant investment, and often support from consortia or government. In the case of IPv6, countries such as Japan, China and South Korea have strong government support to deploy IPv6, and 5) Observability – opportunities to first observe the innovation and learn from others' experiences. If individuals can see the result of the implementation of an innovation from others they are more likely to adopt. Users in the late majority and laggard categories tend to adopt a new technology only after it has been widely adopted, and the possibility to observe others' experiences is maximized (Hovav *et al.*, 2004).

2.2 The Problem of IPv6 Adoption

For the past several years, debates have arisen over the existence of IPv6. Although IPv6 has been available for several years with its strengths and benefits, IPv6 adoption process is very slow, less than expected. There are many articles which have compared and contrast, analyzed, estimated and calculated the benefits of IPv6 (Hovav & Schuff, 2005; Bohlin & Linmark, 2002, Hovav et al, 2001, Kinniah, 2003, Bouras et al, 2003). Several barrier issues of the adoption fall into some categories which are summarized in following section.

2.2.1 The Supplementary Technologies of IPv4

The ability of networking vendors to create optional technologies (e.g. NAT, CIDR, DHCP and IPSec) has been one of major barrier for adopting IPv6 (Emigh, 2002). As mention earlier these technology are used to solve IPv4 shortcoming as well as creating new other problem. Unfortunately, many organizations around the world implement these methods as workaround to IPv4.

According to Chown et al (2004) that 70% of Fortune 1000 Companies have forced to deploy NAT. NAT also can be found in most of small and home network where several hosts must share a single IP address. Most of countries deploy NAT technology to resolve the IP address shortage (e.g China, Indonesia, India etc). NAT has been so successful in slowing the IPv4 address shortages although it was never intended as a long term solution (Chown et al, 2004). It's argued that NAT

has destroyed a key benefit of the Internet, preventing peer to peer communication The introduction of Classes Inter Domain Routing (CIDR) also create complication in packet routing and increases routing table size (Weiser, 2001) an this will affect the decision routing.

2.2.2 A High Switching Cost

The cost of moving is the major factor of causing the slow adoption (Bohli & Lindmark, 2002; Hovav et al, 2004; Pau et al, 2002). When users move to othe technology, they need to invest to the new technology. With most of internet user still use IPv4, the switching cost will be very huge. Other cost, besides replacin hardware and software, which should be considered includes expenditures fo training, hiring experienced workers or consultant, deploying new policies an procedure, establishing supporting infrastructure and absorbing losses i productivity during transition (Fichman, 2004).

Many governments have provided incentives to encourage the transition t IPv6 (Dell *et al*., 2008): South Korea (Hill, 2006), Malaysia (Rao, 2003), the US (Strauss, 2005), Japan, China and various European countries (Hovav and Schuf 2005) have all encouraged the deployment of IPv6 in various ways.

Indeed, government incentives are thought to be essential to "[get] the IPv bandwagon rolling" (Bohlin and Lindmark, 2002: 104). In order to determine wh kind of incentives would be most fruitful in an Indonesian context, this stud focuses on the perceptions and attitudes of relevant ICT practitioners towards IPv

2.2.3 A lack of Infrastructure and Awareness From Consumer and Vendors

IPv6 adoption process is also slowed down by fact that there are not ma infrastructures, services and network devices available that support IPv6 at t moment. This happens because vendors and services providers are hesitant support IPv6 without hearing demand from customers. In the other sid corporations do not have motivation to invest when they see slow progress sho by their competitors and service providers (wait and see) (Hovav & Schuff, 2005)

Awareness of IPv6 existence could be another problem in adopting IPv Siniah (2003) argues that

> *"Many of the end users are not aware of the changes that is taking place in the world especially IPv6 and because of this, the importance of IPv6 remains unknown and this create lack of demands for IPv6"*

Since there are many user ich IPv6, the demand will ren ctor of a lack of infrastructure a

2.4 A Reluctant of Moving

The slow adoption of IP frastructure (e.g. routers, NAT, st of purchasing new hardwa at are satisfied with their curre v6.

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The problems discuss abo port the research. The resear il in the following section.

Since there are many users that are not familiar with emerging technologies such IPv6, the demand will remind low and this factor has correlation with the factor of a lack of infrastructure and support for IPv6 (Siniah, 2003).

2.4 A Reluctant of Moving

The slow adoption of IPv6 is also caused by heavy investment in IPv4 infrastructure (e.g. routers, NAT, IPSec, etc) and benefits of IPv6 do not justify the cost of purchasing new hardware (Bohlin & Linmark, 2002). Hence, companies that are satisfied with their current network infrastructure are reluctant to migrate to IPv6.

Another reluctant is come from the United State of America, as the leading country in IT. It can be seen from no financial and regulatory incentive (Hovaf & Schuff, 2003). Additionally, IPv6 can threaten their position as a technology leader while IPv6 globally implemented. Together with Canada, the US has 70% IPv4 addresses in the world compare to Europe 17% and the only 10% rest of the world. Moreover, since there are still plenty of IP addresses in the North America, many companies in that regional do not see that IPv6 adoption is a main priority (Gwin, 2002). Conversely, Japan and most of Asian countries as well as European countries intensively promote the implementation of this standard by giving incentives or supporting regulation.

2.5 Compatibility Issue

Another problem is concerned about compatibility and migration issues. Because IPv6 is not backward compatible with IPv4, a problem will occur when a client with IPv4 tries to connect with servers on public IPv6 and vice versa. "This incompatibility increases the complexity of the upgrade process and reduces the ability to test, observe and quantify the benefits of IPv6" (Hovav et al, 2004: 282). Although dual stack or translation has proposed to answer this issue, it becomes burdensome for routers or bridges since they need to deal with two protocols and maintain double routing tables.

The problems discuss above are formulated in form of survey question to support the research. The research questions and objectives are described in more detail in the following section.

3. METODOLOGI PENELITIAN

3.1 Research Question

The aim of this research was to determine which factors may influence t
adoption of IPv6 from the perspective of end users in Indonesia. In this conte
"end user" refers to ICT professionals responsible for making or influencing t
decision to adopt IPv6. The principle research questions were as follows: 1) Wh
was the level of adoption IPv6 in Indonesia? And 2) What was the perception
the IPv6 among IT professionals in Indonesia?

Based on these research questions, the following key research objecti
were developed: 1) To investigate whether ICT professionals in Indonesia know
the existence of IPv6, 2) To understand what factors have caused low adoption
IPv6 in Indonesia, 3) To explore the nature of the relationship between each
these factors and the resultant level of IPv6 adoption and diffusion in Indones
and 4) To inform future planning and promotion of IPv6 in Indonesia.

The benefits of this research are both practical and theoretical. In a practi
sense, this study is useful for competent parties, particularly in Indonesia, to p
future efforts such as government policy, promotional campaigns, and so on
increase the adoption of IPv6. From a theoretical perspective, the current resea
adds further support to Diffusion of Innovation theory, particularly its first pha
of knowledge and persuasion. It was also expected to provide important insig
into determinant factors of the IPv6 adoption amongst Indonesian inte
community as well as to know the current level how people know and aware ab
this technology.

3.2 Research Method & Design

This research was carried out using a web-based survey. This method
chosen because it can provide high accuracy and external validity (Neuman, 20
and because it has many practical benefits such as low cost and high flexibi
The Internet is widely used among the target demographic, i.e. Indonesian
practitioners, so the possibility of sample bias was low. The survey was condu
in 2005. Statistical data analysis techniques were used to analyse and interpre
data collected.

Participation in this research was opened to Indonesian ICT practitio
Internet-related communities and academic staff members who teach in ICT re
areas. First, ICT practitioners such as network administrators were selected bec
they were directly involved with Internet Protocol. Ideally, these professi

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DISCUSSION

The survey attracted 90 respo
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Knowledge

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would have knowledge about what IP was, its configuration and related issues. Second, Internet-related communities such as ISPs also play a central important role in the diffusion of IPv6. Hovav and Schuff (2003) argue that ISPs are a logical unit who make the adoption decision for the IPv6 standard. Third, academics who teach in ICT areas were included in the survey because of their potential to diffuse relevant knowledge to their students who would potentially work in ICT industry.

The measurement scales employed in this study were adapted from past studies. Participants were required to express their agreement or disagreement with survey items using a five-point Likert scale ranging from strongly disagree to strongly agree. The items in the questionnaire were divided into six categories relating to different aspects of the knowledge and persuasion stages; the individual survey items were informed by past literature as shown in Appendix A.

DISCUSSION

The survey attracted 90 respondents, most of who were aged between 20 and 0 years of age. It is not possible to calculate exact response rates because it is not nown how many people received an invitation to participate; however, the number f responses is considerable and the results are therefore considered to be reliable.

Responses were dominated by network administrators (29%), academics 8%) and IT managers (12%), reflecting the targeted sampling strategy described ove. 43% of responses were received from education and research institutions, nd 19% from ISPs. This is consistent with the current situation in Indonesia in hich IPv6 development and deployment are likely to be carried out by niversities and ISPs rather than other organisations. Indonesia is a developing untry with low Internet penetration in general; a recent estimate is only 3.4% ww.InternetWorldStas.com, 2004). For this reason, although the sample used in e Indonesian study was not representative of society at large, it is considered presentative of organisations relevant to the potential diffusion of IPv6.

Knowledge

Rogers (1995) describes that the knowledge stage as the phase during which individual becomes aware of the innovation's existence. The survey result ongly indicated that most respondents (88%) were aware of the existence of IPv6 why it was developed (88%). Finally, 76% of respondents believed that IPv4

Desember 2008:219-236

address space exhaustion was likely to occur in the near future, indicating that the was high agreement with the main reason behind the development of IPv6.

Similar results are obtained when responses to "knowledge" questions a further analysed according to job title and organisation type. 96% of netwo administrators, 81% of academics and 91% of IT managers had knowledge of t existence of IPv6.

People in such occupations are likely to be influential in the adoption a diffusion of IPv6. Network administrators are involved with network issues in th daily activities, and may have first-hand experience of IP address problems, as w as routing difficulties and security issues. IPv6 solves these problems, so awaren among this profession is likely to come with positive perceptions of technology. Academics are also important position in diffusing the knowledge a information of IPv6 to their students as well as conducting research into implementation. Finally, IT managers are vital in terms of their involvement determining policies related to ICT. In short, these findings indicate that a v number of relevant ICT professionals in Indonesia are aware of IPv6.

Similarly, 92% of responses from educational institutions and 94% responses from ISPs had knowledge of its existence. Hovav *et al.* (20 reasonably suggest that ISPs are important part to success of diffusing II technology, so this finding is also a positive sign for the eventual diffusion of II in Indonesia.

Indeed, several Indonesian ISPs have implemented IPv6 test-beds in re years and even provided IPv6 services to customers, albeit on a limited basis. national backbone is also capable of carrying IPv6 traffic. These factors indi that Indonesia is ready to adopt the technology more widely. However, with customer demand adoption will remain low; though most relevant ICT profess know of the existence of IPv6, 37% of respondents had not heard of any case IPv6 being deployed in Indonesia.

In summary, responses indicate that relevant ICT practitioners in Indon have a high level of knowledge of IPv6. Factors influencing the knowledge st are summarised in Table 1.

Table1. Factors Influencing the Knowledge Stage

Level of awareness	Level of awareness was high among relevant IC practitioners
Need for IPv6	Majority believed IPv6 was necessary in the long run a relatively few believed that NAT/CIDR would solve problem Perceived need for IPv6 attributed to IPv4 address space shorta rather than other factors (performance, security).
Urgency of IPv6	Majority believed that IPv4 address-space exhaustion wou occur in the near future.

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Persuasion

The difficulties facing IPv4 v
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Notes: 1) CIDR (Classless
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located but unused addresses,

Finally, these results suggest that promotional efforts from government or other organisations do not need to spend time and effort promoting basic awareness of the technology, and would benefit from focusing on persuasion.

4.2 Persuasion

The difficulties facing IPv4 were believed to be of an urgent nature, and 76% of respondents believed that IPv4 address space exhaustion would occur in the near future. Only 16% believed that technologies such as NAT or CIDR (Classless Inter-Domain Routing) would solve IPv4's problems. Although almost 75% believed that IPv6 was important for their organisation's future, only 39% believe that IPv6 should be implemented at the current time. The prevailing perspective was thus somewhat paradoxical: IPv6 is a highly important and pressing issue, but it is not yet timed to adopt it.

This paradox is perhaps partly explained by perceptions of the cost of adopting IPv6. Despite the fact that continued use of IPv4 may have a higher total cost of ownership (TCO) due to the use of technologies such as NAT, DHCP (Dynamic Host Configuration Protocol) and security tools to address shortcomings of IPv4 (Liu, 2006), almost half (47%) of the respondents in the Indonesian study believed that IPv6 would involve high costs, while only 25% believed it would not. It is noted here that past research has noted the importance of switching costs, even in developed countries (Bohlin and Lindmark, 2002; Hovav *et al.*, 2004), so its importance in a developing country such as Indonesia is not surprising.

The importance of cost is also highlighted in the finding that the majority (57%) reported that they would adopt IPv6 if a suitable financial incentive or subsidy was provided. The opportunity to trial or test IPv6 prior to implementation was also important: 79% of respondents indicated this would influence their decision to adopt IPv6, while 90% felt the provision of adequate training would also be important.

It is possible that reluctance is due in part to lack of information about IPv6 support from vendors. Although most major vendors support IPv6, only 58% of respondents understood their vendors' IPv6 capabilities, and there was a fairly high level of respondents who were unsure in this regard (33%). These findings are summarised in terms of Rogers' (1995) five generic factors that influence persuasion in Table 2, below.

Notes: 1) CIDR (Classless Inter-Domain Routing) was introduced in the 1990s and allows more efficient allocation of IP addresses by reducing the number of allocated but unused addresses, and 2) DHCP (Dynamic Host Configuration

Protocol) is widely used in IPv4 networks to centrally allocate IP addresses t computers on a network. This requires maintaining a DHCP server. This i unnecessary in IPv6 networks due to its auto-configuration capability.

Table 2. Factors Influencing the Persuasion Stage

Factor Influencing Persuasion Stage	Finding
Relative advantage	Majority believed IPv6 will be an important technology for their organisation. High dissatisfaction with IPv4, suggesting that retaining IPv4 might be disadvantageous. The advantage of IPv6 was perceived to come at a high initial cost, however.
Compatibility	Majority believed that IPv6 will not pose compatibility problems with IPv4, although only 35% of respondents were confident of compatibility with applications.
Complexity	High degree of uncertainty regarding the complexity of IPv6, and up to one third or more respondents may have a knowledge barrier increasing the perceived complexity of IPv6.
Trialability	Majority wanted training and the opportunity to experiment with IPv6 before adoption.
Observability	Majority of respondents were "late-majority" or "laggards".

These findings indicate that in terms of Rogers' model of diffusion innovation, relevant Indonesian ICT professionals remain largely at the persuasio stage. Although they had basic knowledge of IPv6 and the problems it addresse many respondents lacked detailed knowledge of key aspects such as vend support. Further, the majority of respondents were yet to be persuaded to ado IPv6 and were not actively seeking information about it. In terms of Roger terminology, the majority of respondents (61%) were either "late-majority" "laggards", and will adopt IPv6 only after is already widely adopted.

In this respect, Indonesian ICT professionals are not dissimilar to those other countries. Liebowitz and Margolis (1994) describe how network externaliti influence the decision to use a technology – in this case the disadvantage incurr due to the perceived incompatibility with IPv4 inhibits most users from adopti IPv6.

Promotional efforts in Indonesia should address the concerns described this section to encourage persuasion among Indonesian ICT professionals that IP should be adopted. In particular, information about the following issues should made available to Indonesian ICT professionals: 1) Provide information on t relative costs involved retaining IPv6 and adopting IPv6, 2) Provide information transition strategies to allow IPv4 and IPv6 networks to interqperate such

unnelling and protocol translati
etworks in operation and share e
) Provide opportunities to trial IP

CONCLUSION

According to discussion abo

1) This study has found that professionals is high an positive. Further, there are perceived relative advanta trial the technology and ol perceptions of its compatib as are perceptions of its co
2) Thus, in order to persuade be beneficial to focus pe observe and trial the te compatibility and ease of ICT professionals are also IPv6. Bohlin and Lindmar encourage potential adopt provided such incentives. consider such efforts, poss above by supporting orga providing training to cou complex.
3) Limitations: First, this stud open to ICT practitioners, related areas. There is so single participant could co was no means of controlli low. Another source of sa with the criteria or outside thought not to be a serious provide information on the data revealed the majority Second, although Hovav *et*

tunnelling and protocol translation, 3) Provide opportunities to observe IPv6 networks in operation and share experiences with others who have used IPv6, and 4) Provide opportunities to trial IPv6.

5. CONCLUSION

According to discussion above, we have several conclusion:

1) This study has found that basic awareness of IPv6 among Indonesian ICT professionals is high and general perceptions of the technology are positive. Further, there are three aspects of persuasion that are positive: the perceived relative advantage provided by IPv6, and opportunities to both trial the technology and observe its use in other organisations. However, perceptions of its compatibility with existing systems are generally neutral, as are perceptions of its complexity.
2) Thus, in order to persuade Indonesian organisations to adopt IPv6, it may be beneficial to focus persuasion efforts on providing opportunities to observe and trial the technology, and to make information on its compatibility and ease of administration publicly available. Indonesian ICT professionals are also concerned with the cost involved of adopting IPv6. Bohlin and Lindmark (2002) suggest that subsides or incentives can encourage potential adopters to take up IPv6, and many countries have provided such incentives. It is recommended here that Indonesia also consider such efforts, possibly in conjunction with the recommendations above by supporting organisations' efforts to trial the technology and providing training to counter perceptions that the technology is overly complex.
3) Limitations: First, this study employed an anonymous web survey and was open to ICT practitioners, the Internet community and academics in ICT-related areas. There is some risk of sample bias where, for example, a single participant could complete the survey more than once because there was no means of controlling access. However, this risk is thought to be low. Another source of sample bias was that respondent might not meet with the criteria or outside of the target population. However, this is also thought not to be a serious weakness as the survey required respondents provide information on their occupation and industry and analysis of this data revealed the majority of respondents were within the desired sample. Second, although Hovav *et al.* (2004) argue that ISPs are one of the most

important point in diffusing of the new IP standard, their participation i this study was quite low: from the total 228 ISPs operating in Indonesia a the time the survey was conducted, only 17 participated in this study Efforts were made to increase the response from ISPs by appealing to ISP directly and also by liaising with the ISP association, but without grea success. Fortunately, other relevant ICT positions were well represented however, so this limitation is not considered to be a major flaw. Finall because the original research instrument was in English, it was translate into Indonesian – the common language of the target populatio Although some efforts were made to reduce the risk of problems occurrin in translation, the possibility of problems occurring is difficult to elimina entirely.

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Appendix A. S

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APPENDIX

Appendix A. Survey Constructs and Reference

Construct	Items	References
Awareness	• I understand why IPv6 is needed • IPv6 was introduced mainly to solve the address space issues with IPv4 • The Internet address shortage problem will happen in the near future	Rogers (1995)
Compatibility	• IPv6 is compatible with software applications in use in my company • IPv6 is compatible with the current IP (IPv4) • IPv6 is compatible with my past computer experience • Using IPv6 is completely different to anything that I have used before • Using IPv6 is a new experience for me	Rogers (1995), Davis (1989), Agarwal and Karahanna (1998)
Complexity	• IPv6 is more difficult to implement than IPv4 • Learning to use IPv6 is easy • IPv6 is difficult to administer • My company doesn't have the technical knowledge to use IPv6	Davis (1989)
Trialability Moon	• The chance to experiment with IPv6 before adopting it is an important factor in influencing my decision to adopt IPv6 • Workshops or training are important to obtain knowledge regarding IPv6	Rogers (1995), Hovav *et al.* (2004)

Construct	Items	References
Relative Advantage	• Adopting IPv6 is important, but not now	Rogers (1995), Davis (1989), Emigh (2002), Hovav *et al* (2004)
	• Adopting IPv6 would involve high start up costs	
	• IPv6 will be important for my company for the future	
	• Adopting IPv6 would improve my company's status	
	• I am not satisfied with the current IPv4 infrastructure, so I need IPv6	
	• I will use IPv6 because IPv4 and its supplementary technology (e.g. NAT, CIDR, DHCP, SSL) are not able to overcome the Internet's problems	
	• My company will adopt IPv6 if subsidies/incentives are given	
	• Many major vendors both hardware and software have support IPv6	
	• Many applications have been available to support IPv6	
Observability	• I will use IPv6 when it has been widely adopted.	Rogers (1995), Hovav *et al* (2004)
	• Looking at the result of those who use IPv6 will help my company/organization/institution to decide if we should use it as well	
	• I have heard of IPv6 being deployed in Indonesia	

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