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Review Article

Factors affecting the adoption of IPV6 from IPV4: A systematic mapping study

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Abstract

A systematic review of the literature was performed to understand the IPV6 migration readiness and resistance in organization and to provide an overview of the current state of research in this topic. In total, 30 papers from 5 prominent databases met our inclusion criteria; 16 were on factors affecting the migration adoption from IPV4 to IPV6, 5 discussed the challenges, solutions and deployment strategies and 9 discussed the migration planning. The number of research done in this topic is increasing in years. Based on the reviews, many researches have focused on the functional issues of IPV6 such as on content, transition mechanisms and performance. Research on non-functional issues such as on vendor support, cost of implementation, skill shortage, advantage of early adoption, scope for innovative ideas and lack of immediate benefits are still scarce. Therefore, a complete framework that integrates both the functional and non-functional issues is deemed important as a guideline for organizations' migration to IPV6.

Keywords: *IPV6 migration readiness etc.*

Introduction

With the emergence of the Fourth Industrial Revolution and the entry of Internet of things (IOT) into world markets, private and government organizations must move in the direction of developing their business and keeping pace with this transformation to maintain sustainability and business efficiency. The Internet of things (IOT) has rapidly grow in the last years, every single object on the world can be identified, monitor and controlled through the internet. What distinguishes Internet of things (IOT) from other technology is they can seamlessly communicate with other objects resources (physical and/or virtual) through the internet to provide value information for end users. Hence the importance of following up the development of the Internet and its protocols, the IPv6 protocol is critical to meet the increasing needs of internet and to supporting continued development, network operators, content providers, developers (software and hardware), enterprises and others need to implement this protocol to ensure efficiency, effectiveness and global connectivity to long-term growth.

The Internet Assigned Numbers Authority (IANA) allocated the last unallocated blocks of IPv4 address space to the Regional Internet Registries (RIRs), who in turn allocate blocks of addresses to institutions and Internet Service Providers (ISPs).

As a result, the Internet is on its way to a fundamentally transition motivated by the exhaustion of IPv4 address space. The theme of transition is to move to new addressing scheme having 128 bits so called IPv6 (Graziani, 2012). IPv6 shall provide more than one unique IPv6 address for every connected device regardless of the gadgets or the users exist in the long future (Ali, 2012).

The next generation of internet Protocol is IPV6, this protocol is designed for replacing the currently used protocol IPV4. The migration to IPv6 from IPv4 is also one of the critical areas of any government in the world. Technical foundations of IPv6 have been built but deployment and capability to use it is the ensuing challenge. The awareness on IPv6 is also quite low, the impact of this technological change needs to be deliberated and the technical know-how needs to be assembled.

According to Moh *et al*, 2017 IPV6 along with the new trends of markets for internetworking of physical devices, vehicles, buildings, etc and the widespread use of mobile devices, the demand for addresses to identify the devices connected and allow them to communicate is increasing dramatically. The current addressing scheme is 32 bits Internet Protocol version 4 (IPv4). The migration to IPV6 is needed in order to accommodate the current demand of technology used

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especially on the Internet of Things (IoT) development. Moreover, from the literature review the researcher find that the issue of adoption of the new Internet protocol IPV6 is a global issue. There are a lot of studies search in IPV6 implement in different aspect like analysis of organizations IPV6 deployment strategy (Moh, 2017), analysis of the factor that affecting user acceptance towards IPv6 (Medi, 2016), also study's in assessment of IPV6 readiness, deployment and transition in specific countries (velimir *et al*, 2016). The increasing research on the adoption of IPV6 protocol, a comprehensive overview of the state of the art on this issue is quite relevant.

A systematic review follows methodological procedure to allow other researcher to reduce the same way when exploring the same research topic. To achieve the goal of this paper we established research questions and explicit criteria to evaluate and select the relevant studies in order to provide scientific value to obtain findings. The selection of papers took into account the modernity and recency of the study. Finally, this paper is structured as follows, Section 2 presents the methodology implemented for the systematic review, Section 3 showing how the study select relevant primary studies from the literature. Section4 present the answers of research questions and respective goals of it. Section 5 determine some challenges that can drive research in this context.

Research Methodology

Systematic review study is used to present the results of previous studies to provide a comprehensive overview. Our review follow three basic steps, as adopted from Pearl Brereton *et al*, 2007 (see Figure 1).

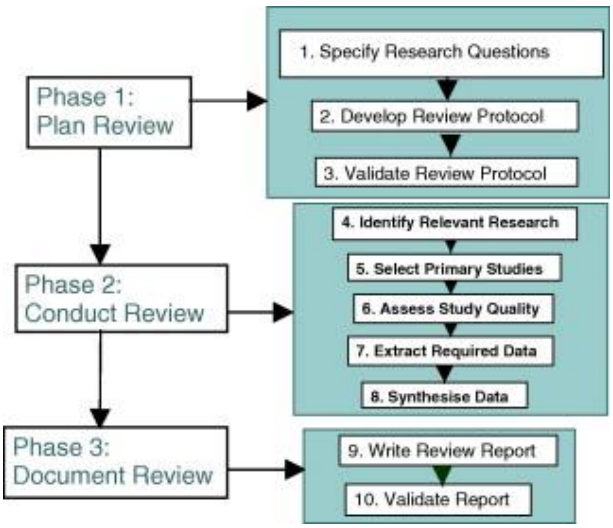

Fig.1 Systematic

Literature Review process

Phase 1 include planning steps, answered and validated review protocol. Phase 2 consists of adopting the criteria used for primary studies selection, study quality assessment and required data extraction and synthetization. In the final phase report is written, reviewed and conclusion are drawn from the finding. In the following, we will explain the research questions set for the systematic review.

Research questions

Proposed the research questions (RQs) is aiming to find a primary studies to understand all issues related to adopt IPV6 and summarize the factors affecting to adopt this protocol, table 1 outline the RQs.

Table 1: Research Questions and goals

RQs	Goal
RQ1: What are the main topics investigated on the adoption deployment and migration of IPV6?	To obtain a comprehensive understanding on the issues of adoption IPV6 and to identify what has been investigated in this context
RQ2: What are the existing factors that affecting on adoption of IPV6 protocol?	to define the factors that affecting adopt IPV6 and find relationships between it
RQ3: What are the strategies for adoption IPV6?	To understand the strategies used in this context
RQ3: What are the suitable plan for adoption IPV6?	to define the best plan with the goals, requirements, and scope defined

Search strategy

The search process for preliminary studies and related studies related on the research topic on several criteria that can be summarized in the following: Research in databases specialized in the subject of research area see Table 2, making sure to obtain the scientific paper in full text, selection of papers with accurate results. In addition, the word IPV6 readiness has been identified and placed between two blocks in the database search engines to obtain more accurate results.

Table 2: Electronic databases used in the search process

Database	URL
Science Direct	http://www.sciencedirect.com
Scopus	http://www.scopus.com
ACM Digital Library	http://dl.acm.org
IEEEXplore	http://ieeexplore.ieee.org
Research Gate	http://www.researchgate.net

Moreover, we used the AND logical operator to link the two words IPV6 and readiness by use this formula IPV6 AND readiness for more accurate result. Every database has its own unique set of commands to get a specific result in any research topic by using Boolean logic (AND) to narrow down or focus a search to get accurate results which should contain articles relating to the research topic IPV6 AND readiness (Jessie Mc *et al*, 2015).

Selection criteria

Specific criteria are used to evaluate studies based on research questions that are important for this paper. Two main inclusion criteria for the adoption of the relevant studies as follows:

IC1: The study presents research topic (IPV6 readiness) and/or discusses scenarios, Effect of different factors on migration from IPV4 to IPV6
IC2: The study presents a strategy or plan on how to migration from IPV4 to IPV6
In addition, Exclusion criteria have been as follows:
EC1: The study is not directly related to IPV6 readiness
EC2: The study is not directly related to effect of different factors on migration from IPV4 to IPV6.
EC5: The study does not have an abstract or the full text is not available.
EC6: The study is just summary of conference/ workshop.
EC7: The study is not written in English, which is the most common language.

Therefore, in this systematic review, a given primary study is considered as relevant if it meets at least one inclusion criterion.

Data extraction

The process of data extraction involves retrieval of data from different sources. Not all choosing studies from a different source sufficiently and clearly describe the details of information to be extracted as data items aiming at supporting the answers to the defined research questions. We have strived to reduce this bias by clearly defining the data items. One of the important thing in data extraction in this systematic mapping is inferred certain pieces of information regarding data items during data synthesis. However, to reduce the inaccuracy of such inferences, we have developed specific criteria for selecting relevant studies and this can be referred to Section 2.3.

Selection process

Based on the protocol of this research paper the process for reviewing literature, the primary studies were searched, selected, and evaluated according to the established protocol. David Budgen, Pearl Brereton,2006 pointed out *The review process has three phases: planning the review; conducting the review; reporting the outcomes from the review*. The planning phases refer to the research topic protocol, conducting the review refer to selecting the relevant primary studies and reporting phases including the main report of this study. Figure 2 showing the process for reviewing literature in systematic mappings.

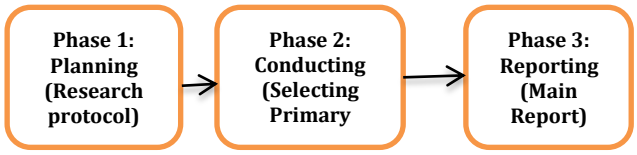

Figure 2: The process for reviewing literature in systematic mappings

Based on selection process the primary studies searched, selected, and evaluated according to the established protocol of this research paper. The researchers take in to the account make minor changes in search process to compatible with the specificities of each database engine. In addition, Researchers worked to make the automated search limited with only (title, abstract, and keyword fields). Moreover, to make sure the work more credible and after selecting the preliminary studies on the subject of the research, researchers exposed the papers selected for two tests, the first one encompassed reading title, abstract, and keywords. The second test encompassed the full reading of the studies. In the final stage of selection process, selection criteria were applied (Refer to section 2.3) and remove the duplicate studies in more than one database and keep only one. Afterwards, and after removing studies retrieved by two electronic databases, 126 studies were evaluated based on their title, abstract, and keywords and reading the full text the resulting of this found 30 relevant studies (see Appendix A). Figure 3,4 below show the number of initial studies selected from each database and number of studies per each year.

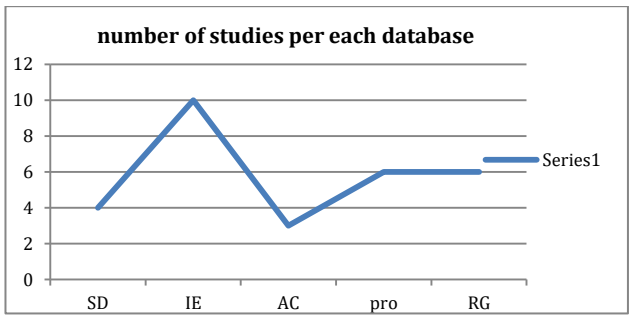

Figure 3: Initial studies selected from each database

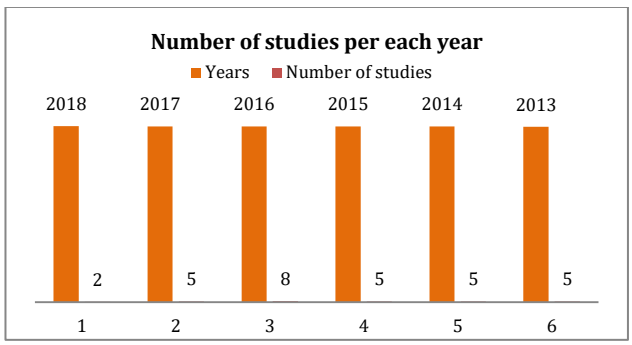

Figure 4: Number of studies per each year

Result

In this section, the researchers summarize the results of this systematic review based on the research questions and the extracted/synthesized data. In section (4.1) will present a brief overview of the selected primary studies, in Section (4.2) the researchers answers to each research question based on the analysis of such studies.

Over view of selected studies

IPV6 migration represent relatively new research fields distribution along the years., it is interesting to observe when studies of these global issue were published, which start since 1995 In the following, we will review factors that influence organizations' readiness to migrate to IPV6, based on the selected literatures. Factors that affect the organizations readiness can be classified into several categories; physical, human and environmental factors. Physical factors include planning, equipment, and cost, while human factors include knowledge, training, and motivation and environmental factors include environmental crisis, environmental factors that affect network externalities. As example, in the study conducted by (Aspalilla Main *et al*, 2015), the results indicate to most of the respondents in this study agree to that the organisations need to be well prepared on their networking equipment and this very crucial in the migration project. Moreover, this study indicates all human factors and based on respondents have a significant influence of readiness to migration to IPV6. In addition, (Reza Tadayoni & Anders Henten,2016) they concluded their study by referring to the switching costs and developed the equipment are related to investments, operations and training has a significant impact on organizations migration to IPV6. While, (Xuequn Wang, Sebastian Zander, 2017) studied the attitude of top management and participants in decision-making in organizations in two countries (Australia and china) which can be included under the human factors affecting the preparation for migration to IPV6 and determine the influence of this factors on the organization readiness. The study concluded that top management and participants in decision-making in organizations play an important role in adoption IPV6 in any organization and this factors has a significant different between this two countries. Furthermore, it is possible to notice the increasing trend on number of publications along the years which examines different trends of migration issue to IPV6 protocol and this supports the conclusion of the paper published by Xuequn,2017 which referred the necessity to extend this study by including another variables aspects as example different political context.

RQ1 – main investigated topics

In this subsection, we explain findings based on our RQ1 (see Section 2.1 for list of questions). The first research question is to indicate ***What are the main topics investigated on the adoption, deployment and migration of IPV6?.*** RQ1 was developed to obtain a comprehensive understanding on the issues of adoption IPV6 and to identify what has been investigated in this context we can find there are several topics investigated on the adoption, deployment and migration of IPV6. We have analyzed the primary goals of each study and found there are several goals for each study and can be broadly classified into as follow:

1. Study the factors affect adoption of IPV6 within physical and humans factors
2. Study the challenges, solutions of migration to IPv6
3. Study the deployment strategies
4. Study the planning to migration and so on.

the table below classified the selected primary studies in four categories, namely:

(i)factors effect,
(ii)challenges and solutions,
(iii)deployment strategies and,
(iv)planning migration

Table 2: Classified the selected primary studies in four categories

Study ID	Study categories			
	(i) factors effect	(ii) challenges and solutions	(iii) deployment strategies	(iv) planning migration
SD1	√			
SD2		√		
SD3	√			
SD4		√		
IE 1			√	
IE 2			√	
IE 3	√			
IE 4	√			
IE 5				√
IE 6	√			
IE 7	√			
IE 8	√			
IE 9				√
IE 10	√			√
AC1	√	√		
AC2				√
AC3	√			
Pro1				√
Pro2				√
Pro3	√			
Pro4	√			
Pro5	√			
Pro6		√		
RG1				√
RG2				√
RG3	√	√	√	
RG4			√	
RG5	√			
RG6			√	
RG7	√			

From the previous table we can see that most of the previous studies focused on determining the factors affecting migration to the sixth version of the Internet protocol, followed by the studies that examined the challenges facing the organizations. The another studies focused on the strategies for migration and the latter there are studies that have drawn up plans for the organizations to migration to IPV6. It should be noted that there are no studies have provided a unified integrated framework on migration to the sixth version of the Internet Protocol. So that the framework includes identifying factors affecting the organizations, and the general challenges faced by these organizations and then proposing strategies and plans for such migration.

RQ2 - the existing factors that affecting on adoption of IPV6 protocol

We have identified three broad categories in which the selected studies can be classified, with respect to the existing factors that affecting on adoption of IPV6 protocol, namely: physical factors, human factors and environmental factors. This classification was made based on an assessment and analysis of 16 study out of 30 study based on selected specific parameters. Xuequn Wang, Sebastian Zander 2017 indicated in their study the physical factors indeed play an important role in adoption of IPV6. Also, in the same study the researchers confirmed that there are significantly different between countries with respect of physical factors. Moreover, the prepareation of the network equipment and end user devices is very important before an IPV6 project initiated (Aspalilla Maina *et al*,2015). In addition, there are some studies indicate that the environmental factors have an indirect effect of migration and adoption of IPV6 (Alan Oxley,2014). Velimir Svedek1,2013 indicated in his study the readiness of internet service provider (ISP) play a major role to push another organizations to migration to IPV6. Planning, policy, assessment and training in any organization it has a direct and strong impact on the organization readiness to migrate to IPV6 based on the study done by Sebastian Zander and Xuequn Wang 2018 on two different countries Australia and china. In addition, the increasing number of users connected over IPV6 and content support over IPV6 puts the organizations in a critical position for the adoption of the new Internet protocol to maintain the sustainability of their business, as John Pickard,2017 noted in his study. According to the Business Wire, 2013 with a growing number of ISP there should be no problem finding on the hardware that support IPV6. Add to the previous factors the achievable for the migration to IPV6, infrastructures deployed, proper technologies identified, suitable national policies, plan and roadmap must be apply from government side (Babu Ram Dawadi & Subarna Shakya,2013). Based on the study done by Nurual Azma & Y.Robiah from UTM Melaka university 2014, the result of this study emphasize on the elements that influence the organization readiness towards IPV6 which can be classified to (Physical factors, human factors). In case of Malaysia government, the government developed Malaysian Advanced Network Integrated system (MANIS) to be ready of the IPV6 (Babu Ram Dawadi *et al*, 2015).

RQ3 - The strategies for adoption IPV6

The moving from IPV4 to IPV6 is not individual interest, it is becoming compulsion between organisations, ISP and individuals. However, no project can succeed without a plan and strategy for implementation. Several strategies have been proposed in IPV6 migration issue, and the ISP must be able to design a strategic to manage all requirement to migrate to IPV6 start from data center, network infrastructure that simultaneously support IPV6 (Babu Ram Dawadi *et al*,2015). Moreover, there are elements need to consider for any organization's before deployment of IPv6. One of the successful strategy that done by Malaysian government, the Malaysian council design the IPV6 roadmap to use it as a strategy and plan to make IPV6 enable at ISPs by 2006, at e-government by 2008 and overall Malaysia by 2010 and this strategy was achieved in 2015 (Babu Ram Dawadi *et al*,2016). In addition, there are many studies measuring IPv6 readiness on the most accessed web-based content Provide and evaluating suitable transition mechanisms for technical perspective (Satriyo Wibowo,2017, Mohammed F.,2017).

RQ4 – The suitable plan for adoption IPV6

For any organization the migration to IPv6 will naturally occur in multiple phases with specific plan over multiple years. So, through migration any potential problems maybe will occur, and the project of any organization without a plan will fail. From previous studies, many researchers have proposed plans seamless transmission to move to the new version of the Internet protocol (IPV6). Most of the studies focused on the presentation of technical methods for rapid transfer and taking into account the size of the institution. Dargin and Mark, 2017 proposed to move forward with complete migration to IPV6 with dual-stack mechanism and this mechanism is typically the best approach for large and medium organizations. Moreover, the researchers pointed to the importance of the observing that their ISP are successfully applied IPV6. Also, the researcher proposed four steps should take in account when planning to migrate to IPV6 and it can be summarize into (cost analysis, readiness assessment, documented any unsupported application and infrastructure and Provide the plan in details)(Dargin and Mark, 2017). Joanna, 2017 in her research paper emphasized the importance testing for the operating systems in the organization and testing all applications within it to make sure all operating systems and application fit with IPV6 protocol to

ensure business sustainability (Jonna,2017). Zainab Abdullah,2018 also suggested the importance of testing the operating systems of the organization and security mechanisms used and stressed the importance of the transition to the sixth edition of the Internet Protocol (IPV6) because of the great advantages in protection of enterprise systems. Confirmed to what suggested by Darwin and Mark, 2017, Samson Isaac 2016 mentioned in his research how can migrate from IPV4 to IPV6 within the same network without one interfering and without any effect of organization business (Samson, 2016).

Limitation and Future work

Our study has several limitations, first there are different approaches were used to collect data and our samples of primary studies have different directions in the research, which lead to take a long time to determine the importance of the study and its relevance to the goal of this paper. Future study could extend this study by involving a different variable to measuring different aspects to examine whether these factors indeed have a significant effects for adopt IPV6. In addition, our future work could consider additional theoretical framework to extend this study.

Conclusion

Finally, we find that over the years research focused on the nature of IPV6 utilization and plan to migration in terms of content, transition mechanisms and performance and this can be classified under functional issues. Non-functional issues have not received much attention from researchers and as we know both functional and non-functional issues affect the acceptance the migration to IPV6. Non-functional issues can be summarize into (vendor support, cost of implementation, inevitability, skill shortage, advantage of early adoption, scope for innovative ideas and lack of immediate benefits) . In short, the level of adopt IPV6 is dependent on a organizations support by governments in each country. There is almost some basic issues promoting appear widely in literature, but in the same time there are no research come up with a complete framework to can be use as a guide to migration to IPV6.

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Appendix A

Study ID	Title	Authors	Publish year	Citation
SD1	Extending the model of internet standards adoption: A cross-country comparison of IPv6 adoption	Xuequn Wang, Sebastian Zander	2017	0
SD2	From IPv4 to IPv6: Lost in translation?	Reza Tadayoni , Anders Henten	2016	4
SD3	Organisation Readiness Factors Towards IPv6 Migration: Expert Review	Aspalilla Maina, Nurul Azma *et al*	2015	1
SD4	IPv4 to IPv6: Challenges, solutions, and lessons	Stanford L.Levina1StephenSchmid	2014	21
IE 1	Measuring IPv6 Readiness on The Most Accessed Web-based Content Provider in Indonesia	Satriyo Wibowo	2017	N/A
IE 2	Analysis of Organizations IPv6 Deployment Strategies in Nigeria and Evaluating Suitable Transition Mechanisms	Mohammed F.	2017	N/A
IE 3	Factors Analysis of IPv6 User Acceptance Against Security Aspects based on Concept of Technology Acceptance Model (TAM) and Technology Threat Avoidance Theory (TTAT)	Dion Kristadi	2016	N/A
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RG3	Government Roadmap for IPv4 to IPv6 Network Migration: A Case of Nepal	Babu Ram Dawadi Subarna Shakya	2016	2
RG4	A Survey of IPv6 Deployment	Hamid Erman *et al*	2015	0
RG5	Service Provider IPv4 to IPv6 Network Migration Strategies	Babu Ram Dawadi *et al*	2015	4
RG6	EU-China IPv6 Roadmap	Latif Ladid	2015	0
RG7	Organisational Readiness Element to Develop Readiness Model for IPv6 Migration	Nurul Azma Zakaria, Y. Robiah	2014	0