INTER-RATER RELIABILITY ASSESSMENT BASED ON COHEN'S KAPPA ANALYSIS FOR IPV6 READINESS FOR MIGRATION FACETS

Aspalilla Main[1], Nurul Azma Zakaria[2], Robiah Yusof[2,] Nin Hayati Mohd Yusoff[3]

[1,3] Department of Electrical Engineering, Politeknik Merlimau Melaka, 77300 Merlimau, Melaka

[2]Faculty of Information and Communication Technology, Universiti Teknikal Malaysia, Melaka Hang Tuah Jaya, 76100, Durian Tunggal, Melaka, Malaysia

∗For correspondence; Tel. + (60) 193890379, E-mail: aspalilla@pmm.edu.my

ABSTRACT: *Component identification involved in the transition process from IPv4 to IPv6 is significant in assisting the organisation to be more prepared and aware in deploying IPv6 in the future. The purpose of this study is to determine the inter-rater reliability of the identified components, which are involved in the IPv6 migration process based on Cohen Kappa reliability analysis. It involved two experts in the field of networking in order to rate the IPv6 readiness components. The components that have been agreed upon are then used to measure their readiness before any action is taken to carry out the migration process. The result indicated that the of Kappa value is 0.62 which is deemed to be in substantial agreement, with 66 out of 79 pairs had perfect agreement, while there were 13 items, which does not have the same agreement between the raters. These results provided the reliability evidence from previous identified components, which were involved in the transition from IPv4 to IPv6. The results had significantly proven that components that were verified based on Cohen Kappa analysis have great potential for organisation to measure its readiness towards being IPv6-compliant. The component identification that was involved in the transition process from IPv4 to IPv6 then would be able to assist organisation to be more prepared and aware in deploying IPv6 in the future*

Keywords: Cohen Kappa, IPv6, Readiness, Migration

1. INTRODUCTION

Most connections to the Internet in the world nowadays rely upon IPv4 protocol, even though it is considered as a legacy protocol since IPv6 has been standardized in year 2000 [1]. Although IPv4 can accommodate a total of 4 billion addresses, it cannot be assigned to all of the world's population which has reached more than 6 billion people [2]. Yet, the implementation of IPv6 not only dealt with the increase of more IP addresses on the network, but rather it is about the upgrading of the network for the next generation of applications, services and better technology such as in enhancing support for Mobile IP and Mobile computing devices [3]. Therefore in future, all Internet-related innovations will occur within the purview of IPv6 protocol for the continuity of growth of the Internet. Thus, organisations need to take immediate action to develop a strategy for their system's migration to IPv6 Internet connection, especially for organisation that depends on the Internet for daily business.

However, the progress of IPv6 implementation is not as planned, as the deployment of IPv6 is seemed to be very slow [4], as there was no serious compelling factor for the organisations to migrate to the new protocol, since the current provisions are still adequate for most users. Hence, very few migration preparations have been made. While many organisations still do not have a strategy and IPv6 implementation plan in their IT technical plan [4], the Malaysian government has published its National Strategic IPv6 Roadmap in 2008, which aimed to promote and create awareness within organisation about this new protocol. Unfortunately in Malaysia, IPv6-test had reported that until September 2015, almost 100% of the hosts are still supporting IPv4 with a slow progression for IPv6. It shows that only a few organisations have taken the steps toward the adoption of IPv6. Based on the previous researches and also current studies, the reason for this is because of the lack of preparation and readiness within organisation towards this new protocol [6]. In fact, the majority of organisations are still at their first level of readiness, showing that they are not actively implementing and adopting IPv6 for their own good, with only 25 percent of the respondents sensed that IPv6 is a critical issue to be noted [4]. Therefore, there is a question whether these organisations are facing any problem to identify the aspects that need to be considered in the planning process of migration from IPv4 to IPv6.

The successes and failures of the change are dependent on the reaction of the members of the organisation. Past researches show that the readiness to change involved both physiological and behavioural components, namely, the willingness and capability to make certain changes [7]. Therefore, to develop and to measure the organisational readiness for change is a process that can be performed in the initial phase of implementation, as this would help organisations to identify any issues and preparedness aspects that should be considered before implementing any changes. At present, the organisations are progressively recognising the benefits of implementing the readiness for changes evaluation to discover whether any preparedness facets existed prior to in carrying out the changes. Otherwise, such changes were often hard to implement efficiently in the absence of proper preparation. In fact, experts have suggested that without adequate readiness for change , change efforts are more likely to lead to failure [7].

Readiness for change has been conceptualised existed at two levels, which are individual and organisational level [9][10] . However, the change of both levels are mutually linked as the organisational level would be functional once the individual level that belong to the organisation is changed [8]. This is because the organisation itself is the collective or sum of all the individuals linked to the organisation. Organisational readiness will be at its highest if the organisational members are willing and want to implement the changes, in addition they feel confident with their capability to effect the change [9].

In the case of IPv6, past researcher had concluded that readiness is a form of preparedness for the staffs, systems and organisations to face the situation and to carry out any action based on what was planned towards IPv6 migration [23]. It is

based on the extent of appropriate planning, adequate training of staffs and supplies to support the process. Organisations that do not have the required skills would not be aware on how this migration process is performed [1]. In addition, readiness was intended at identifying how organisations need to prepare for the migration and implementation of IPv6[10].

There are some researches and surveys that presented data on IPv6 migration readiness from various perspectives. The studies were directed from different viewpoints, such as a study on readiness for public organisations in terms of infrastructures, applications, end-user devices [11] core network, and software [12], training, planning and policies [10]. Also, [13] had studied on the financial side, which covered profit return and cost estimation; and the technical side, which covered infrastructure, project plans, personnel training and, IPv6 architecture. Other than that, the rest of the studies contribute information on an organisation's experiences [14]; and implementation and challenges towards IPv6 migration [15]. In respect, according to an ongoing study conducted before, the researchers have identified six categories of IPv6 preparedness which are equipment, cost, deployment, motivation, training and knowledge [16] as shown in Figure 1.

For that reason, this study aims to determine the inter-rater reliability based on identified components, which were involved in the IPv6 migration process using Cohen Kappa analysis approach. In this case, the opinion of experts should be consulted to verify some of the aspects and both experts would then give a rating for each item that were involved to verify the reliability. This is essential to ensure that these aspects are reliable for instrument development on the IPv6 readiness for migration.

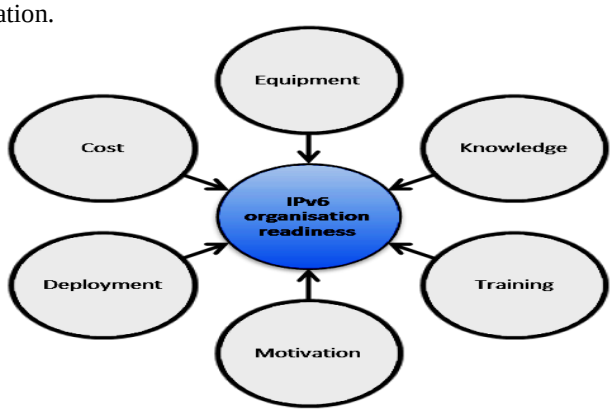

Fig (1): IPv6 Organisation Readiness Facets

2. MATERIAL AND METHOD

This study had recruited the involvement of two experts in the field of networking to give the rating on the components which have been identified as required in the IPv6 migration process. One of the rater is a practitioner engaged in managing the whole computer networks at community colleges throughout Malaysia, while the other one is an academician in a Malaysian higher education institution.

Both raters received prior explanation on how to give the rating through a checklist sheet that review 82 items from 6 categories with two levels of agreements, namely Agree (1) and Disagree (0). In fact, 40 units are sufficient enough to find the level of agreement and to determine the reliability of the data [17]. Therefore, to describe whether the value of the agreement is good or weak, [18] had suggested that the method of calculation is based on the Cohen Kappa agreement scale described in Table 1.

Table 1: Cohen Kappa Agreement Scale

Kappa Value	Degree of consensus
Below 0.00	Poor
0.01-0.20	Slight
0.21-0.40	Fair
0.41-0.60	Moderate
0.61-0.80	Substantial
0.81-1.00	Almost perfect

Beside, Ratings Agreement Table (Table 2) is constructed based of 6 category of aspects and, from the categories, there are 82 items have been developed to assess its consensus by two experts called raters. The result then will be analyzed using the Cohen Kappa values to establish the reliability [17].
Hence, statistical analysis was performed using SPSS version 13.0 to determine the level of agreement between both raters.

Table 2 : Ratings Agreement Table Based on Category

Category	***Dimension***	***Rater 1***	***Rater 2***
Equipment	Networking equipment	/	/
Cost	Infrastructure upgrade	/	/
Deployment	Planning	/	/
Motivation	IPv4 Exhaustion	x	/
Training	Technology Staff	/	/
Knowledge	Technology	/	/

3. RESULTS AND DISCUSSION

3.1 Cohen Kappa Reliability Value for IPv6 Readiness Components

The results of this study had shown that the 82 components identified previously were reliable enough to be involved in the process of migrating to IPv6. However, only 79 valid cases had been analysed. The data rated were the components from six facets of IPv6 preparedness as shown in Table 1.

From Table 3, the number of valid cases was 79 with 66 of 79 pairs, from which 84% of it had perfect agreement, while the other 13 items do not have the same agreement between raters. Rater 1 disagrees with 11 items while rater 2 disagrees with only 2 items.

The result of this study shows substantial agreement between raters, as presented in Table 4 based on the calculation below:

$$K = \frac{fa - fc}{N - fc}$$

Fa = no of agree units
Fc = 50% expected agreement
N = No of valid cases

Table 3: No of Agree and Disagree Cases between Raters

		Rater 2		Total
		Agree	Disagree	
Rater 1	Agree	64	2	66
	Disagree	11	2	13
Total of valid cases		75	4	79

Table 4: Symmetric Measure

Kappa Value	Value
Measure of Agreement Kappa	0.62
Degree of consensus	Substantial
N of Valid Cases	79

From the result, Rater 1 has disagreed with the dimension listed in the construct of motivation that is IPv4 exhaustion. This is because Rater 1 contended that IPv4 exhaustion is not the main motivation for organisation to migrate to IPv4. He believed that the benefits and advantages offered by IPv6 protocol itself should be the main compelling reasons to migrate to IPv6. This finding was in line with other previous researches, which had argued that organisations still adamant that IPv4 will experience run out in the meantime. Previous researchers found out that certain organisations were reluctant to invest money on the migration, since IPv4 NAT can provide short term solution and also it is cost-free [19]; as network address translation (NAT) is a technical mechanism that can be made to handle IPv4 address shortage [20]. In fact, most of the organisations still rely on NAT and there was no urgency for them to migrate [4]. Although motivation did not receive the perfect agreement between the two raters, Rater 2 has agreed with the construct. In this case these components are reliable enough to be involved in the preparation for IPv6 based on overall kappa value findings.

Therefore, equipment, cost, deployment, motivation, training and knowledge can be used to construct an instrument to assess the readiness of an organisation towards the migration process.

The above findings are consistent with the main facets used by [4] to analyse the readiness level of an organisation, which are training, planning, deployment and motivation. However, they used the policy as one of the main facet; while in this study, policy was put into the category of deployment. Hence, some aspects are also preferable among researchers for measuring a country's level of IPv6 implementation, such as knowledge, motivation and training [1]; motivation, cost, training and deployment [21],cost, planning, policy, knowledge and deployment [15]; training, planning, deployment [10]; and equipment, cost, motivation [11].

IPv6 implementation in an organisation involved major changes in physical infrastructure, redesigning of organisational network, which implicates costing, diverse policies and standard operating procedures [22]. From a longer term perspective, agencies should assess how IPv6 planning can be put into long-term strategy, to ensure that these requirements are included in the acquisition and progress of existing initiatives, especially for development that will operate for an extended period of time. Abdul Wahab et al. (2012) concluded that those requirements as physical factors which defined the resources include physical assets, technology, and organisational capabilities and operations procedures. Those factors consists of equipment, cost and deployment have also been suggested by these previous researchers; [11,12,21,10,15].

In addition, there are several studies regarding IPv6 readiness in an organization that uses these facets as a procedure for IPv6 deployment such as which provided the guide for enterprises focusing in equipment [26], cost and program planning specifically for network administrators and network architects to plan their IPv6 deployment. The guidelines also aligned with the study on readiness assessment which found out that cost is among the reasons why progress in Mauritius on IPv6 adoption was lagging behind in other developing countries [1]. He suggested that organisations must identify the benefits, costs and risks before initiating the IPv6 deployment, by performing the budget planning, which includes design, testing and deployment costs. Apart from that, there are also some countries that carry out a survey on IT and IPv6 deployment in their countries that measures those aspects, such as Saudi Arabia [27], Singapore [28] and United States [22]. It was found that the biggest cost on IPv6 deployment is related to infrastructure upgrade, which was obtained through the studies by [10,21,29]. Analysis of the infrastructure cost is necessary as it implicate the upgrading of hardware and software that are incompatible with IPv6 protocol [29].

Incidentally, the second aspect discussed is equipment, as it is mostly related with networking equipment [29,12,21,11]. Those researchers mostly concluded networking equipment as networking devices such as routers, switches, firewalls and load balancers. In this case, the networking equipment above have been proposed as a measurement criteria to measure the ratio of equipment that need to be replaced to support the IPv6 protocol in the network.

The final aspect discussed in physical construct is planning, which is the element for deployment [31] which suggested the deployment process with practical task such as network audit, network component selections, network management, planning and implementation. In another study, [10] measured the organisation's high planning, which divided into IPv6 strategy planning and IPv6 project planning to evaluate the organisation's readiness. Meanwhile, this dimension has also been used to measure the implementation plan in an organization, including the address, training and service planning [15,21,32]. Therefore, organisation should consider planning tasks that are specialised in technical, organisational and promoting perspective while evaluating the IPv6 readiness [24].

In addition to the physical aspects, the migration to IPv6 requires preparation and support in terms of its human factors. It involves the role of human factor in facilitating this process of migration. There is an argument stated that these factors are taken into account because these changes will take a long time and expertise required to integrate those complex technologies within an organization [33]. In fact, human factor is an important issue that can affect the overall readiness of the organisation in the event of an introduction, or a change to a new technology that can affect the personnel in organisation [34]. Table 2 shows the human factors that are involved, such as motivation, training and knowledge.

Although some of the earlier researchers agreed that the organisation needs to identify their motivation that drives them to migrate to IPv6 whether it was due to the exhaustion of IPv4, or the benefits that were offered by this new protocol might be the reason to adopt this new technology. However, there was an argument mentioned that their organisation runs well with the existing IPv4. So they did not need to deploy IPv6 for the time being.

Conversely, training is identified as the second aspect as and described that technology training is related within all IT infrastructure training associated with the benefits and features of IPv6 [35]. The level of training required will vary upon the role of the IT staff member of the organisation who is in charge the development, deployment and integration of IPv6. Additionally, technology training has been divided into engineering training, operational training and special training program training, which is needed to improve the knowledge and skills for personnel to familiarise themselves with the new system [2]. On a similar note, training has been used as a dimension to measure Australian IPv6 readiness by separating the training with security, deployment, equipment configuration, operating configuration and IPv6 application development training [10]. According to this researcher, if the development of IPv6 becomes necessary, the organisation can be poorly placed for adoption because of lack of training and application needs.

In addition, staff general training is also important for the preparation of IPv6 migration and been demonstrated that staff general training as one of the dimension required to develop the model of transitional cost for IPv4 to IPv6 transition [36]. According to these researchers, since IPv6 is considered a new standard for Internet protocol, there is a need to educate people who are responsible for network administration, and the need to train professional staff to deal with this new technology. As a guide for IPv6 migration, staff training is necessary and it must be included in the budget for additional expenses [19]. Likewise, general training has been described the as general training program that aimed to give ordinary users information about IPv6 addresses and other relevant issues that are related to the new protocol [21]. The related training programs for personnel can prepare an ICT workforce once the IPv6 is deployed and implemented in the organisation.

Other than technology training, technology knowledge is an important aspect for IPv6 readiness as technical knowledge, especially on techniques of migration, can be used by network administrator to plan the action that can be taken in preparation for migration. Lack of knowledge and practical experience are some of the weaknesses that led to slower growth of IPv6 networks, thereby hampering and preventing the development of IPv6 research [37]. Furthermore, the affected personnel must develop the appropriate technical knowledge, otherwise it would hamper and damper the spread of technology, as personnel should have sufficient knowledge and skills to configure hardware and software during migration [10]. As a result, the availability of knowledge among employees is the most significant influence for organisations that do not plan to do the migration project [24].

The defined facets as given in Table 2 are important in measuring the physical infrastructure readiness as it would facilitate the proper planning of the financial requirements involved with the replacement and procurement of equipment that supports IPv6. Although there are other aspects that were involved in measuring the IPv6 readiness, previous literature studies had indicated that the three selected constructs were providing a solid basis for IPv6-readiness evaluation. Hence, it is proposed that the organisations must consider all three of these aspects in the strategic planning of their IT projects when anticipating for the adoption of the IPv6 protocol in the future.

Based on the findings above, whether or not the reliable facets can be used for further study, the researchers hoped that these findings would encourage more empirical research related to the topic of IPv6 readiness in order to create a better awareness amongst the decision makers and to the technical staffs about the IPv6 deployment in their organisation.

4. CONCLUSIONS

This study makes primary conclusion and confirmation that there are 6 facets involved in the preparation for IPv6 migration process; equipment, cost, deployment, motivation, knowledge and training.

The feedback provides valuable understanding on some of the things that should be taken into consideration for an organisation so that any incentives and programs can be planned to raise the awareness and motivates them to take action for the transition from IPv4 to IPv6. The future work of this study will be conducted to develop a standardised model using current finding that can be used by organisations to measure their readiness towards IPv6.

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