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Original Article

A Framework for Enhancing Computer Network Dependability in Universities

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Abstract - *Computer networks bring along many benefits in present-day society. The full benefits of computer networking are yet to be realised because of non-resilience issues. Universities are one of the sectors that have been a forefront user of computer networks and are yet to tap into its full benefits. This paper examines computer networks and develops a framework for computer network resilience in achieving computer network dependability in the context of universities. The paper adopted a survey research design targeting universities where Kibabii University was purposively sampled as the case study. The target population comprised (6246) undergraduate, (248) masters and (42) PhD students and (430) Kibabii staff. Random and purposive sampling were used where appropriate. The study used content analysis, questionnaires, interviews for data collection and a focus group for the framework validation process. Data collection tools were given to (3) experts to validate where they scored a validity value of (78.3%). Inferential and descriptive statistics were used to analyse the data. A KMO value of (0.803) justified the use of factor analysis on the collected data. Network, connectivity and human characteristics with factor loadings of (0.1898), (0.4359) and (0.3243) were the main constructs of the framework. The researchers expect that focusing on connectivity, human behavior, and network characteristics guarantees network end users a worthwhile experience, help computer hardware and software vendors fine-tune their solutions and guide governments and universities to plan and invest in enlightened environments when investing in computer networks, especially in universities.*

Keywords - *Network dependability, Network resilience, Framework.*

1. Introduction

A computer network is two or more computing devices linked either by one or more of several wireless technologies or by cables which may or may not be varied in the nature of the technology used to harness or optimise the computing power of the linked devices. As users of computer networks, deployment of computer networks in universities can still be further enhanced. Presently a good proportion of university computer networks are unpredictable, or their performance fluctuates with the number of users or traffic load, thus undermining the objectives of having a computer network infrastructure. Towards resolving the identified problem, the following objectives were set: the establishment of technologies for building computer networks in universities, the establishment of techniques for building computer networks in universities, the development of a framework for enhancing computer network dependability in universities and the validation of that framework.

2. Literature Review

According to [1], designing a resilient network is more than just adding redundancy. As fronted by [2], all connections are slow, some at some point or another, all connections at some point of time or another fail, and it is the experience for all users on these behaviors on their different devices in spite of their carriers, geography or underlying technology. A few points will help guide the designing and building of computer networks as per [4] Universities may decide to build their own networks and therefore set out buying required equipment and installing it on-premises. Alternatively, this task could be outsourced. There is a paradigm espoused by [5] for building resilience in computer networks. They formally call it D^2R^2 + DR. This approach is structured in phases, and the first phase is the D^2R^2. This stands for Defend, Detect, Remediate and Recover. This inner control loop describes what is undertaken for a system to react to disruptions and upsets and still perform at acceptable service levels. The second phase is the DR stage which stands for Diagnose and Refine. This second phase targets long-term improvements to the first phase to provide better future responses to challenges. In their work on network resilience [6] identify some of the following as potential causes of non-resilience in computer networks: Topology failures, overload, lack of integrity, software faults and domino effects. Globally frameworks have been used to provide guidance on the implementation of different specific concepts in information technology. For example, there is a framework, Cyber Resilience: Framework and Self-Assessment Tool [7]. Closer to computer networking resilience, there is research literature by [8] that also seeks to present a systematic approach to the subject of computer network resilience. The 2019 National ICT Policy is "designed to realise the potential of the digital economy by creating an enabling environment for all citizens and stakeholders" (Ministry of Information, Communication and Technology, Kenya[9].

3. Methodology

A hybrid research design was used in this paper in order to achieve its objective. A case study was the first research design of the hybrid research design, with Kibabii University, picked as a case study. A descriptive survey was the other component of the hybrid research design. The (6246) undergraduate students, (248) masters students, (42) PhD students of the institution, its network administrator, the director of ICT and the 430 computer network-using staff formed the target population for the study. Sample sizes of (364, 152, 40 and 205) were used for the undergraduate, master, PhD students and computer network-using staff, respectively, as the network administrator and director of ICT were purposefully sampled. Questionnaires, interview schedules and framework validation by focus groups were used as data collection tools. A Cronbach's Coefficient Alpha of (.809) was obtained when a reliability test was done on the data. A validity value of (78.3%) was reached when three experts examined the instruments.

4. Findings

This section discusses the development process of the Enhanced Computer Network Dependability Framework and its validation process.

4.1. Enhanced Computer Network Dependability Framework (ECNDF)

The sub-framework can be further classified to form the framework constructs. Network and connectivity and network determinants as network construct, Connectivity method and internet access as Connectivity construct and human factor and gender as human characteristics construct. The constructs and their respective sub-constructs can be summarised in Table 1.

The average of factor loadings for the sub-constructs was computed as follows: Network and Connectivity, (0.571+0.571+0.750+0.760+0.610)/5 = 0.6524, Network Determinants (0.622+0.660-0.514-0.541)/4 = 0.05675. Connectivity Methods (0.704+0.801+ 0.680)/3 = 0.7283 Internet Access (0.902)/1 = 0.902, Human Factors (0.804+0.641+0.632+0.507)/4 = 0.646, Gender (0.754)/1 = 0.754. Network (0.6524+ 0.05675)/2 = 0.3546, Connectivity (0.7283+0.902)/2 = 0.81515 and Human Characteristics sub-construct as (0.646+0.754)/2 = 0.7. This information was summarised to form the architecture of an Enhanced Computer Network Dependability Framework (ECNDF), as in Figure1.

Figure 1 presents an architecture of the framework having three (3) main constructs, i.e. network with a weighted score of (0.355/1.8702) = (.1898), connectivity with a weighted score of (.8152/1.8702) = (.4359) and Human Characteristics with a weighted score of (.7000/1.8702) = (.3743).

Table 1. Summary of constructs

Constructs	Sub-constructs	Factors	Loading
Network (0.355)	Network and Connectivity (0.652)	Hardware and Resource Sharing	.571
		Connectivity	.571
		Daily Reliable Internet	.750
		Semester Reliable Internet	.760
		Cloud Services	.610
	Network Determinants (0.05675)	Frequency of Network Access	.622
		Network Experience	.660
		Device Type	-.514
		Network Utilisation	-.541
Connectivity (0.81515)	Connectivity Methods (0.7283)	Hotspot Access Points	.704
		Cabled Connections	.801
		Data Sharing	.680
	Internet Access (0.902)	Internet Access Method	.902
Human Characteristics (0.7)	Human Factors (0.646)	Age Bracket	.804
		Level of Education	.641
		Faculty/School	.632
		Network Utilisation	.507
	Gender (0.754)	Gender	.754

Table 2. Experts' demographic data

Respondents	Frequency	Percentage (%)
ICT Experts	8	57.14%
IT Postgrads	6	42.86%
Total	**14**	**100%**

Table 3. Responses mean scores

	Mean	Std. Deviation	N
Could the presented framework give a representation of real-world concepts?	2.64	.633	14
Was it an accurate representation of the theories supporting the study?	2.64	.633	14
Was it easy to use or apply in the real world?	2.71	.611	14
Could this framework be acceptable?	2.57	.756	14

Grand mean=2.64

Table 4. Acceptance reliability test

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
.921	.924	4

This indicates that to realise resilient and dependable network connectivity is key and needs to be addressed as the first element, followed by Human Characteristics and, finally, the network factors. The first and last factors involve hardware and software, while the Human characteristics involve liveware factors. The three factors interrelate as key constructs that define the architecture forming the purpose of the study.

4.2. ECNDF Validation

To uphold the veracity of framework generation, validation was done. This procedure was carried out to guarantee that the framework created was sufficiently accurate for the purpose it was meant for. The significance of framework validity is critical and should be carried out by all who have a stake in the framework. The study realised that with failure to involve the ICT staff and the IT experts, there was a probability of constructing a wrong framework. The purpose of this part was to validate the developed framework. The main concern was whether the framework and its construct made sense to the researcher and other scholars and also to check whether the framework presents a reasonable theory for scholars studying the concept from different disciplines. This process started with the researcher, who then sought validation from outsiders. According to [10], the validation process is meant to ascertain that the research participants determine whether the researcher's interpretation of the meaning and the events with their own tallied; it was used to check biases and the quality of research.

4.3. ECNDF Validation Process

The process of validating a framework usually involves "outsiders". Validation was done via a focus group discussion in a seminar. This provided an excellent opportunity to discuss and receive feedback on the acceptability of the framework. Validation theory was to ascertain that the research participants determined whether the study interpretation of the connotations and dealings agreed with their own.

The results indicate that 57.14% of the respondents were ICT Experts, and 40.86% were IT Postgrads. A higher number of ICT Experts were included since they were the main part of the study that required using the framework in the implementation. The IT experts validated the framework's suitability to technological concerns and applicability in the adoption process. At the conclusion of the seminar presentation, the researcher used the question-asking protocol to get the members concerned and feedback about the framework and its concepts. The questions of interest were: if the presented framework represents real-world concepts? If it is an accurate representation of the theories supporting the study? If it is easy to use or apply in the real world? And be acceptable? The responses to these questions were graduated on a Likert scale as follows {1= Not Accepted, 2= I am not sure and 3= well mapped}, tabulated and a reliability test computed as summarised in Tables 3 and 4.

The results in Table 3 indicate a mean of (2.64) and std dev. (.633) on whether the framework concepts represent the real-world concepts, a mean of (2.64) and std dev. (.633) was also achieved on whether there was an accurate representation of the theories supporting the study, a mean of (2.71) and std dev. (.611) was realised on ease of use or application of the framework to the real world and a mean of (2.57) and std dev. (.756) on whether the framework was acceptable. The grand mean recorded is (2.64). If this is evaluated on a scale of 1-3, it follows that the acceptance score is over (70%) this is also supported by Cronbach's Alpha Coefficient. Scores were correlated and expressed as Pearson r, as in Table 4.

Table 4 reveals that A Cronbach's Alpha Coefficient of 0.921 was generated. [11] Notes that the tested device is deemed reliable if the Cronbach's Alpha Coefficient value is above (0.70). Nonetheless, lower thresholds are sometimes used in the literature. This method was used by correlating the attainments in one item and the attainments in other items in the same instrument [12].

In addition, a higher coefficient suggests that items correlate highly among themselves, and there is consistency among the items in measuring the concept of interest [12]. [13] notes that stable reliability is concerned with securing consistent results with repeated measurements on the same respondent and with the same instrument. The Cronbach's Alpha Coefficient of 0.921 was achieved on the framework test, which considers the framework reliable and acceptable for use.

5. Summary of the Findings

The finding discussed in this section was about the development process of ECNDF. It has looked at model constructs which are the parameters of interest in the framework construction, including network, connectivity and human characteristics. The constructs were derived through a factor analysis statistical process. In addition, the chapter presented the framework's architecture and looked at the choice of the framework and validation testing. The framework development (Enhancing Computer Network Dependability) was the main objective of this paper. The process was pursued using factor analysis (Principal Component Analysis), where the KMO Measure of Sampling Adequacy test and Bartlett's Test of Sphericity were tested and were (.803). Total Variance explained that principal component analysis was run, and the ECNDF framework was developed. The architecture of the framework has three (3) main constructs, i.e. network with a weighted score of (.1898), connectivity with a weighted score of (.4359) and Human Characteristics with a weighted score of (.3743). This indicates that to realise resilient and dependable network connectivity is key and needs to be addressed as the first element, followed by Human Characteristics and, finally, the network factors. The first and last factors involve hardware and software, while the Human characteristics involve liveware factors. The three factors interrelate as key constructs that define the architecture forming the purpose of this paper.

6. Conclusion

Computer networks are enablers for learning, teaching and work in universities. This study's examination of computer network resilience to enhance computer network dependability, particularly in the context of universities, greatly contributes to improved network life cycle management to make the user experience more trouble-free and improve productivity.

Recommendation

The study recommends further research in the following:

- Further studies be carried out to establish the efficacy and use of the network based on the core network attributes in non-education-based institutions.
- Further studies be carried out on the nature of network connection and the user attitudes in use and adoption.

References

[1] Terry Slattery, Network Redundancy or Resilience?, 2013. [Online]. Available: https://www.nojitter.com/network-redundancy-or-resilience

[2] Ilya Grigorik, *High Performance Browser Networking: What Every Web Developer Should Know about Networking and Web Performance*, O'Reilly Media, p. 400, 2013. [Google Scholar] [Publisher Link]

[3] Ilya Grigorik, Resilient Networking: Planning for Failure, 2015. [Online]. Available: https://www.igvita.com/2015/01/26/resilient-networking/

[4] Tech Donut Building a Network, 2017. [Online]. Available: https://www.techdonut.co.uk/communications/networks/building-a-network

[5] James P.G. Sterbenz et al., "Resilience and Survivability in Communication Networks: Strategies, Principles and Survey of Disciplines," *Computer Networks*, vol. 54, no. 8, pp. 1245-1265, 2010. [CrossRef] [Google Scholar] [Publisher Link]

[6] Ali Fessi, and Nils Kammenhuber, *Introduction to Network Resilience*, 2011. [Publisher Link]

[7] Government of Scotland, Resilience: Framework and Self-Assessment Tool, 2020. [Online]. Available: https://www.gov.scot/publications/cyber-resilience-framework/

[8] Vesa Kuikka, and Heikki Rantanen, "Resilience of Multi-Layer Communication Networks," *Sensors*, vol. 23, no. 1, p. 86, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[9] "Ministry of Information, Communication and Technology, Kenya," *National Information, Communications and Technology (ICT) Policy*, 2019. [Online]. Available: https://www.ict.go.ke/wp-content/uploads/2019/12/NATIONAL-ICT-POLICY-2019.pdf

[10] P Anselemo, "*Technical Factors and User Personality Characteristics as Indicators of Smart Phone Integration into Self-Directed Learning in University*," Research Thesis, MMUST, 2014. [Google Scholar] [Publisher Link]

[11] Jum Nunnally, and Ira Bernstein, *Psychometric Theory*, 3rd ed., New York: McGraw-Hill, vol. 19, no. 3, 1994. [CrossRef] [Publisher Link]

[12] Olive M. Mugenda, and Abel G. Mugenda, *Research Methods: Quantitative and Qualitative Approaches*, Nairobi: ACTS Press, 2012. [Publisher Link]

[13] C. R. Kothari, *Research Methods: Methods and Techniques*, 2nd ed., New Delhi, India: New Age International LTD, 2017. [Google Scholar] [Publisher Link]