Evaluating Mobility Management Models for Content Forwarding in Named Data Networking Environments

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Muhammed Zaharadeen Ahmed (✉), Aisha Hassan Abdalla Hashim, Othman. O. Khalifa
International Islamic University, Kuala Lumpur, Malaysia
khapress22@rediffmail.com

Abdulkadir H Alkali
University of Maiduguri, Maiduguri, Nigeria

Nur Shahida Bt Midi, Faridah Bt Abd. Rahman
International Islamic University, Kuala Lumpur, Malaysia

Abstract—Named Data Networking (NDN) performs its routing and forwarding decisions using name prefixes. This removes some of the issues affecting addresses in our traditional IP architecture such as limitation in address allocation and management, and even NAT translations etcetera. Another positivity of NDN is its ability to use the conventional routing like the link state and distance vector algorithm. In route announcement, NDN node broadcasts its name prefix which consists of the knowledge of the next communicating node. In this paper, we evaluate the performance of mobility management models used in forwarding NDN contents to a next hop. This makes it crucial to select an approach of mobility model that translates the nature of movement of the NDN mobile routers. A detailed analysis of the famous mobility model such as the Random Waypoint mobility and Constant Velocity were computed to determine the mobility rate of the NDN mobile router. Simulation analysis was carried out using ndnSIM 2.1 on Linux Version 16.1. we build and compile with modules and libraries in NS-3.29. The sample of movement of the mobile router is illustrated and our result present the viability of the Constant Velocity model as compared with the Random Way point.

Keywords—Named Data Networking, Prefix, Broadcast, ndnSIM, NS-3.29

1 Introduction

ICN is a platform whereby contents are recovered based on names in place of IP addresses. The platform is designed to offer seamless distribution of data in both infrastructure and infrastructure-less network. Between all the various architectures of ICN, the Named Data Networking provides the most promising solution on a network. The best features NDN offers are the independent or autonomous model of naming, multi-cast support and routing based on names[1][4] With the current Internet archi-

tecture, the massive rate at which IoT devices increase could not be handle only with IP architecture[4]. This makes researchers to think beyond the future and come up with an architecture for efficient dissemination of information. Based on performance, NDN has been seen to have the most of capabilities for data distribution in today's heterogeneous equipment/devices. However, mobility becomes a bottleneck in NDN despite all the improvements it could offer to heterogeneous networks. Besides, data objects is demanded or needed with no idea of its location. This challenge basically exist in heterogeneous network setups as a result of ever-increasing updates in computer technology. It is imperative for researchers to find means of improving location information. This paper will assess the reduction of time gap in forwarding content between preceding connections of the content to the point reachable to the acquired position of the content. The paper will also assess the pathway where a mobile heterogeneous device traverse to access its mobile producer in term of forwarding.

2 Literature Review

A research is carried out efficiently on Information Centric Networking to create a clear model of evaluating ICN by testing, making comparison and stating their advantages [1]. The document presents various research gaps such as showcasing the need to implement mobility, scalability, efficiency of network and to minimize complexity in NDN. The achievement in the paper involves pointing out security information, network availability and independence of consumer and producer location identification in forwarding NDN contents. However, the document presented a brief evaluation methods across scenarios such as network complexity. A research paper was conducted on "Making Name-Based Content Routing More Efficient than Link-State Routing". The paper investigates on a protocol known as Diffusive Name based Routing for ICN naming to have efficiency. The protocol can ensure loop less routes and maintain it as well by illustrating name prefix with a single information. The protocol also reduces the periodic forwarding updates in NDN, keeping records of the information of the topology, and keeping in cache the overall paths of named content. The paper presents a result of simulation which instantiates the protocols efficiency as compared to link state routing algorithm. However, the paper discourage link state routing but not mention all the reasons as future directions for research [2]. [3] Conducted a study on "Network Mobility in ICN". The study investigates how the trends concerning 5G networks and the rapid recognition of Internet of Things devices and the need for greater mobility support on information concentric network. The paper presents the process where ICN networks handles content with priority and the content transfer between routers according to their unique identity. A major contribution of the study was the proposal of NeMol which is a reliable and strong anchor based scheme of mobility. It main function is to implement and maintain a mobile network called the network-on-the move. The paper also shows the support ICN offers to consumer mobility and also expressing that there are ongoing research to improve more on producer mobility. However, a major challenge always remain as the paper did not analyses performance on producer mobility. A research on "Producer Mobility Sup-

port for Information Centric Networking Approaches" was conducted. The paper perform an analytical review to promote producer mobility on some of the various architectures of ICN by reviewing the basic features. The paper perform a task of comparing the mobility in ICN with respect to IP. The paper further noted out the open issues on content concentric networking and named data networking that could not promote mobility of content by the producer. Finally, the paper mentioned the techniques that ease content producer in various architecture to be employed for other architecture. However, the paper suggest more research work should be conducted to counter the issues arising on producer mobility and prepare to replace the current Internetwork with ICN as the future Internet [5]. [6] Research on "MobiNDN: A Mobility Support Architecture for NDN". The paper analyze the process involved in forwarding a protected data from preceding and to reaching another access point. Also, the analysis computes on how to ensure consistency in routing during handoff. Results presents the effective minimization of delay and packet transmission during handoff. However, the paper could not cover the addition of software define networking in their design. Forwarding mechanism is encouraged to be researched on to minimize the quantity of transmission of the interest packets in NDN.

Table 1. Summary of Literature Review

Author	Contribution	Results Obtained	Limitation
[1]	Create model of evaluating ICN by testing, making comparison and stating their advantages. Showcasing the need to implement mobility, forwarding, scalability, efficiency of network and to minimize complexity.	Coming up with a security information, network availability and independence of consumer and producer location when forwarding NDN contents.	Brief evaluation methods across scenarios such as network complexity.
[2]	An investigation on a protocol known as Diffusive Name-based Routing for NDN naming to have efficiency. Ensure loop less routes and maintain it by illustrating name prefix with a single information. Reduction of the periodic forwarding NDN updates, keeping records of the information of the topology, and keeping in cache the overall paths of named content.	The paper presents a result of simulation which instantiates the protocols efficiency as compared to link state routing algorithm.	However, the paper discouraged the use of link state routing protocol for NDN named-base routing
[3]	The introduction of NeMol which is a reliable and strong anchor based scheme of mobility. Support on how NDN offers to consumer mobility and also shows that there are works that ongoing on producer mobility.	An investigation on how the trends concerning 5G networks, the rapid recognition of Internet of Things devices and the need for greater mobility enhancement on ICN.	A major challenge always remain as the paper did not analyses more on producer mobility.
[5]	Conducted an analytical review to promote producer mobility and content forwarding on some of the various architectures of ICN such as NDN by reviewing the basic features. Mention out open issues on content concentric networking and named data	The paper perform a task of comparing the mobility in ICN with respect to IP. Mentioned the techniques that ease content producer in various architecture to be Employed for	Suggestion of more research work should be conducted to counter the issues arising on producer mobility and prepare to replace the current Internetwork with ICN as the

	networking that could no promote mobility of content by the producer.	other architecture.	future Internet
[6]	Analysis on the process involved in forwarding a protected data from a preceding to reaching access point. Analysis on how to ensure consistency in routing at handoff.	The effective minimization of delay and packet transmission during handoff.	However, the paper could not cover the addition of software define networking in their design. Forwarding mechanism is encouraged to be researched on to minimize the quantity of transmission of the interest packets in NDN.

2.1 Name based forwarding

Routing based on names in ICN is performed efficiently using a protocol known as the Diffusive Name-based Routing [2]. The protocol is more efficient when compared with the link state routing protocol. Diffusive Name-based Routing as a protocol locates a shortest route path to a closest name prefix. In an ICN network, every single data is a Named Data Object. The NDO symbolize a name prefix which is clear and readable. An anchor is a router node connected to a content producer which broadcast a name prefix. The protocol computes routes to the closest anchor which has an accurate name. If it finds the prefix name in during its computation, it picks a subclass of the connecting anchor as it correct next hop. This will ensure no loop in the forwarding table on each router.

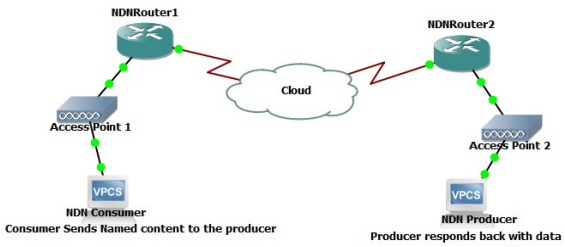

Fig. 1. Routing Based On Name

In figure 1 above, the scenario shows a typical network of an NDN communication. An NDN consumer sends an enquiry of a named content to an NDN producer on a different location. Under normal NDN scenario, the producer replies the enquiry in return with a data. Claiming a content by its name using name based routing relies on the name hierarchy with no resolution to forward an enquiry from a consumer and to producer [4].This require all routers to have each other's routing information. However, there will be a lot of topology information on the NDN network. In this design, it is realized that name based routing with the support of the Name Resolution system is absolutely capable of supporting producer mobility. This is because the producer frequently provide notice of its position change to the mobile consumer.

2.2 Routing and forwarding

NDN performs its routing and forwarding decisions using names. This removes some of the issues affecting addresses in our traditional IP architecture such as limitation in address allocation and management, and NAT translations. However, in ICN architecture particularly NDN, the challenge of address limitation is fixed because namespace is limitless. Also, NAT translation is removed because NDN does not use neither private nor public IP address. Another positivity of NDN is its ability to use the conventional routing like the link state and distance vector algorithm. In route announcement, NDN node broadcasts its name prefix which consists of the knowledge of the next communicating node. Then the routing protocol fully broadcast the initial announcement to various FIBs all over the network [17].NDN uses almost similar mode of routing and forwarding as in IP. Basically, the NDN router manipulates its routing table more efficiently as compared to the IP router [4]. The routing table of NDN is numbered with content names such that in the process of routing. In case of forwarding, the forwarding information base will give various destinations for one record as a result of its presence in the router buffer. Control plane in NDN's major task is to crowd the routing table such that topology information will be distributed. It also notice packet loss and try to fix it when network information changes as a result of mobility. Similarly, the Data plane has an indirect function because no computation is required by it. This is because the primary function of the data plane is to pass on the receiving enquiries to the appropriate path based on the records placed in the FIB. Routing protocol on a network is solely meant to distribute policy of how contents will exit and come in to interfaces of the network.

2.3 Named data networking mobility

Mobility in named data networking is categorized into consumer and producer mobility [4]. Names are ascribed hierarchically to data objects in named data networking. In ICN, consumers tender their bids to contents by distributing interest packets containing their names couple with the corresponding data objects. These distributed interest packet get routed according to names directly towards the content providers Forwarding Interest Base. Demand is gratified by a catch node (i.e a content producer) that uphold the most needed content in its Content Store [10]. The Data packet is later reverted to the consumer along with the copy given via the Interest packet in the Pending Interest Table.

Figure 2 shows how to forwarding is carried out between the consumer and a server connected to an NDN producer router. The customer initially send an Interest packet via a producer router to a yahoo server1. The server reply back with data to the customer. Similarly, a backup copy object content is available at a different location but have full access. This serves as the Multi homing interface for content availability for every time need of the NDN network.

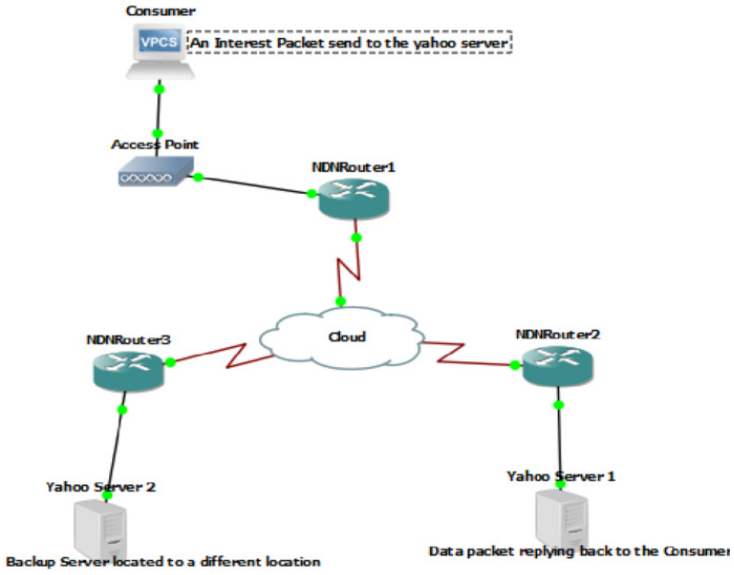

Fig. 2. NDN mobility architecture

Named Data Networking is a revolutionary scheme in ICN. It uses two manners of packets that are known as a Data packet and an Interest Packet. A packet sender in an ICN network is called a consumer. The consumer transmit an Interest packet to be served with a Data packet format. In a process of mobility, the Data and Interest packet must contain the accurate name of the enquired data object. In the process of mobility, each NDN router contains data structures such as content store (CS), Forwarding information Base (FIB) as well as Pending Interest Table (PIT). In an NDN router, the content store holds each incoming content by caching it temporarily [15]. The consumer must not stress the need to have the knowledge of the position of the requested content. However, the content may be position on its publisher server in the first place but in the process of mobility it will be required. By the time the data is cache, more request will be tendered for that similar interest and that will then be transmitted to the next connecting NDN router which has the copy already cached so as to ease the reply to the host consumer. Considering forwarding processes and lookup, NDN packet is more simplified as compared to the forwarding process in IP as can be deduced in the figure above [12]. When an Interest packet is received by an NDN router, the router runs lookup process from the content store for a single record that is relative to the enquired content. When the record is found then it will forward it to the accurate consumer as a data packet. If otherwise however, another lookup will be performed to verify if the content is located in the pending interest table [12][10].

2.4 Mobility for named data networking router

Node mobility in an NDN scenario promote network scalability. To achieve producer mobility, the network service provider prefix is transferred in a fresh forwarding code name on the interest packet. The data and Interest packets are identified using application name on the producer node. In the system of forwarding interest, nodes lookup data within the CS containing application name and afterwards perform another lookup on the PIT record containing another application name. On the contrary, if this process of mobility has not been achieved, the forwarding codename will be employed in the forwarding information base at a period where the interest is processed. The code name specified by the consumer device give router nodes information on where to move the interest packet as a destination. A practical scenario is when Umobile offers internetwork services for a particular enterprise skype. Umobile may advertise its forwarding codename /umobile to an exit autonomous system whereas skype is permitted to only advertise its forwarding codename /umobileskype to Umobile's home network [10]. A mobile producer that is situated within the skype network might advertise its name prefix in the local network of skype. This will make the router nodes to perform forwarding accurately.

3 Simulation Set-up

Simulation is carried out using ndnSIM 2.1 which consist of libraries in NS-3.29. This is to achieve a seamless forwarding strategy between the producer/subscriber to the consumer within an NDN network and another network. A number of 10 mobile routers is developed to be mobile within the scope of the forwarding zone. The simulation parameters taken are presented in a tabular form in the result section.

Forwarding is the act of relocating a content from one transmitting node to another. For forwarding to take place in a mobile routing situation, it must use an algorithmic state that is driven from a routing protocol and it will be conserved as a forwarding state known as the forwarding information Base (FIB) [7] In addition, it depends on the network management system to set up the nature of the FIB as well as the directions where contents will be forwarded. Forwarding in IP architecture is done by sending the packet to a neighbor destination using path with the lowest cost.

In this forwarding scheme for VANETs, content transmission between mobile vehicles is addressed using hop-by-hop forwarding scheme.This means that each mobile NDN node keeps its FIB details in two forms. These are the name prefix as well as the forwarding face. The NDN node then examine its FIB to locate the longest corresponding name prefix and transfer the interest to the matching face list to the next node. However, if there is a failed content interest, it will be stored in the node's Pending Interest Table. Immediately the data content arrived the next node, it will then revisit the PIT to verify if there are newer faces of the matching interest where data contents will be moved next. A spot light has to be set on the Mobile Router to achieve efficiency in forwarding. Various forms of mobility are based on crucial parameters that are associated with the Mobile Router. These are the initial location of

the mobile router, mobility paths of the mobile router, the speed interval (delay), variation in interval (delay variation) with respect to time.

The forwarding strategy in this paper involves assessing the pause interval between links where vehicle mobility and forwarding content takes place. We used the strategy to evaluate the performance using NS-3.29 having an updated library of ndnSIM 2.1. In addition, a direct stochastic model of evaluating performance has been more friendly to use while describing the mobility rate of the mobile router within the region of its node. However, the model is not fully adequate when evaluating high speed mobility of vehicles in VANET. In the contrary, Constant Velocity model of mobility management has an already builded library in the NS-3 simulator. Here, the mobile router maintain its initial speed and node path for the entire period of simulation of 100secs which can be illustrated below [18].

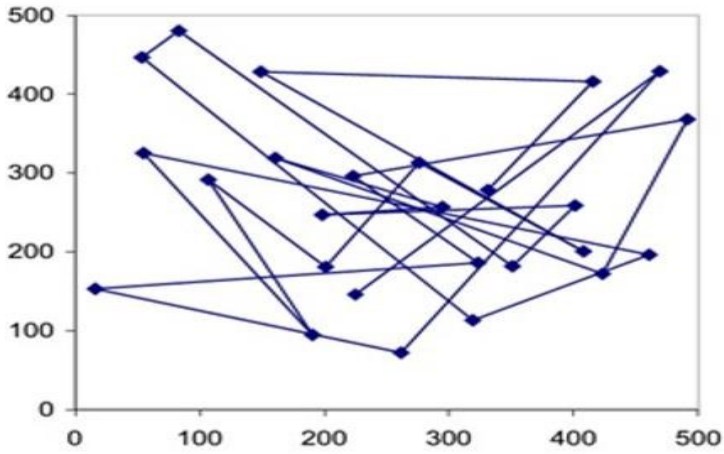

Fig. 3. Random Waypoint Approach of Mobility

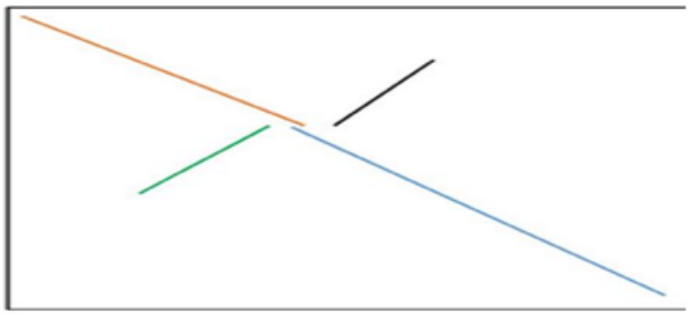

Fig. 4. Constant Velocity approach of Mobility

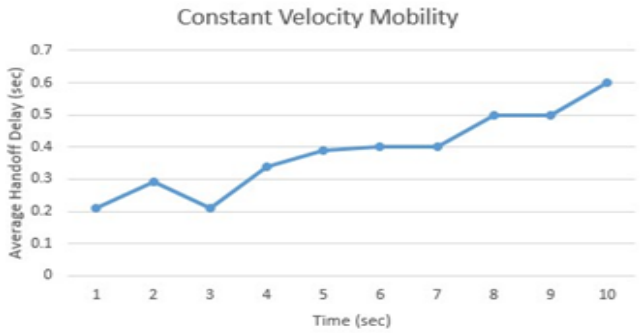

Fig. 5. Average Handoff delay against Time for Constant Velocity in NDN

4 Result Analysis

This simulation parameters that is considered in this paper is presented below as follows

Table 2. Simulation Information

Simulation Considerations	**Metrics**
Operating System	Ubuntu 16.
Simulator	ndnSIM (NS-3-based)
Simulation time	100sec
Correspondent nodes	2
Pause time	25milliseconds

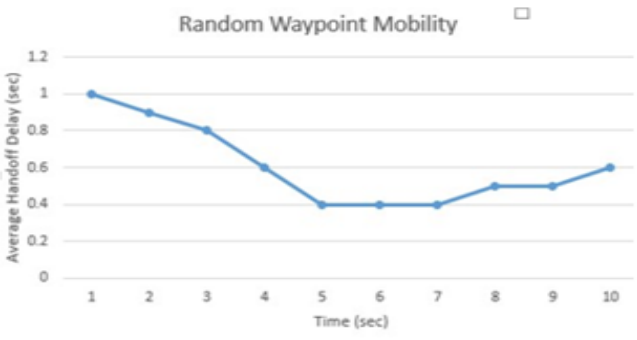

Fig. 6. Average handoff delay against time for random way point in NDN

The results obtained presents the effect of changing time based on the average handoff delay in forwarding NDN contents that is considered for the model of random way point as well as the constant velocity model of mobility. Based on the design, the speed of the mobile router is kept at 80 meter/seconds. Hence, the random way point and the constant velocity performance present almost similar trend of the handoff delay as it constantly decrease when the time (sec) is increased. This shows in NDN architecture that forwarding content based on constant velocity model offers impressive stability of the average handoff delay as compared to the random way point model of forwarding ndn content. At a point, the average handoff delay in constant velocity became minimal to about (0.02 secs) compared to the random way point of (0.4 sec) at different interval of time.

5 Conclusion

In this paper, the performance of mobility management scheme in forwarding NDN content is implemented based on random waypoint mobility and constant mobility model as our major parameters. Simulations scenarios were created by building and compiling NDN modules and libraries embedded in NS-3.29 edition. The results presents signaling prerequisites for the random waypoint and constant velocity differently. In addition, the results also depicts comparison of handoff delay in forwarding content based on NDN scheme vary much differently based on the considered model of mobility management schemes

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7 Authors

Muhammed Zaharadeen Ahmed received (Ph.D. in Engineering (In View), M.Sc. in Computer and Information Engineering and B.Eng. in Computer Engineering) from International Islamic University and University of Maiduguri.

Muhammed Zaharadeen Ahmed professional interests focus on Data Networking (Named Data) and my current research area is on content Mobility and published a few articles. In addition, Muhammed Zaharadeen Ahmed serves as a research Assistant for International Islamic University with my Research supervisor and mentor.

Aisha Hassan Abdalla Hashim Professor Aisha Hassan Abdalla Hashim received her PhD in Computer Engineering (2007), M.Sc. in Computer Science (1996), and B.Sc. in Electronics Engineering (1990). She won the best graduating PhD student Award during the IIUM Convocation ceremony in 2007. She joined IIUM in 1997 and currently working as a Professor at the Department of Electrical and Computer Engineering. Professor Aisha has taught several courses related to Communication and Computer Engineering. She is actively participating in curriculum development and program accreditation. She is a member of the Department Board of Studies for several years. She received Best Teacher Award by IIUM during the Quality Day in 2007. She has been appointed as external examiner/visiting professor/adjunct professor at different universities.

Professor Aisha is actively involved in research and postgraduate programs. She has published more than 300 journal/conference papers. She has supervised/co-supervised more than 50 PhD/Master students. She received

Promising Researcher Award in 2009 during IIUM Quality Day. She has also received many Medals/Awards in different national/international research exhibitions. One of her research exhibitions won Promising Commercial

Value Award (Second Runner Up) in IRIIE 2014. She has acquired several research grants from IIUM, Ministry of Higher Education (MOHE) and Ministry of Science, Technology and Innovation (MOSTI). She has actively contributed as a reviewer /technical committee member in many journals/conferences.

Professor Aisha is highly contributing to the University promotion. She established several teaching/ research networks between IIUM and overseas Universities. She is appointed as IIUM Internationalization Ambassadors in Sudan

(October 2014). She participated in initiating several MoUs as well as encouraging PhD Student Mobility program between IIUM and Sudanese Universities.

Othman Omran Khalifa is a Professor in the Kulliyyah of Engineering International Islamic University Malaysia, Gombak Campus. He held a Doctor of Philosophy in Electrical and Electronics Engineering, a Master of Science in Electronics Engineering and a Bachelor of Science in Electronic Engineering.

He held the position of the Head of Department in the Department of Electrical and Computer Engineering IIUM and received several awards and research grants.

Othman Omran Khalifa isinvolved in Teaching Responsibilities Which Includes Communication Engineering Lab Ii 2018/2019, Communication Engineering Lab IV 2008/2009, Communication Principles 2003/2004 2004/2005, Communication Principles (Lab) 2003/2004, Communications Lab 2002/2003 2006/2007 And Computer Graphics 2005/2006

Othman Omran Khalifa is supervising several PhD, Masters and Undergraduate students who have already completed and in progress. He has published more than 400 journal articles and book sections

Abdulkadir Hamidu Alkali received his PhD in Computer & Electronics Engineering (2015), M.Sc. in Computer and Network Engineering (2010), and B.Eng. in Electrical & Electronics Engineering (2003).

Engineering Research Prize (Maiden prize) for “undertaking challenging and progressive research or project which has had significant impact on society”, Sheffield

Hallam University, Sheffield, November 2014. Abdulkadir Hamidu Alkali also won NI Engineering Impact Award 2014, Finalist – Biomedical, to "honour engineers and scientist who, using graphical system design are addressing some of the most challenging engineering problems and improving the world around us" National Instruments UK & Ireland, London, November 2014. He also won 2 nd prize, 2013 MERI/BMRC winter poster award, Sheffield Hallam University, Sheffield, December 2013.

Abdulkadir Hamidu Alkali al so won Petroleum Technology Development Fund Overseas Scholarship award for PhD, 2011. Abdulkadir Hamidu Alkali joined Unimaid in 2007 and currently working as a Senior Lecturer at the Department of Computer Engineering. Abdulkadir Hamidu Alkali has taught several courses related to Communication and Computer Engineering. He is actively participating in curriculum development and program accreditation. He has been appointed as external examiner/visiting Senior Lecturer at different universities in Nigeria.

Abdulkadir Hamidu Alkali is actively involved in research and postgraduate programs. He has published several journal/conference papers. Abdulkadir Hamidu Alkali has acquired several research grants from IMAGINE Connectivity for multidisciplinary research at Sheffield Hallam University, For Thermal imaging developments for wrist fracture screening in children, January 2014. He also received the Petroleum Technology Development Fund PhD Overseas Scholarship Award, 2011. He has actively contributed as a reviewer/technical committee member in many journals/conferences.

Nur Shahida Binti Midi is anAssistant Professor who held a Doctor of Engineering (Science and Technology) - Doctor of Engineering, from Tokai University, Japan. She also has SIJIL TINGGI PELAJARAN (STPM) / SIJIL TINGGI AGAMA MALAYSIA (STAM), UniversitiIndustri Selangor and a Bachelor Degree, Tokai University.

NurShahidaBinti Midi isinvolved in teaching responsibilities which includes Computer and Information Eng. Lab II 2015/2016 2016/2017 2017/2018, Electrical and Computer Engineering Lab III 2017/2018 2018/2019, Electronics 2015/2016 2016/2017 Engineering Electromagnetic 2014/2015 2015/2016 2016/2017 2017/2018 2018/2019, Engineering Electromagnetics 2016/2017 2017/2018 2018/2019, Electrical and Computer Eng. LAB- Iii 2017/2018 2018/2019, Final Year Project I 2018/2019 and Introduction to Electrical Power Systems 2017/2018 2018/2019. She has published several journal/conference papers and has actively contributed as a reviewer/technical committee member in many journals/conferences.

Nur Shahida Binti Midi is involved in research projects such as Modeling Novel Maximum power point Tracking Algorithm for Small Scale Wind Turbine System2017 – Present and An Enhanced Modulated Predictive Control of AC/AC Converter for Wind Turbine to Reduce the Cost of Electricity2015 – Present

She also has a Book Section in Numerical calculation of current distribution due to spark discharge on water surface with surface potential as boundary condition. In: Proceedings of the School of Engineering/the School of Information Science and Technology of Tokai University The School of Engineering Tokai University , pp.1-6 2014.

Faridah Binti Abd. Rahman held a Doctor of Philosophy and is a lecturer in the department of Computer & Electronics Engineering International Islamic University. She is involved in teaching responsibilities which includes electric circuits 2016/2017, electrical engineering lab 2017/2018 2018/2019, programming for engineers 2017/2018 2018/2019, and project ii 2018/2019. She has published several journal/conference papers and has actively contributed as a reviewer/technical committee member in many journals/conferences.

Faridah Binti Abd. Rahman is involved in research projects such as Classification of Stress Level Using Deep Learning Algorithm Based on Electroencephalograph (EEG) Signals from 2018 – Present, Classification of Stress Level Using Deep Learning Algorithm Based on Electroencephalograph (EEG) Signals2018 – Present and Modelling of band bending profile of indium adsorbed Si(111) Surface2017 – Present.

Some of her few article Conference or Workshop Item include Discrimination of residual and recyclable household waste for automatic waste separation system. In: 2018 7th International Conference on Computer and Communication Engineering (ICCCE) and Comparison on performance of adaptive algorithms for eye blinks removal in electroencephalogram. In: International Conference on Computer and Communication Engineering (ICCCE) 2018

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