

GSJ: Volume 6, Issue 11, November 2018, Online: ISSN 2320-9186

www.globalscientificjournal.com

ENTITY PARAMETERS AND COMP TECHNOLOGY TO INCREASE NUMBER OF SERVED USERS IN COGNITIVE RADIO NETWORKS

¹Jinadu O.T.(yimikajinad@gmail.com); ²Ijawoye O.R.(progressiveijawoye@gmail.com) ³Ijarotimi O.(ijarotimiolumide1@gmail.com); ⁴Owa V.K.(vkorede.owa@gmail.com) ⁵Akinboyewa N.E.(nelsonboye@yahoo.com)

^{1,4}Dept of Computer Science, Rufus Giwa Polytechnic, Owo, Nigeria

^{2,3}Dept of Electrical Electronics Engineering Technology, Rufus Giwa Polytechnic, Owo, Nigeria ⁵Dept of Computer Engineering Technology, Rufus Giwa Polytechnic, Owo, Nigeria

ABSTRACT

Reconfigurable infrastructure has ability to communicate more than one pattern at different frequencies and polarizations. Supporting QoS requirements of multimedia applications over ordinary network is a difficult task not easily achieved where availability to spectrum is not always guaranteed. Also, costly bandwidth resource remains a limiting factor and adoption of cognitive wireless system became expedient. Aim is to specify parameters for learning and adaptation for modulation and routing techniques for efficient reconfiguration. To flexibly access Internet for more profitability, ICT application deployment on campus require entities presented in the reconfigurable infrastructure. These includes Base Stations (BTSs), Access Points (APs), mobile devices, wireless network controllers and geolocation database. Channel state information use by the backbones support mobility and connection management via cloud-based modules. BTS and AP duo deliver co-operative multiple input multiple output (co-MIMO) technology and the system matches modulation, coding, radiation, signal propagation and routing protocol to offer adaptation based on user needs and not radio link availability. Cognitive Radio (CR) networking provides real-time connection to multiple Radio Access Technologies (RATs) reliably signifying bandwidth extension. Adaptive 'beamform' implement signal maximization and interference minimization to provide for seamless roaming, intelligent transport, flexible access and integration with Wi-Fi interface. Tangible economic benefits of CR and co-MIMO techniques offer spatial structural advantage of wireless propagation and improved bit error rate for higher throughputs. Co-operating MultiPoint (CoMP) technology is implemented for multiplied link capacity and enhanced link adaptation.

Keywords – adaptation, beamform, channel, co-operative, protocol, radio-link, signal

1.0 **INTRODUCTION**

Reconfigurable infrastructure has ability to communicate more than one pattern at different frequencies and polarizations. CR and co-MIMO techniques offer co-operating multi-point (CoMP) architectural technology to facilitate learning necessary for efficient adaptation. A paradigm change in mobile communication enables transition from ordinary radios to multi-user radio systems such as co-operative multiple input multiple output (Co-MIMO) and intelligent (cognitive) radio. Multi User-MIMO is specified in Akyildiz et al (2006), cognitive radio systems specify new spectrum allocation policy, which allow unlicensed users (secondary users) access radio spectrum when it is not occupied by licensed users (primary users).

Adaptive beamforming is the signal processing technique used to automatically adapt response to different situations based on set criterion, achievable in receiving or transmitting entities in wireless communications (Golbon-Haghighi, 2016). Adaptive modulation capability of CR is a promising area of development when combined with multiple- input-multiple-output (MIMO) systems because the beamforming techniques used in cellular/air standards have advanced through the generations to produce high throughput network standards. Technically, an implementation of matching modulation, coding, radiation, signal propagation and protocol parameters to condition available at radio link is described as link adaptation (Wikipedia, 2018).

The key feature of reconfigurable infrastructure is cognition (Bicen, 2012). Embedded in CR transceivers, awareness of radio environment (spectrum usage, power spectral density of transmitted or received signals, wireless protocol signaling) and intelligence is achieved through learning implemented on radio operating parameters. Increasing number of mobile devices (MDs) with MIMO capability supports beamforming to boost data communication rates. With IEEE 802.11ac and 802.11af network standards, high throughput in WLANs is guaranteed on 5GHz and 11GHz respectively (IEEE WG, 2013).

As defined in Haykin (2007) and revised in Bhargava and Hossain (2007), cognition is extra information CR nodes have about their wireless environment. It is side information for providing information theoretic limits of communication. In simpler terms, cognition procedure includes perception, memory, reasoning and judgment (decision). It utilizes learning concept to effect required adaptations for dynamic spectrum access (Benmammar, 2013). Discussing routing stability as a major factor for link availability where bit error rate (BER) performance metric remains unaffected especially with derived protocols, dynamic routing scheme is used more efficiently in cognitive environments (Jinadu and Ijawoye, 2016).

1.1 MOTIVATION FOR THE RESEARCH

Reconfigurable infrastructure is a cognitive radio system and its components include a fully decentralized architectural-based entity management module (spectrum control plane) and autonomous centralized pooled components. The infrastructure exploits cognition and reconfigurability technologies to enable flexible accommodation of the increasing amount of services and applications of all existing wireless networks. Therefore, an adaptive tuning parameters for the operating parameters (transmit power, carrier frequency, and modulation (at physical layer) and higher-layer (routing) protocol parameters essential for cognition and desired adaptation needs to be specified.

Also, as real-time changes in these operating parameters enable transmission adjustment to user needs and network requirements (Mauri *et al.*, 2014), minimal interference and maximal signal usage must be sustained with evaluated metrics envisaged for multiplied link capacity.

1.2 OBJECTIVES OF THE RESEARCH

Aim of the research is to deploy a wireless infrastructure, which implements co-ordinated multipoint technique to facilitate cognitive networking. CR receiver or transmitter will target IEEE 802.22 standard to adapt application requirements and extend the capability of BTSs and resource allocation APs. To achieve this, the research objectives include:

- (i) specification of receiver parameters to demonstrate adaptive modulation;
- (ii) develop algorithms to improve performance and
- (iii) devise strategy to extend bandwidth and achieve 'multiplied link' (spectra efficiency accommodating more users.

2.0 PROBLEM ANALYSIS AND MOTIVATION FOR RESEARCH

The IEEE 802.22 standard aimed first at commercial deployment of Cognitive Radio over US regions. MIMO radio receiver as an essential element in communication includes IEEE.802.11n (Wi-Fi); IEEE 802.11ac (Wi-Fi); IEEE 802.11af (White-Fi); HSPA+ (High Speed Packet Access 3G), Worldwide Interoperability for Multiple Access WiMAX (4G) and Long Term Evolution (LTE 4G) (Amira, Ayadi, Kammoun and Loulou, 2011). Co-MIMO is an advanced technology, which effectively exploits spatial diversity over mobile fading channels to reduce co-channel interference but CR characteristic features of WiMAX technology mitigates signal interference. MIMO exploits multipath propagation to multiply link capacity. Extendable to CR, OFDMA and WiMAX standards, MIMO, Orthogonal Multiple Division Multiplexing (OFDM), Direct Sequence Spread Spectrum (DSSS) and Frequency Hoping Spread Spectrum (FHSS) modulation techniques are supported in cognitive radio systems. Specified in Wang, Ghosh and Challapali (2012), OFDM enables and supports dynamic spectrum access (DSA) techniques.

With cognition and reconfiguration technology, CR flexibly avoid the 'limited spectrum' bottleneck assumption of hardware designers. With Cognitive radio techniques, each radio measures the spectrum in use and communicates that information to other cooperating radios, so that transmitters can avoid mutual interference by selecting unused frequencies only (Mao, 2010). Alternatively, each radio connects to a geolocation database to obtain information about spectrum occupancy, other user location and flexibly adjusting the operating frequency and transmit power while avoiding interference with other wireless services. This is enabled by adaptive modulation. CR systems' feature of centralized-pooling and distributed (but collaborative) control management architectures achieve resource maximization. Interoperability capability is also used to integrate existing communication standards. Properly facilitated, associated frequency bands handling different transmission formats would be supported to deliver improved radio link services (Sauter, 2010) and (Kumar and Joseph, 2012).

One important characteristics of 802.22 WRAN consists on its BTS coverage range that is capable of reaching 100 Km when power is not a dominant factor. This coverage is favourably exploited in extended bandwidth offer and plans of effective cognition is therefore necessary to exploit entities' performance while achieving targeting effectual reconfiguration capability for link multiplication. Hence, system level parameters associated with the operating entities, the behavior of the entire system with respect to adaptation requirement for performance is evaluated and considered in this research.

3.0 MODEL ARCHITECTURE: COGNITIVE NETWORK LAYERS

Cognitive network is based on four CR-specific functions (spectrum sensing, spectrum allocation, spectrum sharing and spectrum mobility) in addition to the main functions of coding/decoding, modulation/demodulation, routing etc. To actualize dynamic spectrum access (DSA) through which frequency spectrum is shared among primary users and secondary (CR) users in a dynamically changing radio environment, operating parameters of MD moving from one zone to another needs to be monitored. MDs interfaces with different APs (different channels) as depicted in fig. 1a. The architectural layers in CRN is also shown in fig. 1b to consist of enabled cloud-based management modules, where a radio entity receives packet from IP layer and handles it as input at the physical-wireless medium.

Each MD transmits and/or receives while enabling dynamic changes to its *modulation scheme*, *frequency channel (bandwidth)*, *data rate (bit rate)* and *transmit power* at the PHY radio level. Each MD is equipped with multiple RATs. The radio parameters, which are the decision variables for switching the model for reconfiguration are optimized in collaborative sensing techniques. While implementing the co-operating multi-point (CoMP) techniques, the model exploits the CR and co-operative MIMO capabilities of all backbone infrastructures (BTS and AP). Resources of each MDs can be pooled into a centralized architecture, and centrally coordinated to function to deliver continuous service while the MD transits form one region (zone) to another. Also, each MD is capable of decentral reconfiguration capability to offer seamless communication services.



Fig. 1a Cognitive system entities enabling CoMP techniques



Fig. 1b. Conceptualized cognitive network layers

4.0 ADAPTATION TECHNIQUES USING CoMP AND CSI

Since cognitive receiver receives all frequencies sent by the transmitter, scanning the radio environment for channel state information (CSI) enable each MD find transmitter for certain amount of time, after which it switches to another channel (if it has not received any packet during the time of dwelling on channel 1). Reflecting on the frequency operational range that evidently increased to drastically reduce dropped packets, re-transmission of error packets is accommodated as SU presence on allocated channel is detected. Each radio or transmitter entities 1, 2, ..., n adapts the radio environment dynamically to offer access flexibly and autonomously. On the contrary, each receiver counterpart, the cognitive transmitter (APs) receives information by changing its frequency of reception while keeping on receiving samples from BTSs. Every time a cognitive transmitter changes band, the cognitive receiver adjusts its parameters to adapt modulation selected by the transmitter, thereby making the bandwidth to be technically altered.

The algorithm used by each cognitive receiver to detect CSI includes:

(i) Start

(ii) cognitive receiver dwell and scan channel

(iii) cognitive transmitter detected?

(iv) If No, cognitive transmitter should change channel; if Yes, Go Back to step (ii)

(5) Stop

With cognitive receivers' awareness of frequencies used by cognitive transmitters, scanning and dwelling on selected channel(s) to find transmitter is effected by cognition. Dwelling on say channel 1 for certain amount of time and packet is not received within that time signifies the Time-To-Live (TTL) reduction to zero. Therefore, with TTL = 0, cognitive receiver switches to another channel 2 and on reception of at least one packet from any of the cognitive transmitter(s) during that time make the receiver stay on that channel 2 for transmission in another transmission cycle. This means the idle band of channel 2 is exploited. This is the technique of co-operative scanning employed by CoMP to signify CR collaboratively detecting idle bands using the combined effort of all co-operating MIMO entities (Jinadu and Ijawoye, 2016).

Simulated results obtained using NS2 while adopting various protocols are shown in Table 1. Default Destination/distance based vectors (DSDV), Ad-hoc Online Multi-Distance vector (AOMDV) and Zone-based ZBR algorithms were used and evaluated. An extension of bandwidth

for reception was evidently noticed as the throughput measured remain stabilized for all MD locations within the simulation area when ZBR and AOMDV was implemented. Measurements obtained is recorded as shown in Table 1 while the performance of implemented protocols is compared in fig. 3.

Also, the effect of each protocol on signal maximization was measured to denote an increased number of served users. In the same vein, inter signal or inter channel interferences (isi and ici) minimization was recorded to be moderate with ZBR and AODMV as movement does not inhibit required adaptations. This signify more reliable communication with derived routing formula, which implements dynamically than the static mode as shown in Table 2.

| Distance moved by MN (m) | Packet Received (Throughput in Kbps) | | |
|--------------------------|--------------------------------------|------|-----|
| | AOMDV | DSDV | ZBR |
| 150 | 200 | 215 | 195 |
| 230 | 228 | 235 | 218 |
| 367 | 325 | 338 | 236 |
| 430 | 356 | 368 | 268 |
| 485 | 448 | 370 | 215 |
| 550 | 485 | 393 | 305 |

Table 1: Throughput of receiving 2MB packet by approximation

Table 2: Evaluation of routing metrics in service delivery

| Effects produced | Signal maximisation | End to End QoS | Interference Minimization |
|------------------|---------------------|----------------|------------------------------|
| | | | |
| AODMV | Moderate | Highest | Highest |
| DSDV | Poorest | Moderate | Moderate |
| ZBR | Highest | Poorest | Lowest |
| | | | |



Fig. 3 Comparing throughput with the different protocols used

4.0 **DISCUSSION AND EVALUATIONS**

Conceptually, WRAN BTSs, APs and MDs as transmitters/receivers respectively show performances indicating the cross-layer effects of IEEE 802.22 standards. The simulation revealed an insignificant BER as transmit power remain unaltered when MDs move around. Notably, in the download link usage, packet loss was insignificant as MDs move around. This is attributed to the backbone location either within the zone of transmission. Adopting, energy detection spectrum sensing technique to initiate cognition, CR transmitter is enabled to distinguish used and unused spectrum bands as shown in equation 1.

$$r(t) = \begin{cases} n(t) & H_0 \\ hx(t) + n(t) & H_1 \end{cases}$$
(1)

where r(t) is received signal, x(t) the transmitted signal of PU while n(t) is Additive White Gaussian Noise (AWGN) for h amplitude gain of channel. Designating n(t) and hx(t)+n(t) respectively as null H_0 and alternate H_1 hypothesis of transmitter detected license user signal existence and non-existence, permissible transmit power of allocated spectrum is given in equation 2.

$$C = B \log\left(1 + \frac{S}{N+1}\right) \tag{2}$$

where B is the bandwidth of allocated spectrum, S the received signal power on channel C and N and I respectively the noise and interference experienced at receiving node.

Adopting energy detection technique in CRN, equation 3 feature optimal detector to distinguish used and unused spectrum using sufficient information on PU power and random Gaussian noise known at receiver. Measuring received signal energy, output signal of band pass filter (bandwidth B) is squared and integrated over the observation interval T used by primary transmitter.

With an integrator output expressed as $\frac{1}{T_U} \int_0^{T_U} r(t) \cdot e^{-j2\Pi k\Delta f t} dt$, pooled spectrum received at

destination node becomes

$$\frac{1}{T_U} \int_{0}^{T_U} \left(\sum_{q=0}^{N_c - 1} a_q \cdot e^{j2\Pi_q \Delta ft} \right) \cdot e^{-j2\Pi k \Delta ft} dt$$
(3)

for transmitted packets arriving exponentially at each receiving node, guided by orthogonal principle defined in equation 3.1. A general expression of harmonic exponential function satisfying orthogonal principle is also given in 3.6 for frequency separation of $\Delta f = \frac{1}{T_{u}}$.

$$\sum_{q=0}^{N_c-1} \frac{a_q}{T_U} \int_{0}^{T_U} e^{2j\Pi(q-k)\frac{1}{T_U}t} dt = \begin{cases} a_k, k=q\\ 0, k \neq q \end{cases}$$
(4)

This is another proof of possibility of sub-carrier separation at receiver, which further suggested an optimal use of pooled spectrum in CRN and coexistence of primary and secondary users in collaborations (Akyildiz, Lee, Vuran and Mohanty, 2006).

4.1 **JUSTIFICATION**

Adaptive beamforming implements phased array with signal maximization mode and interference minimization modes. Using the CSI at the transmitters, adaptation occurs and this knowledge can also be measured directly at each receiver and shared among the neighbours, which are the BTSs engaged in the defined CoMP technology. A spatial advantage of wireless propagation defined in Guowang and Guocong (2014) is established. IEEE 802.22 PHY layer needs and high modulation offer of flexible coding is achieved with multi-cell evaluation of a large-scale deployment of CR and Co-MIMO technologies. Shown in fig. 1, different MDs located at various distances from their associated BTSs conduces to reduced Signal-to-Noise Ratio (SNR) qualities as the BTSs alter dynamically measured bandwidth range, the modulation and coding schemes whilst communicating via different mode of MDs (operating on different channels).

Orthogonal Frequency Division Multiple Access (OFDMA) is promised as efficient allocation of sub-carriers are able to convene MDs constraints. Throughput of about 94kbps was measured download packet rate in WRAN transmission rate of 100kbps. High throughput offer with AOMDV and ZBR offer required reliability than ordinary WLAN (Apurva, 2013). Also, WiMAX standard implementation in CRT and rate adaptation algorithm was established. Coding scheme adjustment to radio channel quality for stabilized data rate required for robust transmission and QoS was established (Shami, 2010).

CONCLUSION

The dependence of performance objective of cognitive networks on operating parameters is discussed in Chen and Wyglinski (2009). Link adaptation technique as a dynamic process is effected via changes in signal and protocol parameters. By standard, this changes occur in Universal Mobile Telecommunication Systems (UMTS) HSDPA typically every 2milliseconds.

CoMP technology exploits centralized spectrum pooling architecture while engaging in SUs' collaborative channel scanning to offer required changes. Distributed architecture and autonomic processing of cognitive information (CSI) offered efficient adaptation techniques to support multiple antenna structure of MIMO. Reconfiguration capability of CR enhanced the developed model with multi-path propagation and adaptively co-operating MultiPoint techniques.

Mobile relay characteristic feature of CR therefore offers more flexibility to accommodate varying traffic patterns while adapting the different propagation environment of wireless networks (Berger, 2014). The virtual antenna array characteristics feature of co-MIMO *beam form* both transmitters and receivers to enhance spatial selectivity. Reliability of multi-user multi-point connection for efficient service delivery is guaranteed/evaluated with CoMP technology. With CR and Co-MIMO techniques combined, spectra efficiency, spatial diversity and reduced co-channel interference (ici) is eliminated via flexible cognition and reconfiguration techniques, which are embedded in CoMP (DaSilva, 2012 and Jain, 2013).

Finally, CoMP technology implemented to offer multiplied link capacity because signal maximization signifies an extension of bandwidth for communication channel while interference minimization signifies reduced co-channel interferences. A resultant increase in spectral usage evidently increases the number of served users. This additional gain is also attributed to energy saving in agreement with Kumar and Joseph (2012). More concern is therefore required on the various strategies to achieve stability using either static or dynamic routing techniques in future.

REFERENCES

- Akyildiz I.F., Lee W.Y., Vuran M.C., and Mohanty S. (2006), Next generation/dynamic spectrum access/cognitive radio wireless networks: a survey, *Computer Networks Journal (Elsevier)* 50 (13):2127-2159.
- Amira R.B, Ayadi D. Kammoun I. and Loulou M.(2011). System level design for a cognitive radio receiver – application for IEEE 802.22 standard. *Electrical and Electronics Group, LETI Laboratory, Sfax, Tunisia.* 1-10.
- Apurva N.M.(2015). Wireless regional area networks (WRAN). *Wireless Networking Standard*. Accessed 24/11/2016 from <u>www.ieee802.org/22/.</u>
- Benmammar B. Amraoui A. Krief F.(2013). A survey on dynamic spectrum access techniques in cognitive radio networks. *International Journal of Communication Networks and Information Security (IJCNIS)*. 5(2):68-79.
- Berger L.T., Schwager A., Pagani P. Schneider D.M.(2014). Mimo powerline communications: narrow and broadband standards, emc and advanced processing. *Devices, circuits and systems*. CRC Press
- Bicen A.O. (2012). Investigating adaptive transport protocols for cognitive radio networks. *Next Generation Wireless Communication Laboratory (NWCL),* Istanbul, Turkey (unpublished).
- Chen S. and Wyglinski A.M.(2009). Efficient spectrum utilization via cross-layer optimization in distributed cognitive radio networks. *Computer Communications*, Elsevier, vol 32 Issue 18, pp 1931–1943.
- DaSilva L. (2012), Cognitive networks: theory and practice of cognitive radios, *Aalborg University*, *VirginiaTech*. May 9-11, 2012.
- Golbon-Haghighi M.H. (20160. Beamforming in wireless networks. In Tech Open pp 163-199. Doi:10.5772166.399.
- Guowang M. and Guocong S. (2014). Energy and spectrum efficient wireless network design. Ambridge University Press.
- Haykin S.(2007). Fundamental issues in cognitive radio. In Cognitive Wireless Communications Networks, edited by Bhargava V. and Hossain E, Springer, 2007, 1-18.
- IEEE802.11 WG (2013). IEEE 802.11AF DRAFT 5.0, amendment 5: TV white space operation.
- IEEE802.22 WG (2015). WRANs (Wireless Regional Area Networks) Standards. Accessed 25/11/2015 from http://www.ieee802.org/22/.
- Jain R. (2013) Introduction to software defined networking. Accessed 20/7/2014 from https://www.cse,wustl.edu/.
- Jinadu O.T. and Ijawoye R.A.(2016). Design specification for reconfigurable radio in cognitive communication. *International Journal of Software & Hardware Research in Engineering (IJSHRE), May, 2016.* 4(5):61-68.
- Kumar P.N. and Joseph N. (2012). Power consumption reduction in a SDR based wireless communication system using partial reconfigurable FGPA. *International Journal of VLSI Design & Communication Systems (VLSICS)* 3(2):203-210, April 2012.
- Mao S. (2010). Fundamentals of Communication Networks. *Cognitive Radio Communications and Networks*. pp. 201–234.
- Mauri J.L., Ghafoor K.Z., Rawat D.B., Samuel J. and Perez A. (2014), *Cognitive Networks: Application and Deployments*. Technology and Engineering Google Books, 1st ed. CRC Press Amazon.
- Sauter M.(2010). From gsm to lte: an introduction to mobile networks and mobile broadband. (https://books.goggle.com John Wiley & Sons Inc. p. 177.

- Shami A., Maier M. and Assi C.(2010). Broadband access networks: technologies and deployments. (https://books.goggle.com) Springer Science & Business Media. p.100.
- Wang J., Ghosh M. and Challapali K. (2012). Emerging cognitive radio application: a survey. *IEEE Personal Communications*. Special Issue.
- WiMax Forum (2015). Accessed 15/12/2015 from http://www.wimaxforum.org; WiMax. White papers downloaded from http://www.wimaxforum.org/technology/White-Papers/

Yadav P., Chatterjee S. and Bhattacharya P.(2012). A survey on dynamic spectrum access techniques in cognitive radio. *International Journal of Next-Generation Networks*, 4(4): 27-46
 Wikipedia (2018). Wikipedia available on https:en.wikipedia/wiki/.org retrieved 24 April, 2018.

ABOUT THE AUTHORS

¹Jinadu O.T. works with the Department of Computer Science in Rufus Giwa Polytechnic, Owo, Nigeria. She earned PhD degree in Computer Science from the Federal University of Technology, Akure, Nigeria and had published several papers in computer architecture, artificial intelligence and software defined networking. Her current research area is on data communication in cognitive radio wireless networks. She is a member of CPN (Nigeria) and IAENG (UK) Professional bodies.

²Ijawoye is with the Department of Electrical Electronics Engineering Technology in Rufus Giwa Polytechnic, Owo, Nigeria. He had M.SC in Electronic Communication & Computer Engineering from University of Nottingham, UK. He had published papers on power control and communication engineering. Currently, his research is on mobile communication. He is a member of Institute of Electrical Electronics Engineer (IEEE).

³Ijarotimi O. is with the Department of Electrical Electronics Engineering Technology in Rufus Giwa Polytechnic, Owo, Nigeria. He had M.SC in Electronic Communication & Computer Engineering from University of Nottingham, UK. He had published papers on power control and communication engineering. Currently, his research is on mobile communication. He is a member of Institute of Electrical Electronics Engineer (IEEE).

⁴Owa V.K. is with the Department of Computer Science in Rufus Giwa Polytechnic, Owo, Nigeria. He had B.Sc. in Electrical and Electronic Engineering and M.Sc. in Computer Science from the Federal University of Technology, Akure, Nigeria. He had published papers on hardware maintenance. Currently, his research is on construction of antenna. He is a member of Institute of Electrical Electronics Engineer (IEEE).

⁵Akinboyewa N.E. works with the Department Computer Engineering in Rufus Giwa Polytechnic, Owo, Nigeria. He had M.Sc. in Communication Engineering. He had published papers on system engineering. Currently, his research is Internet applications. He is a member of CPN (Nigeria).

ACKNOWLEDGEMENT

Special thanks to the Tertiary Education Fund (TETFund) of Federal Republic of Nigeria for providing support for this research and the Polytechnic community for providing an enabling environment to carry out research in diverse fields of study.