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## **Research Cluster**

Communications Engineering Department has 27 full-time staff members specialized in 4 areas of Research. The Research clusters in the Department are:

- Digital Signal Processing
- Electromagnetics and Antenna systems
- Electronics and Microcontrollers
- New Generation Technologies and Internet Of Everything (IOE or IOT)

In addition, there is also a number of experience Engineers and Technicians who maintain the different Research Laboratories in the Department.

**Completed Research Works**

**(2012-2019)**

**Name:** Samira Abdulhamid Lawal

**Matric Number:** M.Sc./ENG/3928/2011-2012

**Dissertation Title:** Development of an Artificial Fish Swarm Algorithm Based Energy Efficient Target Tracking Scheme in Wireless Sensor Networks

### **ABSTRACT**

Optimal deployment of sensor node in other to ensure optimum network coverage is one of the challenging problems faced by Wireless Sensor Network (WSN) researchers due to the complexity and exhaustive nature of WSN. Target tracking problem is concerned with maximizing the lifetime of the network while continuously monitoring a set of targets. This dissertation presents an optimal deployment of WSN and target tracking scheme using the intelligent swarming behaviors of Artificial Fish Swarm Algorithm (AFSA). The preying, swarming and chasing behaviors of AFSA were initially replicated using MATLAB R2013b simulation environment. The position of network nodes was randomly deployed in a network coverage area of 60 square meters with a total of 60 sensor nodes of 4m radius and communication range of 15m using the replicated AFSA algorithm. Thereafter, the replicated AFSA was used to detect event based on target discovery probability model. A series of simulation was performed, and results showed that the proposed technique can attain maximum network coverage of 77.87% when the number of iterations was 25 after which it kept an almost constant value for the rest of the simulation process. The relationship between network coverage and number of mobile nodes also showed that network coverage increased with increase in mobile nodes. The approach indicated maximum network coverage of 80.07% when the mobile node was 50. Thereafter, it tended towards stability when the number of network nodes was above 50. Effects of various attenuation factors on the proposed model were evaluated and

simulation results show that the proposed method successfully attains maximum network coverage of 70.58%, 70.99%, 72.69% and 77.15% when the attenuation factors are 0.75, 0.8, 0.85 and 0.90 respectively. Target tracking simulation scenarios were presented and results showed that the computation energy required to successfully track 30, 45 and 60 targets were 21.63%, 28.003% and 36.99% less than the energy (time taking) required to track the 15 targets respectively.

**Name:** Risikat Folashade Onundi

**Matric Number:** M.Sc/ENG/25654/2012-2013

**Dissertation Title:** Development of Traffic Light Controller Model Using Artificial Bee Colony Based Adaptive Dynamic Scheduling Algorithm

### **ABSTRACT**

An Adaptive Dynamic Scheduling Algorithm (ADSA) based on Artificial Bee Colony (ABC) was developed for vehicular traffic control. The developed model optimally schedules green light timing in accordance with traffic condition in order to minimize the Average Waiting Time (AWT) at the cross intersection. A MATLAB based Graphic User Interface (GUI) traffic control simulator was developed. Three scenarios of vehicular traffic control were simulated and the results presented results shows that scenario one and two demonstrated the variation of the AWT and performance of the developed algorithm with changes in the maximum allowable green light timing over the simulation interval. In the third scenario, an AWT of 38 secs was recorded against a maximum allowable green light duration of 120 secs, during which 1382 vehicles were evacuated from the intersection, leaving 22 vehicles behind. The algorithm also had a performance of 98.43% over a simulation duration of 1800 secs. In order to demonstrate the effectiveness of the developed ADSA this research was validated with the literature. The result obtained for the AWT of the developed ADSA had a performance of 76.67%. While, for vehicular queues cleared at the

intersection the developed ADSA had a performance of 53.33%. The results clearly expressed that the developed ADSA method has been successful in minimizing the Average Waiting Time and vehicular queues at intersection.

**Name:** Mohammed Faruk Munkailu

**Matric Number:** M.Sc./ENG/28294/2012-2013

**Dissertation Title:** Development of a Constrained Radio Frequency Identification Reader Deployment Algorithm to Achieve Optimal Network Topology Design

### **ABSTRACT**

The major challenge in most Radio Frequency Identification (RFID) network planning is the effective utilization of multiple RFID readers to achieve a reliable network, while minimizing power consumption and cost of deployment. In this work, a constrained Optimal Radio Frequency Identification Network Topology Design Algorithm (ORNTDA) was developed through the logical integration of a set of sub-algorithms involving Tag Placement (TP); Reader Initial Population Deployment (RIPD); Useless Reader Detection and Elimination (URDE) and Redundant Reader Elimination (RRE). Approaches A, B, and C were developed for RIPD. A MATLAB based Graphic User Interface (GUI) based on the ORNTDA for optimal reader deployment simulation was also developed. The performance of the three approaches in terms of Optimal Number of Readers (ONR) and Optimal Power Dissipated (OPD) was demonstrated through simulation. Five cases of reader deployment problems were considered in order to study the effect of the variation of some of the topology design parameters with changes in other parameters. The developed Optimal RFID Network Topology Design Algorithm was observed to perform well in all cases. In view of 0.35 seconds convergence time of approach B, ORNTDA could be integrated into real-time systems that have mobile readers. The developed ORNTD



models and algorithms were validated with a standard RFID Network Planning (RNP) benchmark tag topologies of C30, C50, C100, R30, R50 and R100 as presented in Yue-jiao *et al.*, (2015). ORNTDA improved the OPD of Von Neumann Particle Swarm Optimization RFID Network Planning (VNPSO-RNP) by 45.65%, 14.23%, 5.34%, 17.16%, 6.21%, and 2.4%, respectively for the six topologies. However, the ONR generated by ORNTDA is either less or equal to 3, 5, 5, 6, 6, and 8 produced by VNPSO-RNP. In view of the improvement of ORNTDA over VNPSO-RNP in terms of OPD and ONR, it has been demonstrated that less energy is expended if the former is used for reader deployment in an RFID network.

**Name:** Elvis Obi

**Matric Number:** M.Sc./ENG/45404/2012-2013

**Dissertation Title:** Development of an Improved Dynamic Algorithm to Enhance Energy Saving in Long Term Evolution Mobile Access Networks

### **ABSTRACT**

This research work presents a dynamic algorithm for improving energy saving in Long Term Evolution (LTE) mobile access networks through off mode, sleep mode and multi-cell cooperation utilization at the eNodeBs. The LTE mobile access network environment and the eNodeBs energy saving models were developed with a view to implementing a dynamic energy saving algorithm. The dynamic energy saving algorithm is an integration of two algorithms, namely: energy estimation algorithm and load/traffic sharing algorithm. The energy estimation algorithm is use to estimates the energy consumption of the eNodeBs when they are powered on, irrespective of the traffic loading. The load/traffic sharing algorithm transfers traffic between eNodeBs which enabled the off mode, sleep mode and multi-cell cooperation of the eNodeBs. The dynamic energy saving algorithm was implemented in MATLAB 2013b environment. The performance of the dynamic energy saving algorithm

was carried out by simulation using the developed MATLAB graphical user interface (GUI) program called the LTE network energy saving analysis software based on dynamic scheduling. Energy savings were analyzed for call blocking probabilities of 0.001%, 0.01%, 0.1% and 10% while varying the energy load proportionality constant between 0 and 1 in steps 0.1. An optimum energy saving for the network was achieved when maintaining a call blocking probability of which corresponded to 51.84%, 49.82%, 46.08%, 44.35%, 41.14%, 34.71%, 28.03%, 22.95%, 17.95%, 13.34% and 7.56% for the energy-load proportionality constant of 1, 0.9, 0.8, 0.7, 0.6, 0.5, 0.4, 0.3, 0.2, 0.1 and 0 respectively. Validation of the proposed dynamic energy saving algorithm was carried out by comparison with the “always-on” algorithm by Chiaraviglio *et al.*, (2012) and the “sleep-wake” algorithm by Hossain *et al.*, (2013). The result showed that the proposed dynamic energy saving algorithm achieved the highest energy saving of 51.84% and 11.84% as compared to the “always-on” algorithm by Chiaraviglio *et al.*, (2012) and the “sleep wake” algorithm by Hossain *et al.*, (2013) which achieve an energy saving of 0% and 40% respectively while guaranteeing a call blocking probability of 1% at an energy-load proportionality constant of 1.

**Name:** Babatunde Emmanuel Ajagbonna

**Title:** Development of a Hybrid Channel-Gain Access-Aware Algorithm for Improving Load Balancing in Various User Distribution LTE Advanced Heterogeneous Networks

**Matric Number:** P13EGCM8012

### **ABSTRACT**

Long Term Evolution (LTE)-Advanced Heterogeneous Networks (HetNets) deployment was introduced to address the increasing demand for Quality of Service (QoS), high data rates, and coverage extension. However, despite the major gains of HetNets in improving the mobile wireless network performance, load balancing still remains a critical problem in such networks. Adopting the conventional Reference Signal Receive Power (RSRP)-based cell selection in HetNets causes

most user equipment (UE) to connect with the Macro eNodeBs (MeNBs) due to their higher transmit power as against that of the Pico eNodeBs (PeNBs), thus leading to serious load imbalance in HetNets. Therefore, this research work developed a hybrid algorithm that combined the channel gain-aware and the access-aware cell association metrics as a single metric for UE to base station association in LTE-Advanced HetNets deployment scenarios. The access-aware (access probability) was formulated as the reciprocal of the number of UEs in a cell to prevent UE from connecting to cells that are overcrowded. The scenarios considered are the HetNets configuration 1 (uniform user distribution); which comprise of 4 PeNBs and 25 uniformly distributed UE and configuration 4b (hotspot distribution); which comprise of 4 PeNBs and 30 UE, two-third of which are clustered around the thePeNBs, as defined by the 3<sup>rd</sup> Generation Partnership Project (3GPP) standard. Time domain muting of certain subframes of the MeNB frames was adopted in order to mitigate interference. The developed Hybrid Channel-Gain Access-Aware (HCGAA) scheme performed better than the RSRP and RSRP+Cell Range Extension (RSRP+CRE) based cell association in terms of load balancing fairness and pico connection ratio. The developed HCGAA scheme improved load balancing performance by 25.4% and 12.1%, respectively compared with the 3GPP RSRP and RSRP +CRE cell selection schemes for configuration 1 and by 6.7% and 2.1%, respectively for configuration 4b. Also, an enhanced pico connection ratio of up to 40.2% and 21.3% more than that of the RSRP and RSRP +CRE cell selection schemes for configuration 1 and 22.6% and 12.7%, respectively for configuration 4b was achieved by the HCGAA algorithm. These improvements translate to the efficient utilization of the network resource and prevent crowding of certain cells in the network.

**Name:** Ayuba Kwasako Danburam

**Title:** Development of an Improved Cell Selection Algorithm to Enhance Transmission Energy Efficiency in LTE-Advanced Heterogeneous Network

**ABSTRACT**

Heterogeneous Network (HetNet) deployment is one of the ways of improving transmission energy efficiency in Long Term Evolution (LTE)-Advanced wireless cellular systems. The major challenge of HetNet is poor cell selection when the conventional Reference Signal Received Power (RSRP) or Biased RSRP (BRSRP) cell selection algorithm is used. Poor cell selection limits the potential of HetNet in improving transmission energy efficiency. Therefore, this research work proposed an improved cell selection algorithm to enhance transmission energy efficiency in two LTE-Advanced HetNet deployment scenarios. The scenarios were defined by the 3<sup>rd</sup> Generation Partnership Project (3GPP) standard namely: configuration 1 and configuration 4b. The proposed cell selection algorithm uses transmission energy efficiency and downlink Signal to Interference and Noise Ratio (SINR) as cell load metrics for adaptive Cell Range Extension (CRE) bias setting. The algorithm efficiently estimated the varying load in each cell using SINR mapping for link adaptation. Simulations were carried out in LTE system level simulator toolbox, using MatLab 2013b. It was observed that the proposed algorithm performed better for all traffic load in terms of transmission energy efficiency. The proposed algorithm improved transmission energy efficiency by 3.80% and 14.14% when compared with RSRP and BRSRP with 16dB bias, respectively in HetNet configuration 1. Similarly, in HetNet configuration 4b, improvement of 0.76% and 5.60% was achieved in comparison with the RSRP and BRSRP with 16dB bias, respectively for peak traffic load. This improvement is translated into reduction in network operational cost.

**Name:** Abubakar Sadiq Ahmed

**Title:** Development of a Data Rate-based Sleep Mode Algorithm for Energy Savings in an LTE Heterogeneous Network for a Pico eNodeB Cell

**ABSTRACT**

There are several energy saving algorithms proposed to save energy in heterogeneous networks, but most of these algorithms achieved energy savings at the expense of service provisioning. Base stations significantly contribute to power consumption in cellular networks. This research work presented a Data Rate-Based Sleep Mode Algorithm for energy savings for a pico evolved NodeB (eNodeB) cell in a Long-Term Evolution (LTE) heterogeneous network (HetNet). The algorithm was able to track traffic situations and estimate user data rate and energy consumption in the heterogeneous network. The algorithm switched the operating state of some pico eNodeB cells to sleep mode (inactive state) at low (less than or equal to 10 user equipment per macro area coverage) and medium traffic (greater than 10 user equipment per macro area coverage) during which the users are offloaded to other pico eNodeB and macro eNodeB cells to save overall energy consumption in the network. As traffic increased (greater than 10) and the average user data rate of the overall network reduced (less than 2Mbps), the pico eNodeB cells woke up (active state) to ensure service delivery was not obstructed. The work considers temporal fluctuations of traffic with a view to achieving higher energy savings. The traffic model, data rate model, and a power consumption model are developed to implement the sleep mode algorithm. The developed sleep mode algorithm is implemented in Matrix Laboratory (MATLAB) R2013a. The developed algorithm was compared with the relevant specification of the 3rdGeneration Partnership Project (3GPP) Always-on scheme. The results show that the developed sleep mode algorithm achieved an improvement of up to 75% and 50% in terms of energy savings for the pico eNodeB cells at low and medium traffic, respectively. For the overall HetNet, the improvements of 9.28% and 6.19% were achieved for low and medium traffic, respectively. The improvements of 9.45% and 6.30% are achieved in terms of the energy efficiency in 3GPP HetNet Configuration 4b for low and medium traffic while the improvement of 9.45% and 6.22% are achieved in 3GPP HetNet Configuration 1 while guaranteeing a good service delivery.

**Name:** Aminu Akindele Saba

**Matric Number:** P13EGCM8016

**Dissertation Title:** Development of an Adaptive Tracking Area List Location Management Scheme in Long Term Evolution (LTE) Networks

### **ABSTRACT**

Tracking Area List (TAL) was developed to improve location update and paging in in Long Term Evolution (LTE), similar to Location Area Code (LAC) developed in Global Systems for Mobile Communications (GSM) and Universal Mobile Telecommunication System (UMTS). Tracking Area list have significant high Location update and paging in movement pattern such as ping pong and regular movements. One of reason of high paging load in LTE is due to mass User Equipment (UE) movement in same direction due to its inability to adapt to UE movement. This research developed Adaptive Tracking Area List (aTAL) for Long Term Evolution (LTE) to improve Location Management (LM) cost by reducing the number of location updates and paging required to track and setup call to UEs successfully. The sum of location update and number of paged cells are called location management cost. This aTAL strategy systematically allocates Tracking area list (TAL) to UEs based on its movement across rings of contiguous Tracking Areas (TAs). The algorithm use initial state of 1 TA allocation to a UE and subsequent allocation, is group of TAs regarded as a TAL segment in this work. A TAL segment is a group of 3 TAs after the first initial TA allocation. To implement this algorithm, A TAL table is configured with respect to the contiguous arrangement of the TAL. The adaptive algorithm is embedded in the configured TAL table. This adaptive TAL strategy improves location management cost for ping pong, regular, irregular and mass movement patterns by 45.07%, 9.86%, 24.32% and 33.51% respectively compared to Conventional Tracking Area List Strategy.

**Name:** Isiyaku Yau

**Matric Number:** P13EGCM8017

**Dissertation Title:** Enhancing Capacity in Underlay Cognitive Radio Network through Interference Alignment

### **ABSTRACT**

As the number of wireless systems and services grow exponentially, the radio spectrum is becoming increasingly a scarce resource. Again, the current fixed spectrum-licensing policy has made the radio spectrum underutilized. Cognitive Radio (CR) aims at providing solution to address the imbalance between spectrum scarcity and spectrum underutilization by allowing cognitive users, called Secondary Users (SUs), to share the spectrum with the licensed users called Primary Users (PUs) in a manner that the PUs are unaffected as possible. This work proposes to consider an underlay cognitive radio network with a single PU and three SUs. The work is aimed at mitigating the cognitive intra-network interference with a view to enhancing the effective sum capacity of the SUs. The PU is protected through interference temperature (IT) model. Ergodic interference alignment scheme under the IT constraints is developed for mitigating the mutual interference among the SUs. To provide a benchmark to gauge the performance of the developed model, the sum capacity through time-division scheme is first obtained. A closed form expression for the sum capacity of three-user underlay cognitive channel is derived. Applying the ergodic IA with IT constraints enhances the sum capacity of the SUs thereby achieving 23.54% and 24.77% gain in the channel sum capacity under maximum and average IT limits respectively. This gain is with respect to time-division scheme at signal-to-noise-ratio of 19 dB. By utilizing the long delay time associated with ergodic IA to send more bits in time-division scheme, 3.0094 bps/Hz and

3.1741 bps/Hz gains in spectral efficiency was achieved under maximum and average IT limits over a full time-division scheme at SNR of 19 dB. MATLAB 2013b was used for the simulations.

**Name:** Aliu Sala Saliu

**Matric Number:** P13EGCP8018

**Dissertation Title:** Development of an Algorithm for the Analysis and Classification of Intercepted Airborne Radar Signals Using Spectrogram

### **ABSTRACT**

In the field of Electronic Warfare (EW), the military make use of new forms of radar signal waveforms for security purposes in order to conceal some of their characteristics. As such, better signal processing tool is required to analyze the echo signal for the detection of radar capabilities. In this work, an algorithm was developed based on time-frequency technique in order to estimate and classify radar signals of different time and frequency modulations. The signals considered are the simple modulated, Pulse Repetition Interval (PRI) modulated, frequency hopping modulated and the agile pulse modulated signals. The Time-Frequency Distribution (TFD) used in order to achieve the aim is the spectrogram, the square magnitude of short-time Fourier Transform (STFT) with the aid of other statistical signal processing tools such as Hilbert transform, Instantaneous Frequency (IF) and Instantaneous Power (IP). The appropriate functions in MATLAB R2014a that involved parameter estimation and classification of these aforementioned signals were used to implement the algorithms. The estimation and classification accuracy were validated using Monte Carlo simulation performed at various ranges of Signal-to-Noise Ratios (SNRs) in the presence of noise modeled by the Additive White Gaussian Noise (AWGN). Results obtained showed Probability of Correct Parameter Estimation (POCPE) of 100% at SNR equal or greater than -10 dB for time-based parameters estimation and SNR equal or greater than 2 dB for frequency-based parameter estimation. Furthermore, Probability of Correct Identification (POCI) of 100% was



achieved at SNR greater than or equal to 2 dB irrespective of the signal considered. It was observed that the results obtained in this research outperformed the results of similar work by Stevens *et al.*, (2016).

**Name:** Henry Aikhionbare

**Matric Number:** P13EGCM8030

**Dissertation Title:** Improved Modelling of Harmattan Dust Effect on the Cross Polarization of a Microwave Access Radio Link Operating Between 15 GHz and 38 GHz

### **ABSTRACT**

Dust carry non-spherical particles which in the absence of turbulence or shear wind and hydrodynamic forces, tend to orient their major axis in the vertical plane, thus resulting in particles anisotropy which may contribute to Cross Polarization Discrimination (XPD) degradation due to differential phase shift. This research presents an improved model of harmattan dust effect on cross polarization of microwave access radio link operating between 15GHz and 38GHz. Meteorological data such as dust mass concentration, visibility, etc. for ten years (that is, 2003 to 2012) were obtained from Nigerian Meteorological Agency (NIMET) and the five months harmattan period data was sorted out. The sorted data were used to deduce important parameters like dielectric constant, relative particle volume and so on. Then, the complex propagation coefficients (attenuation and phase shift) were deduced as a function of wave frequency, media dielectric constant depolarization factor and fractional volume of dust storm using Maxwell's electromagnetic equation for a random medium. Mathematical background for XPD was then established as a function of signal frequency, dielectric constant of dust storm, particle size probability distribution function and visibility. Finally, a link budget analysis was done for some selected frequency values of 18 GHz, 23 GHz, 27 GHz, 30 GHz and 35 GHz to deduce a fade margin of 52.073 dB, 50.5313 dB,

41.2168 dB, 43.1843 dB, 41.6434 dB and 41.3091 dB respectively due to the depolarization factor of harmattan period in Kano. A percentage time availability of 99.99% was obtained for the selected antenna thereby showing the validity of the developed model based on Rayleigh's distribution Model for Link availability.

**Name:** Aduma Fred Okoh

**Matric Number:** P14EGCM8001

**Dissertation Title:** Development of Measurement-Based Admission Control Algorithm for Edge Carrier Ethernet Network to Reduce Packet Loss and Improve Bandwidth Utilization

### **ABSTRACT**

Admission Control is a vital component for end-to-end Quality of Service (QoS) delivery in a packet flow network. It is more effective when implemented at the edge of the network. The edge of a mobile network is dominated with multiplexer which either uses Synchronous Digital Hierarchy (SDH) or Wavelength Division Multiplexing (WDM) for transport. The edge of the carrier Ethernet network suffers QoS due to packet loss and underutilization of bandwidth. Measurement-Based Admission Control (MBAC) Algorithm which reduced the IP Packet Loss Ratio (IPLR) of WDM system by 30.36% and SDH system by 25.34% was set to be achieved in this work. The developed Algorithm was also set to improve the bandwidth utilization of WDM system by 30.36% and bandwidth utilization of SDH system by 25.34%. The developed Algorithm was implemented using C-sharp (C#) platform. Based on the simulation results, WDM system IPLR was reduced by 30.36% and SDH system IPLR was reduced by 25.34% as compared to the measured data from the network result before implementation of the MBAC algorithm. WDM system bandwidth utilization was improved by 30.36% and SDH system bandwidth utilization was improved by 25.34% as compared to the baseline result before implementation of the MBAC Algorithm. From the t-test results obtained, the probability levels

(P-values) of IPLR and bandwidth utilization for both edge systems were less than 0.05. This implied that the developed Algorithm has better performance in comparison with the measured data from MTN Lagos network.

**Name:** Aminu Muhammad Abba

**Matric Number:** P14EGCM8004

**Dissertation Title:** Development of an Improved Ergodic Capacity of Underlay Cognitive Radio with Imperfect Channel State Information

### ABSTRACT

This research work presents the development of an improved ergodic capacity of underlay Cognitive Radio (CR) with imperfect Channel State Information (CSI). An underlay CR network under a Peak Interference Power (PIP) constraint imposed by a Primary User (PU) was considered. A closed form ergodic capacity expression of the Secondary User (SU) under PIP constraint was derived in order to determine the ergodic capacity under different fading types using Nakagami-m distributions. The m-parameter of the Nakagami-m fading channel measures the ratio of the Line-of-Sight (LoS) signal power to that of the multipath component. The improved ergodic capacity expression developed was validated with the existing ergodic capacity expression at  $m = 1$ . The results showed that the ergodic capacity of the SU could be extended to different fading types in the CR path by adjusting the m-parameter. The impact of channel estimation errors,  $\sigma^2$  and channel correlation coefficient,  $\rho$  on the SU ergodic capacity was studied under different fading types to provide an insight on the capacity behavior of CR network. The results obtained at different values of m parameters showed the ergodic capacity degraded as a result of increasing  $\sigma^2$  and it increases with increasing  $\rho$ . It was observed that at  $m = 1/2, 1, 2$  and  $3$ , a significant capacity gains of 21.65%, 19.71%, 17.43%, and 15.82% were achieved, when 3% interference outage ( $P_{out}$ ) was considered for all the m values from  $\sigma^2 = 1$  to  $\sigma^2 = 0$ . However, a capacity

gains of 23.59%, 22.31%, 21.02%, and 20.26% were also achieved respectively at 1%  $P_{out}$ . It was also found that at  $m = 1/2, 1, 2$  and  $3$ , a spectral efficiency in (bits/S/Hz) of 0.5007, 0.2888, 0.2660, and 0.2596 were achieved when 3%  $P_{out}$  was considered from  $\rho = 0$  to  $\rho = 1$ , while a spectral efficiency of 0.2548, 0.1771, 0.1211, 0.0931 were also achieved at 1%  $P_{out}$  for the respective  $m$  values.

**Name:** Husseina Jibrin Abubakar

**Matric Number:** P14EGEE8005

**Dissertation Title:** Development of an Improved Security Aided and Group Encounter PROPHET Routing Protocol of an Opportunistic Network with Node Cooperation

### **ABSTRACT**

One of the requirements for enabling two nodes to communicate through a network is the existence of a fully connected path between them. However, there are scenarios in wireless networks where this is not the case and yet nodes still need to communicate freely. Despite concerted efforts to resolve this problem of unconnected wireless nodes trying to relay crucial information, network users still experience significant communication challenges owing to failures or non-existence of critical infrastructural links between nodes and their security challenges. This research work is aimed at enhancing the security component of PROPHET routing protocol by incorporating internodes cooperation. Simulation was carried out using the opportunistic network environment (ONE). This report presents the modeled opportunistic network using the security aided and group encounter for PROPHET routing protocol. Node cooperation technique was developed and incorporated into the security aided and groups encounter PROPHET routing protocol in order to improve its security. For the 20-node test

scenario considered, the improved security aided and group encounter PROPHET routing protocol outperformed the method proposed in the security aided and group encounter PROPHET routing protocol of Basu et al., (2015) by 19.6%, 7.9%, 34.7% for delivery probability, hop count and buffer time and for the benchmark Helsinki simulation area considered, it outperformed the method implemented in the work of Basu et al., (2015) by 25.7%, 62.9%, 55.5% with respect to delivery probability, hop count and buffer time respectively. Results showed that, node cooperation technique improved the security aided and groups encounter PROPHET routing protocol because it increased the delivery probability, reduced the latency, reduced the hop count and increased the buffer time when tested on a 20-node test program and on the bench mark Helsinki simulation area at the end of the simulation time of 44000 s

**Name:** Wasiu Olayinka Ajadi

**Matric Number:** P14EGCP8005

**Dissertation Title:** Determination of an Improved Spectrum Sensing Threshold for Cognitive Radio Using Smoothed Pseudo Wigner-Ville Distribution

### **ABSTRACT**

Cognitive radio (CR) has been suggested as the solution to spectrum scarcity due to the fixed allocation employed worldwide by regulatory bodies. A secondary user can opportunistically access the licensed frequency bands without causing harmful interference to the licensed user. In order to avoid interference to a primary user signal, the CR has to be aware about the spectrum usage in the geographic area in which it wants to operate. The process of spectrum sensing is a fundamental task for obtaining this awareness and the result of this process determines the successful operation of cognitive radio. Energy detection is one of the methods of spectrum sensing with the lowest computational complexity but with low performance at low signal to noise ratio. Exploring energy detection has led to the application of many techniques one of

which is the use of time-frequency analysis. This method employs distribution techniques for analyzing the energy spectral density of an observed signal with a view to setting a sensing threshold. However, the distribution techniques that were used in literature suffered from the problem of cross-terms which affect the analysis of the resulting distribution thereby leading to poor sensing performance at low signal-to-noise ratio. Smoothed pseudo Wigner-Ville distribution (SPWVD) of the time-frequency analysis has been employed in this work to reduce the effect of cross-terms and a better sensing threshold was gotten validated through comparison with the existing work which employed pseudo Wigner-Ville Distribution (PWVD) with an average reduction of 2.7% and 3% for additive white Gaussian noise (AWGN) channel, 4.1% and 4.7% for Rician channel, 6.4% and 8% for Rayleigh channel in the probabilities of missed detection and false alarm respectively. These results showed that significant reduction was achieved using SPWVD to set threshold. This work was carried out using the MATLAB R2013b time-frequency tool box

**Name:** Kelechi Nnanna Okogwu

**Matric Number:** P14EGCM8007

**Dissertation Title:** Development of a Modified Handover Decision Algorithm for Inter-Femtocell Handover in Long Term Evolution Network

## **ABSTRACT**

The present-day cellular network faces an increasing problem of providing capacity and coverage for users. The long-term evolution (LTE) system provides a number of ways in mitigating this problem among one of which is the femtocell technology. The femtocell is an example of a heterogeneous network which comprises of different layers of different cell sizes ranging from

microcell, picocell and radio relay nodes. The femtocell is the least in size of network densification and is deployed at indoor environments. However, challenges with the femtocell still persist, one of which is frequent handover. The problem of frequent handover arises from the nature of the femtocell owing to its unplanned deployment, small cell size and access control techniques. The frequent handovers in femtocells reduces the user's call quality. This research work addressed the frequent handover problem by considering the users motion as it changes, using the link expiration time (LET) method and the handover scheme of Rajabizadeh and Abouei in order to accommodate mobile users whose speeds are varying. The proposed handover scheme was designed to establish a communication link with the nearest femtocell when the users speed undergoes an abrupt change. The proposed handover scheme was implemented using a developed graphical user interface (GUI) in MATLAB and its performance was evaluated with the traditional handover scheme based on the handover rate and the time interval between handovers. It was observed from the results obtained that the proposed handover scheme performed fewer handovers in comparison to the traditional handover schemes by 24.

**Name:** Magaji Suleiman

**Matric Number:** P14EGCM8011

**Dissertation Title:** Adaptive Hybrid Technique to Mitigate Cross-Tier Interference in a Femto-Macro Heterogeneous Network

## **ABSTRACT**

The deployment of small cell node such as femto-cell within macro area coverage has been considered a promising solution to provide better throughput and Quality of Experience (QoE) to users. However, co-channel deployment of femto-cell operating in a closed access mode causes

severe cross-tier interference. This dissertation presents the development of an adaptive Hybrid Power control and Time domain Technique (aHPTT) to mitigate cross-tier interference in Heterogeneous Network (HetNet). The hybrid technique was developed to handle limitations associated with using a single interference mitigation technique such as Power Control (PC) and Time Domain (TD). aHPTT integrate PC and TD technique to mitigate interference simultenuoesly depending on the position of the user in the network, for users at cell edge of the femto enhanced Node B (eNodeB) or passer-by the technique implements PC, while TD is implemented for users who are in close proximity or within the femto eNodeB coverage area. The hybrid technique was implemented in a Graphical User Interface (GUI) using MATLAB R2013a. System level simulation was carried out to evaluate the performance of the hybrid technique in terms of user's throughput. The aHPTT was validated with the 3<sup>rd</sup> Generation Partnership Project (3GPP) enhanced Inter-Cell Interference Coordination (eICIC) interference mitigation technique, results obtained showed that the aHPTT performs better than PC technique by 2.90% and TD technique by 82.60%.

**Name:** Mosunmola Bosede Sidiku

**Matric Number:** P14EGEE8062

**Dissertation Title:** Development of a Modified Link Budget for Low Earth Orbiting (LEO)-Based Land Mobile Satellite Communications System

### **ABSTRACT**

This research work presents the development of a Modified Link Budget for Low Earth Orbiting (LEO)-Based Land Mobile Satellite Communications System operating at Ku, K and Ka frequency bands by taking into cognizance the effect of additional loss due to Doppler frequency shift. Doppler frequency shift poses the problem of receiving higher or lower



frequencies than the original transmitted frequency, this may be as a result of a relative movement between the source of the signal and the object (satellite or receiver) or both. In satellite communication system, this phenomenon constitutes the problem of signal loss. Effect of Doppler shift on satellite link budget is assumed negligible in conventional approach thereby resulting in the design of an unrealistic link budget, particularly in Low earth orbit (LEO) where it is more pronounced. In view of this, a more reliable approach to the estimation of satellite link budget at Ku, K, and Ka bands by the inclusion of Doppler frequency shift effect was investigated and its effect was investigated at different satellite orbits (LEO, MEO and GEO). The results obtained show that at maximum satellite converge angle and central frequencies for Ku, K and Ka bands, the Doppler frequencies for LEO (780 km) are: 325.50 kHz, 423.20 kHz and 726.90 kHz; for MEO (20000 km) we have 88.33 kHz, 114.80 kHz and 197.30 kHz; while GEO (35786 km) stood at 55.26 kHz, 71.84 kHz and 123.40 kHz . Variation of Doppler frequency shift with respect to the latitude (location) of the earth's terminal relative to the satellite motion was also studied. A typical earth terminal location in the range of 0 km – 100 km was selected for the study; from which it was verified that effect of Doppler shift in LEO increased as the distance from the initial location of the user terminal increased. These analyses further confirm that Doppler Effect is more pronounced in LEO than in MEO and GEO. Comparative analyses between the conventional and the modified link budget at Ku, K and Ka bands was achieved thereof. The results obtained show the Carrier to Noise density ratio for Ku frequency band dropped by 40% (from 25 dB without Doppler shift to 15 dB with Doppler shift). The Carrier to Noise density ratio for K frequency band dropped by 57% (from 70 dB without Doppler shift to 30 dB with Doppler shift). The Carrier to Noise density ratio for Ka frequency band dropped by 52% (from 110 dB without Dopplershift to 53 dB with Dopplershift). This further confirmed that Doppler shift is most pronounced at LEO orbit hence the need to incorporate its effect in link budgeting. This work was validated against the work of Snehasis and Barsha, (2014). The results obtained through comparison show the Carrier to

Noise density ratio for Ku frequency band dropped by 58% (from 31 dB without Doppler shift to 13 dB with Doppler shift). The Carrier to Noise density ratio for K frequency band dropped by 62% (from 54 dB without Doppler shift to 20 dB with Doppler shift). The Carrier to Noise density ratio for Ka frequency band dropped by 55% (from 85 dB without Doppler shift to 38 dB with Doppler shift). This clearly shows the need for inclusion of Doppler shift effect in LEO-based link budget.

**Name:** Yahaya Otuoze Salihu

**Matric Number:** P14EGEE8069

**Dissertation Title:** Development of a Modified Weather Monitoring and Information System in the Former Department of Electrical & Computer Engineering, A.B.U Zaria

### **ABSTRACT**

The popularity of weather sensors has encouraged the advancement of campus weather station, which helps to automatically or manually measure temperature, humidity, wind speed and direction, pressure and solar radiation. Most of the Weather Monitoring Systems (WMS) were implemented with high-cost sensing devices for detecting weather data but lack the capacity to remotely monitor weather and information update using the available wireless technology. In this study, a modified Weather Monitoring and Information System (WMIS) was developed which is capable of displaying other information by allowing remote sending and accessing of information in addition to weather monitoring. An Atmel 809C52 microcontroller and weather sensor was deployed to support the weather monitoring within the Department of Electrical & Computer Engineering, Ahmadu Bello University, Zaria. The weather station transmits data such as relative humidity, daily temperature, and location using zigbee protocol to a base station. The base station is fully equipped with 160 cm x 32 cm display board developed using ARM Cortex

M3 microcontroller for the visualization of the system. It has the capability of an SMS through which information can be sent and retrieved remotely. Smart RF™ Packet Sniffer was used for Measurements mainly to help visualize the actual operating condition and performance of Received Signal Strength Indicator (RSSI) and Link Quality Indicator (LQI). Performance evaluation of the system was conducted for RSSI and LQI based on indoor and outdoor basis. The path loss exponent for indoor and outdoor environment of 4.7 dB and 2.7 dB, respectively were obtained. This falls within the path loss exponent for obstructed building and urban area radio environment of 4 dB to 6 dB and 2.7 dB to 3.5 dB respectively. Therefore, these results indicate that the system is suitable for use in the Department of Electrical & Computer, Ahmadu Bello University.

**Name:** Haruna Ocholi Enoch

**Matric Number:** P14EGEE8055

**Dissertation Title:** Development of an Improved Frame Level Redundancy Scrubbing Algorithm for Static Random-Access Memory Based Field Programmable Gate Array

### **ABSTRACT**

The use of Static Random-Access Memory (SRAM)-based Field Programmable Gate Array (FPGA) in critical applications has been considered a solution in space and avionics domain due to its flexibility in achieving multiple requirements such as re-programmability and good performance. However, SRAM-based FPGAs are susceptible to radiation induced Single Event Upset (SEU) that affects the functionality of the implemented design. This research presents the development of an improved Frame Level Redundancy (FLR) Scrubbing algorithm for SRAM-based FPGA to mitigate against radiation-induced SEU. The improved FLR uses Cyclic Redundancy Check (CRC) as an error detection technique

to enable configuration memory scrubbing as a solution to mitigate SEU through upset detection and correction. Fault injection was performed on FPGA configuration memory frames on different number of modules to emulate SEU. The improved FLR algorithm was implemented and system level simulation was carried out using MATLAB R2013a. The performance of the improved FLR algorithm was compared with that of the existing FLR algorithm using error correction time and energy consumption as metrics. The results of this work showed that the improved FLR algorithm produced 31.6% improvement in error correction time and 61.1% improvement in energy consumption over the existing FLR algorithm.

**Name:** Yohanna Ali Mshelia

**Matric Number:** P15EGCM8004

**Dissertation Title:** Development of an Improved Semi-definite Programming Algorithm using Dynamic Weight Adaptive Technique for Radio Frequency Energy Harvesting

### **ABSTRACT**

This research presents the development of an Improved Semi-definite Programming Algorithm (IS-PA) for radio frequency energy harvesting using dynamic weight adaptive techniques in simultaneous Wireless Information and Power Transfer (SWIPT) systems. The energy constrained in wireless networks such as wireless sensor networks are powered by batteries which have limited lifetime and even long-lasting batteries have a limited lifespan which largely confines the network performance. The Semi -definite Programming Algorithm (S-PA) was solved using the Lagrangian method for maximum transmit power at the energy harvesting receiver for powering mobile devices. However, the Lagrangian methods rely on the balance between descents in objective space and ascents in the Lagrangian multiplier in order to arrive at equilibrium points. Without good balance, the search trajectory may converge very slowly, oscillate forever and diverge. The

convergence speed and solution quality can be affected by adjusting the weight of the objective function and it is difficult to select a proper static weight for each problem instance. To mitigate this, a dynamic weight adaptive technique is used to automatically adjust the weight based on the behavior of the search progress for optimal power allocations and user selection algorithm. The results showed an improvement of 24.24%, 12.11% and 56.05% for IS-PA over S-PA when the number of transmitting antennas ( $N_T$ ) are 4, 3, and 2 respectively with total average harvested power in terms of maximum transmit power as performance metric. Similarly, an improvement of 26.07% and 18.67% when the number of receiving antennas ( $N_R$ ) are 3 and 2, respectively with total average harvested power in terms of the normalized maximum channel estimation error as performance metric. All simulations were carried out using MATLAB 2016.

**Name:** Funom Samuel Dadah

**Matric Number:** P15EGCM8013

**Dissertation Title:** Development of an Improved Multi-Hop Routing Protocol in Wireless Sensor Networks based on Cluster Head Load Balancing Technique

### **ABSTRACT**

Energy conservation in Wireless Sensor Networks (WSNs) is a key area of research aimed at addressing the challenge of efficient energy utilization. This is due to the fact that the Sensor Nodes (SNs) have limited energy. The limited energy has to be utilized efficiently in order to provide longer network lifetime for the wireless sensor network (WSN). To reduce energy consumption in WSNs, an improved multi-hop routing protocol (mEEMRP) in WSNs based on cluster head (CH) load balancing technique was developed in this research work. The protocol used the residual energy (RE) of cluster heads (CHs) and adopted an election energy threshold ( $T_{nhCH}$ ) to reduce the energy consumption of the SNs in the network, thereby increasing the network lifetime. This research work was carried out on MATLAB R2015b and the performance of the improved protocol was compared in terms of network lifetime (node death percentage), energy consumption percentage and number of packets received at the base station (BS) in a homogeneous WSN. Results obtained from simulation showed that mEEMRP achieved an average percentage improvement of the network lifetime, energy consumption percentage and number of packets received at the BS by 1.77%, 4.83%, and 7.41% respectively in a 200m by 200m network field.

Also, results obtained from simulations showed that mEEMRP in a 400m by 400m network field improved the network lifetime, energy consumption percentage and number of packets received at the BS by 10.65%, 9.2%, and 12.5% respectively. Two network field scenarios were used to test the scalability of the improved protocol. The results of this research work showed that mEEMRP has a better network lifetime, better energy consumption and a greater number of packets received at the BS when compared with an existing energy efficient multi-hop routing protocol (EEMRP) in a WSN.

**Name:** Ehime Ezekiel Agbon

**Matric Number:** P15EGCM8016

**Dissertation Title:** Development of an Improve Ad-hoc on-demand Distance Vector Routing Protocol for Mobile Ad-hoc Network using a Modified Location Aided Routing Protocol

### **ABSTRACT**

This research work presents the development of an improved energy aware routing protocol for Mobile Ad-hoc Network using a modified location aided routing protocol (IE-AODV) to improve network lifetime and throughput. The major challenging issues in Mobile Ad-hoc Networks (MANETs) are low network lifetime, low throughput and intermediate bottleneck node in the network usually due to packet overhead. The problem of selecting energy efficient route with limited bottlenecks at intermediate nodes was modeled as the knapsack problem. The efficiency of a route discovery mechanism critically affects the scalability of a routing protocol. A modified location Aided Routing (mLAR) protocol using a Time-to- Live (TTL) threshold value was used to locate nodes and to define packet hop limit as it did not require any frequent route update as compared to topology-based routing algorithm. Simulation was carried out in NS2 environment. Simulation was carried out to evaluate the performance of the developed protocol IE-AODV. The result of IE-AODV was compared with the existing energy aware routing protocol based on current

processing state of node (E-AODV) from the work of Mohammed *et al.*, 2016. Results obtained showed that IE-AODV performed better than E-AODV by 4.94% when network lifetime was tested against node mobility and 2.30% when network lifetime was tested against number of nodes. IE-AODV also showed improvement over E-AODV by 2.91% when throughput was tested against simulation time and 3.75% when throughput was tested against node mobility.

**Name:** Baffa Abdulkadir Jibrin

**Matric Number:** P15EGCM8026

**Dissertation Title:** Development of an Improved Robust Image Watermarking Algorithm using Discrete Orthonormal Stockwell Transformation Technique

### **ABSTRACT**

An effective way for image copyright protection is digital image watermarking. This refers to a process of embedding code or some watermark information into digital image without affecting its visual quality. In this research work, image watermarking algorithm was developed to mitigate both signal processing manipulations and geometric attacks on watermarked image. The novelty in this work was achieved by the replacement of traditional transformation algorithms used in image watermarking standards such as: Discrete Wavelet Transform (DWT), Discrete Cosine Transform (DCT) with Discrete Orthonormal Stockwell Transform (DOST) for more efficient image decomposition and energy de-correlation. In addition, watermark embedding was achieved using Arithmetic Progression Technique (AP) to eliminate the need for scaling factor. The developed watermarking algorithm was implemented using MATLAB R2015b and its performance was evaluated by comparison with traditional watermarking scheme based on Peak Signal to Noise Ratio (PSNR) and Structural Similarity Index Measurement (SSIM) using three images (Lena, Baboon and Barbara). It was observed from the results obtained that the developed



watermarking algorithm applied on these three images produced respective robustness improvement of 0.5%, 5.4%, and 3.9% and respective imperceptibility improvement of 3.3%, 2.8%, and 3.5% over existing watermarking algorithm for the same three images of Lena, Baboon and Barbara.

**Name:** Hamisu Ibrahim Yarima

**Matric Number:** P15EGCM8030

**Dissertation Title:** Enhancing Selective Mapping Technique for Peak-to-Average Power Ratio Reduction in Orthogonal Frequency Division Multiplexing System using Normalized Hilbert Matrix

### **ABSTRACT**

This research work presents enhancement of Selective Mapping (SLM) technique for Peak-to-Average Power Ratio (PAPR) reduction in Orthogonal Frequency Division Multiplexing (OFDM) using normalized Hilbert matrix. The major challenging issues in OFDM transmission system is high PAPR, which distorts transmitted data and reduces power efficiency of amplifier used within OFDM transceiver. SLM is an attractive technique for PAPR reduction, whose large number of candidate's signals representing original OFDM information are generated and the one with minimum PAPR is then selected for transmission. The performance of SLM in terms of PAPR reduction is largely affected by the magnitude of Phase Rotation Vectors (PRV) used to generate the candidate's signals. PRV with large magnitude when used to multiply input data lead to escalation of amplitudes of signals when summed up together, causing the signals to exhibit peak power. Signals with peak power affect the power amplifier efficiency. In this work, four normalization schemes were used to enhance SLM technique using Hilbert matrix. Computer simulations were carried out using MATLAB 2016Ra. The performance of the enhanced SLM (eSLM) was then compared with that of SLM technique with Hilbert matrix using Complementary

Cumulative Density Function (CCDF) and Bit Error Rate (BER) as performance metrics. Amongst all possible CCDF values generated from the simulation results, CCDF of  $10^{-2}$  was found to be the most suitable available lowest value to be used due to power and power processing issues. With this value the eSLM had a better PAPR reduction when compared to SLM technique using Hilbert matrix with percentage improvement of 36.0%, 14.2%, 14.0%, and 14.0% for both Eigenvectors and eigenvalues, Inverse of matrix order, Determinant, and Euclidean normalization schemes, respectively. In addition, 9.6% SNR improvement was achieved using inverse of matrix order normalization at BER of  $10^{-3}$  compared to SLM using Hilbert matrix.

**Name:** Saidu Waziri Muhammad

**Matric Number:** P15EGCM8046

**Dissertation Title:** Development of a Pilot Allocation Protocol to Mitigate the Effect of Contamination in Massive Multiple Input Multiple Output System

### **ABSTRACT**

Pilot Contamination (PC) has been considered as a major limiting factor of Time Division Duplexing (TDD) Massive Multiple-Input Multiple-Output (M-MIMO) systems, as it will make the signal to interference plus noise ratio (SINR) saturated. Similarly, several mitigations techniques such as Eigenvalue decomposition, cooperative Bayesian channel estimation, blind equalization technique, time staggering pilot, smart pilot assignment, etc. proposed in literature to address PC issue have limitations. These proposed methods are either based on initializing all pilot sequences allocated for training as requested by users or require coordination among neighboring cells. Either process is found to be difficult as synchronizing different levels of the network (micro, nano, and pico-cells) and possibly many cells is not only difficult but a huge task of highly computational complexity that requires coordination among neighboring cells. Therefore, this research work developed a Pilot Allocation Protocol

(PAP) decontamination technique. The developed scheme was based on sectional pilot sequence initialization and sharing which allocate more than one user to share the same orthogonal pilot sequence within a cell. As a result of the sharing, intra cell interference was created, which in turn suppresses inter cell interference between users sharing the same pilot sequence and mitigate the effect of PC. Simulation was carried out using MATLAB 2016Rb and the performance of the developed PAP technique was then compared with conventional; and; Soft Pilot Reuse and Multi-Cell Block Diagonalization (SPR and MBD) schemes utilizing average Uplink (UL) and Downlink (DL) cell throughputs, and Bit Error Rate (BER) as performance metrics. Results obtained showed that, PAP technique had a better average UL and DL cell throughputs over the conventional; and; SPR and MBD schemes with an improvement of 2 b/s/Hz, 3b/s/Hz when the number of BS antennas considered was set at 64, 20.5 b/s/Hz for uplink and 20.3 b/s/Hz for downlink when the number of BS antennas was set

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at 250, and 20.2 b/s/Hz for uplink and 19 b/s/Hz for downlink when the number of BS antennas was set at 256, when Zero Forcing (ZF) detector/precoder was adopted while when Matched Filter (MF) detector/precoder was used, the developed PAP technique had an average uplink and downlink cell throughputs improvement of 1.5 b/s/Hz for both UL and DL when the number of BS antennas considered were set at 64, 8.1 b/s/Hz for both UL and DL at 250 BS antennas, and 8.1 b/s/Hz for both UL and DL when the number of BS antennas was set at 256

**Name:** Franklin Chibueze Njoku

**Matric Number:** P15EGCM8048

**Dissertation Title:** Development of an Improved Vertical Handover Decision Algorithm FOR Macro-Femto Cells in Long Term Evolution Network

This research work presents the development of an improved vertical handover decision algorithm for macro and femto cells in long term evolution networks. A key design feature for vertical handover decision algorithms is to guarantee seamless handover process between varying wireless access technologies without degrading the Quality of Service (QoS) and Quality of Experience (QoE) of the users. There are unwanted scenarios in vertical handover schemes, where due to poor handover process, frequent handovers occur resulting in wastage of network resources, handover failures, and subsequent dissatisfaction of the users. Despite a number of efforts made to mitigate this problem of poor handover, network users still experience significant degradation in call quality owing to the dissimilarities in access technologies available and the changing speed of the user. A vertical handover decision algorithm, which is based on the user's changing speed and network connection time, was developed in this research work by incorporating a dwell time into a proximity model prediction technique in order to make the handover decision more efficient. The developed algorithm was designed to establish communication link with either the macro or femto network depending on the changing speed of the user and the dwell time served as the expected network connection time the user should spend on either of the networks. The developed vertical handover decision scheme was implemented using a developed graphical user interface (GUI) in MATLAB R2015b and its performance was evaluated with the existing vertical handover algorithm (EVHA) based on the number of unnecessary handover and packet loss ratio. Results obtained showed that the developed vertical handover algorithm (DVHA) attained a 77.46% and 77.07% reduction in the number of unnecessary handover and packet loss ratio respectively.

**Name:** Mohammed Miftah Abdullahi

**Matric Number:** PhD/ENG/01022/2008-2009

**Dissertation Title:** Estimation of Detection Threshold for Spectrum Sensing in Cognitive Radio using Adaptive Neuro Fuzzy Inference System (ANFIS) and Monte Carlo Techniques

### **ABSTRACT**

An important component of cognitive radio is spectrum sensing to detect the presence or absence of primary (licensed) user in the spectrum band of interest. However, the traditional static spectrum allocation strategies cause temporal and geographical holes of spectrum usage in licensed bands. Spectrum occupancy was categorized into completely free (white hole), partially free (grey hole) and fully occupied (black hole) in spectrum usage. Cognitive radio has a potential to improve spectrum utilization by opportunistically identifying and exploiting the available spectrum holes without causing harmful interference. One such detection method is the energy detection, used for this research, which is capable of sensing primary user transmitted energy signal. Furthermore, due to signal degradation caused by multipath fading and path loss, a single secondary user running the cognitive software on-board cannot accurately detect the presence of primary user and thus leads to missed detections. This drawback in a single user demands a different approach to the sensing in terms of number of active sensors which lead to the introduction of multiple cognitive radios in a network called a cooperative spectrum sensing network. A major challenge in spectrum sensing is the uncertainty associated with the detection of the primary user by the secondary users. This uncertainty arises from the effects of noise, multipath effects like randomness of primary user's presence in radio spectrum. In order to reduce the impact associated with the uncertainty problem and improve detection performance, this research carried out a comprehensive study between the use of Adaptive Neuro-Fuzzy Inference

System and Monte Carlo techniques with a view to estimating detection threshold value for both cooperative and non-cooperative sensing for efficient utilization of radio spectrum. The ANFIS estimation gave a threshold value of -39 dBm while the Monte Carlo gave a simulated threshold value of -71 dBm. A simulated threshold value of -71 dBm was obtained for the non-cooperative spectrum sensing using Monte Carlo technique. This was validated by conducting extensive indoor and outdoor measurements using a commercially available energy detector with an incorporated spectrum analyzer. A measured threshold value of -71.138 dBm was obtained which was similar to the threshold value of -71 dBm realized from the non-cooperative model. Measurements were also conducted at two GSM frequencies viz: 900 MHz and 1800 MHz with a view to ascertaining existence of spectrum holes at those frequency bands and for noise level characterization. The measurements were twofold: Indoor measurements for the determination of benchmark for noise level and for calibration of the outdoor measurements. From the experiments and measurements made, a minimum noise level of -91 dBm and maximum noise level of -69 dBm were obtained for 1800 MHz and Outdoor measurements gave the signal plus noise levels of -91 dBm and -64 dBm for minimum and maximum sensed energy at 1800 MHz respectively. While at 900 MHz -79 dBm and -55 dBm were obtained for the minimum and maximum respectively.

**Name:** Hassan Abubakar Abdulkaem

**Matric Number:** PhD/ENG/1456/2010-2011

**Dissertation Title:** Development of a Video Frame Enhancement Technique Based on Pixel Intensity and Histogram Distribution for Improved Compression

### **ABSTRACT**

Research attention has been focused on the reduction of image data size (major problem) for its efficient compression, storage, and transmission. In this work, the developed brightness

enhancement model was used to enhance the Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT), Lifting Wavelet Transform (LWT), and Firefly Optimization Algorithm (FOA) compression, which were then used to compress the six video data. These video samples were obtained from the cameras of National Agricultural Extension Research Liaison Service (NAERLS), Ahmadu Bello University, Zaria (as NAERLS1.avi and NAERLS2.avi), Nigerian Television Authority (NTA), Abuja (as NTA1.avi and NTA2.avi), and the benchmark online media database (as Foreman.avi and Akiyo.avi). In the preprocessing stage, the video data were converted into frames of pictures for easy analysis. The hue and saturation were then extracted and the images were noised and filtered using MATLAB R2014b simulation environment. Based on the analysis of random variation of pixel intensity and histogram distribution, the developed brightness enhancement technique was used to improve frame signal as a result of loss during compression. The performances of various enhanced compression techniques were evaluated through a number of MATLAB R2014b simulations using Peak signal to noise ratio (PSNR) as a performance metric. The results showed that the PSNR values for the grey level (black and white) images were improved by 31.95 dB and 22.30 dB for NAERLS1.avi and NAERLS2.avi when subjected to brightness enhancement technique. Also, PSNR improvements of 17.71 dB and 23.31 dB were obtained for the NTA1.avi and NTA2.avi, respectively, as well as 15.06 dB and 19.17 dB improvements were obtained for the Foreman.avi and Akiyo.avi benchmark samples respectively. Similarly, improvement in terms of PSNR was also registered when colored images were subjected to the developed brightness enhancement technique. The research implemented four video compression techniques DCT, DWT, LWT, and FOA compression, which were used as benchmarks for the developed modified FOA (mFOA) compression technique. Their respective outputs were improved using the developed brightness enhancement model in order to account for the loss of signal quality which might have occurred during compression. PSNR simulation results showed that the FOA compression technique performed better than DCT, DWT, LWT, and FOA compression techniques. For example, before enhancement, it was found that the mFOA PSNR

result was better than the LWT by 73.64%, 80.04%, 80.03%, and 80.40%, respectively for NAERLS1.avi, NAERLS2.avi, NTA1.avi and NTA2.avi captured video frames and an improvement of 75.78% and 77.56% for Akiyo.avi and Forman.avi benchmark video frames. The mFOA was also discovered to outperform the FOA by 7.34%, 3.30%, 4.90%, and 5.75% for NAERLS1.avi, NAERLS2.avi, NTA1.avi and NTA2.avi captured video frames before enhancement and an improvement of 3.56% and 3.86% for Akiyo.avi and Forman.avi benchmark video frames. Similarly, the enhanced mFOA (E-mFOA) compression technique also produced PSNR improvement of 72.09%, 79.04%, 79.51% and 78.81% over enhanced LWT (E-LWT) for NAERLS1.avi, NAERLS2.avi, NTA1.avi and NTA2.avi capture video frames and an improvement of 74.67% and 76.08% for Akiyo.avi and Forman.avi benchmark video frames. The EmFOA compression technique also produced a better PSNR improvement of 4.59%, 1.14%, 2.08%, and 1.17% over E-FOA for NAERLS1.avi, NAERLS2.avi, NTA1.avi and NTA2.avi captured video frames, except for the Akiyo.avi and Forman.avi benchmark video frames, where an insignificant improvement of 0.41% and -0.06% were registered. These might have been as a result of the low level of light present when the video clips were taken.

**Name:** Ahmad Rusai Wada

**Matric Number:** P15EGCM8063 [rwada1018@gmail.com](mailto:rwada1018@gmail.com)

**Dissertation Title:** Design and simulation of a compact single feed broad band millimeter wave antenna for wireless mobile application using electromagnetic band gap.

#### ABSTRACT

The increasing demand for high-speed, low latency, data communications between devices has envisioned feature networks to ease the burden on the current infrastructure by offering significantly higher data rates through increased channel bandwidths. Considering the shortage of



available frequencies traditionally used for mobile communications, millimeter wave (mmWave) bands became a suitable alternative. The huge amount of bandwidth available at these frequencies offers data rates that satisfy 5th Generation (5G) networks demands. However, the mobile environment at mmWave bands is more complex than at frequencies currently in use, with higher propagation losses and atmospheric absorption, as high gain broadband antenna is required. This work designed a compact high gain mmWave broadband antenna with wide Half Power Beam-Width (HPBW). It can operate in the frequency range of 33.2 GHz to 40 GHz, which has low specific attenuation due to atmospheric gases. The design was carried out using two Rogers's substrates, one of the substrates for the patched antenna while the other for the Electromagnetic Band Gap (EBG) and the ground plane. The antenna was fed by an off centered microstrip transmission line. The design was implemented using Computer Simulation Technology (CST) Microwave Studio (MWS) software. The result showed significant improvement over that of existing works at 38 GHz center frequency, with a bandwidth improvement of 75 %, 8.1 % increase in HPBW and 17.6 % reduction in size.

**Name:** Zakka Augustine

**Matric Number:** P16EGCM8035 [zax.austen@yahoo.com](mailto:zax.austen@yahoo.com)

**Dissertation Title:** development of an improved spectrum sensing time algorithm using filtered orthogonal frequency division multiplexing scheme in centralized cooperative sensing

### **ABSTRACT**

The advancement in mobile devices and the ever increasing mobile users consumes the limited mobile radio spectrum daily. This spectrum limitation caused by static radio policies result to spectrum scarcity in the mobile wireless network. Cognitive Radio Network (CRN) is one of

the emerging technology proposed for 5G and beyond to overcome spectrum scarcity problem and facilitate seamless interoperability among networks in order to sustain wireless network effectiveness for decades. This research aimed at minimizing Spectrum Sensing Time (SST) to improve Transmission Efficiency (TE) by integrating CRN with a Filtered Orthogonal Frequency Multiplexing Division (F-OFDM) scheme using Centralized Cooperative Spectrum Sensing (CCSS) technique. The CCSS proposed in this work is the Listen-before-Talk (LbT) method, where the Secondary Users (SUs) adopt proactive approach about the Primary User (PU) availability. Using CCSS of CRN and F-OFDM waveforms for spectrum sensing and data transmission in this work hybridized a new waveform that achieved a null detection probability ( $Q_{oe}$ ) of 0.95 and false alarm probability ( $Q_{gb}$ ) reduction 0.05 above the IEEE set threshold of 0.9 and 0.1. This improved both sensing time and accuracy by 5.5% and reduced false alarm by 50%, respectively. The modified SST scheme was simulated on a Graphical User Interface (GUI) using MATLAB R2018a script. The results were validated and compared with those of Spread Slotted ALOHA (SSA) scheme of the work of Jia et al., (2016) using spectrum sensing time, transmission efficiency and throughput as the performance measures. The throughput of the F-OFDM CR system with packets transmitted ( $Q_{usb}$ ) was tested under  $Q_{oe}$  and  $Q_{gb}$  in a fixed channel state,  $Q_{gb}$  and channel occupancy rate ( $q$ ) in dynamic channel state, and was found to achieve an improvement over SSA CR system by 81%, 83.4%, 88.4% and 85.6%, respectively.

**Name:** Lateef Agboola Olanrewaju

**Matric Number:** P16EGCM8031 [lati.lanre@gmail.com](mailto:lati.lanre@gmail.com)

**Dissertation Title:** Development of a secure mobile agent in computer networks for mobile service protection using an identity based signature scheme

## ABSTRACT

A Mobile Agent is an extension to distributed computing paradigm which has provided alternatives for moving data across a network to improve the computing efficiency. Due to the autonomous nature of mobile agents, they are prone to several attacks, thereby raising security challenges. Mobile Agent (MA) security has become a serious challenge for researchers. Different approaches like Identity Based Encryption (IBE) have been developed by different authors and many cryptography methods have been proposed such as IBE. In IBE, the Public Key Infrastructure (PKI) needs to be built which is costly and difficult to implement, this shortcomings of IBE made Identity-Based Signature (IBS) to be attractive. The Identity-Based Signature (IBS) scheme is more secure and it is easy to implement. This study focus on development a secure MA using an IBS scheme in computer network. The aim of the study is achieved by develop a mobile agent, which was built on the services (data bundle, airtime, and so on) rendered by the major GSM operator (MTN, GLO and AIRTEL) in Nigeria. The IBS scheme is use to secure the system. The security of MA was tested on computer network. The results show that the security objectives was 71% better than that in the blowfish scheme and reduced the total running time to approximately 69ms . The contribution of this study is twofold. Firstly, it presents a practical secure MA by using IBS scheme. This method is used in such a way that the entire scheme becomes efficient and feasible to deploy. Secondly, the development of a MA can be used by GSM operators for e-commerce and m-commerce to improve their service delivery to customers.

**Name:** Funom Samuel DADAH

**Matric Number:** P15EGCM8013, [funomdadah@gmail.com](mailto:funomdadah@gmail.com)

**Dissertation Title:** Development of an improved multi-hop routing protocol in wireless sensor networks based on cluster head load balancing technique

## ABSTRACT

Energy conservation in wireless sensor networks (WSNs) is a key area of research aimed at addressing the challenge of efficient energy utilization. This is due to the fact that the Sensor Nodes (SNs) have limited energy. The limited energy has to be utilized efficiently in order to provide longer network lifetime for the wireless sensor network (WSN). To reduce energy consumption in WSNs, an improved multi-hop routing protocol (mEEMRP) in WSNs based on cluster head (CH) load balancing technique was developed in this research work. The protocol used the residual energy (RE) of cluster heads (CHs) and adopted an election energy threshold ( $T_{nhCH}$ ) to reduce the energy consumption of the SNs in the network, thereby increasing the network lifetime. This research work was carried out on MATLAB R2015b and the performance of the improved protocol was compared in terms of network lifetime (node death percentage), energy consumption percentage and number of packets received at the base station (BS) in a homogeneous WSN. Results obtained from simulation showed that mEEMRP achieved an average percentage improvement of the network lifetime, energy consumption percentage and number of packets received at the BS by 1.77%, 4.83%, and 7.41% respectively in a 200m by 200m network field. Also, results obtained from simulations showed that mEEMRP in a 400m by 400m network field improved the network lifetime, energy consumption percentage and number of packets received at the BS by 10.65%, 9.2%, and 12.5% respectively. Two network field scenarios were used to test the scalability of the improved protocol. The results of this research work showed that mEEMRP has a better network lifetime, better energy consumption and more number of packets received at the BS when compared with an existing energy efficient multi-hop routing protocol (EEMRP) in a WSN.

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**Dissertation Title:** Development of a constrained radio frequency identification reader deployment algorithm to achieve optimal network topology design

## ABSTRACT

The major challenge in most Radio Frequency Identification (RFID) network planning is the effective utilization of multiple RFID readers to achieve a reliable network, while minimizing power consumption and cost of deployment. In this work, a constrained Optimal Radio Frequency Identification Network Topology Design Algorithm (ORNTDA) was developed through the logical integration of a set of sub-algorithms involving Tag Placement (TP); Reader Initial Population Deployment (RIPD); Useless Reader Detection and Elimination (URDE) and Redundant Reader Elimination (RRE). Approaches A, B, and C were developed for RIPD. A MATLAB based Graphic User Interface (GUI) based on the ORNTDA for optimal reader deployment simulation was also developed. The performance of the three approaches in terms of Optimal Number of Readers (ONR) and Optimal Power Dissipated (OPD) was demonstrated through simulation. Five cases of reader deployment problems were considered in order to study the effect of the variation of some of the topology design parameters with changes in other parameters. The developed Optimal RFID Network Topology Design Algorithm was observed to perform well in all cases. In view of 0.35 seconds convergence time of approach B, ORNTDA could be integrated into real-time systems that have mobile readers. The developed ORNTD models and algorithms were validated with a standard RFID Network Planning (RNP) benchmark tag topologies of C30, C50, C100, R30, R50 and R100 as presented in Yue-jiao *et al.*, (2015). ORNTDA improved the OPD of Von Neumann Particle Swarm Optimization RFID Network Planning (VNPSO-RNP) by 45.65%, 14.23%, 5.34%, 17.16%, 6.21%, and 2.4%, respectively for the six topologies. However, the ONR generated by ORNTDA is either less or equal to 3, 5, 5, 6, 6, and 8 produced by VNPSO-RNP. In view of the improvement of ORNTDA over VNPSO-RNP in terms of OPD and ONR, it has been demonstrated that less energy is expended if the former is used for reader deployment in an RFID network.

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**Dissertation Title:** Development of an adaptive tracking area list location management scheme in long term evolution (LTE) networks.

### **ABSTRACT**

Tracking Area List (TAL) was developed to improve location update and paging in in Long Term Evolution (LTE), similar to Location Area Code (LAC) developed in Global Systems for Mobile Communications (GSM) and Universal Mobile Telecommunication System (UMTS). Tracking Area list have significant high Location update and paging in movement pattern such as ping pong and regular movements. One of reason of high paging load in LTE is due to mass User Equipment (UE) movement in same direction due to its inability to adapt to UE movement. This research developed Adaptive Tracking Area List(aTAL) for Long Term Evolution (LTE) to improve Location Management (LM) cost by reducing the number of location updates and paging required to track and setup call to UEs successfully. The sum of location update and number of paged cells are called location management cost. This aTAL strategy systematically allocates Tracking area list (TAL) to UEs based on its movement across rings of contiguous Tracking Areas (TAs). The algorithm use initial state of 1 TA allocation to a UE and subsequent allocation, is group of TAs regarded as a TAL segment in this work. A TAL segment is a group of 3 TAs after the first initial TA allocation. To implement this algorithm, A TAL table is configured with respect to the contiguous arrangement of the TAL. The adaptive algorithm is embedded in the configured TAL table. This adaptive TAL strategy improves location management cost for ping pong, regular, irregular and mass movement patterns by 45.07%, 9.86%, 24.32% and 33.51% respectively compared to Conventional Tracking Area List Strategy.

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**Dissertation Title:** Development of an algorithm for the analysis and classification of intercepted airborne radar signals using spectrogram

### ABSTRACT

In the field of Electronic Warfare (EW), the military make use of new forms of radar signal waveforms for security purposes in order to conceal some of their characteristics. As such, better signal processing tool is required to analyze the echo signal for the detection of radar capabilities. In this work, an algorithm was developed based on time-frequency technique in order to estimate and classify radar signals of different time and frequency modulations. The signals considered are the simple modulated, Pulse Repetition Interval (PRI) modulated, frequency hopping modulated and the agile pulse modulated signals. The Time-Frequency Distribution (TFD) used in order to achieve the aim is the spectrogram, the square magnitude of short-time Fourier Transform (STFT) with the aid of other statistical signal processing tools such as Hilbert transform, Instantaneous Frequency (IF) and Instantaneous Power (IP). The appropriate functions in MATLAB R2014a that involved parameter estimation and classification of these aforementioned signals were used to implement the algorithms. The estimation and classification accuracy were validated using Monte Carlo simulation performed at various ranges of Signal-to-Noise Ratios (SNRs) in the presence of noise modeled by the Additive White Gaussian Noise (AWGN). Results obtained showed Probability of Correct Parameter Estimation (POCPE) of 100% at SNR equal or greater than -10 dB for time-based parameters estimation and SNR equal or greater than 2 dB for frequency-based parameter estimation. Furthermore, Probability of Correct Identification (POCI) of 100% was achieved at SNR greater than or equal to 2 dB irrespective of the signal considered. It was observed that the results obtained in this research outperformed the results of similar work by Stevens *et al.*, (2016).

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**Dissertation Title:** Development of a Modified Weather Monitoring and Information System in the Former Department of Electrical and Computer Engineering, Ahmadu Bello University Zaria.

### ABSTRAT

The popularity of weather sensors has encouraged the advancement of campus weather station, which helps to automatically or manually measure temperature, humidity, wind speed and direction, pressure and solar radiation. Most of the Weather Monitoring Systems (WMS) were implemented with high-cost sensing devices for detecting weather data but lack the capacity to remotely monitor weather and information update using the available wireless technology. In this study, a modified Weather Monitoring and Information System (WMIS) was developed which is capable of displaying other information by allowing remote sending and accessing of information in addition to weather monitoring. An Atmel 809C52 microcontroller and weather sensor was deployed to support the weather monitoring within the Department of Electrical & Computer Engineering, Ahmadu Bello University, Zaria. The weather station transmits data such as relative humidity, daily temperature, and location using zigbee protocol to a base station. The base station is fully equipped with 160 cm x 32cm display board developed using ARM CortexM3 microcontroller for the visualization of the system. It has the capability of an SMS through which information can be sent and retrieved remotely. SmartRF™ Packet Sniffer was used for Measurements mainly to help visualize the actual operating condition and performance of Received Signal Strength Indicator (RSSI) and Link Quality Indicator (LQI). Performance evaluation of the system was conducted for RSSI and LQI based on indoor and outdoor basis. The path loss exponent for indoor and outdoor environment of 4.7 dB and 2.7 dB,



respectively were obtained. This falls within the path loss exponent for obstructed building and urban area radio environment of 4dB to 6dB and 2.7dB to 3.5dB respectively. Therefore, these results indicate that the system is suitable for use in the Department of Electrical & Computer Engineering, Ahmadu Bello University, Zaria.

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**Dissertation Title:** Development of an improved semi-definite programming algorithm using dynamic weight adaptive technique for radio frequency energy harvesting

### ABSTRACT

This research presents the development of an Improved Semi-definite Programming Algorithm (IS-PA) for radio frequency energy harvesting using dynamic weight adaptive techniques in simultaneous Wireless Information and Power Transfer (SWIPT) systems. The energy constrained in wireless networks such as wireless sensor networks are powered by batteries which have limited lifetime and even long-lasting batteries have a limited lifespan which largely confines the network performance. The Semi-definite Programming Algorithm (S-PA) was solved using the Lagrangian method for maximum transmit power at the energy harvesting receiver for powering mobile devices. However, the Lagrangian methods rely on the balance between descents in objective space and ascents in the Lagrangian multiplier in order to arrive at equilibrium points. Without good balance, the search trajectory may converge very slowly, oscillate forever and diverge. The convergence speed and solution quality can be affected by adjusting the weight of the objective function and it is difficult to select a proper static weight for each problem instance. To mitigate this, a dynamic weight adaptive technique is used to automatically adjust the weight based on the behavior of the search progress for optimal power allocations and user selection algorithm. The results showed an improvement of 24.24%, 12.11% and 56.05% for IS-PA over S-PA when the number of transmitting antennas ( $N_T$ ) are 4, 3, and 2 respectively with total average harvested

power in terms of maximum transmit power as performance metric. Similarly an improvement of 26.07% and 18.67% when the number of receiving antennas ( $N_R$ ) are 3 and 2, respectively with total average harvested power in terms of the normalized maximum channel estimation error as performance metric. All simulations were carried out using MATLAB 2016.

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**Dissertation Title:** Development of an improved multi-hop routing protocol in wireless sensor networks based on cluster head load balancing technique

### ABSTRACT

Energy conservation in wireless sensor networks (WSNs) is a key area of research aimed at addressing the challenge of efficient energy utilization. This is due to the fact that the Sensor Nodes (SNs) have limited energy. The limited energy has to be utilized efficiently in order to provide longer network lifetime for the wireless sensor network (WSN). To reduce energy consumption in WSNs, an improved multi-hop routing protocol (mEEMRP) in WSNs based on cluster head (CH) load balancing technique was developed in this research work. The protocol used the residual energy (RE) of cluster heads (CHs) and adopted an election energy threshold ( $T_{nhCH}$ ) to reduce the energy consumption of the SNs in the network, thereby increasing the network lifetime. This research work was carried out on MATLAB R2015b and the performance of the improved protocol was compared in terms of network lifetime (node death percentage), energy consumption percentage and number of packets received at the base station (BS) in a homogeneous WSN. Results obtained from simulation showed that mEEMRP achieved an average percentage improvement of the network lifetime, energy consumption percentage and number of packets received at the BS by 1.77%, 4.83%, and 7.41% respectively in a 200m by 200m network field. Also, results obtained from simulations showed that mEEMRP in a 400m by 400m network field improved the network lifetime, energy consumption percentage and number of packets received at the BS by 10.65%, 9.2%, and 12.5% respectively. Two network field scenarios were used to test

the scalability of the improved protocol. The results of this research work showed that mEEMRP has a better network lifetime, better energy consumption and more number of packets received at the BS when compared with an existing energy efficient multi-hop routing protocol (EEMRP) in a WSN.

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**Dissertation Title:** Development of an improved ad-hoc on-demand distance vector routing protocol for mobile ad-hoc network using modified route search algorithm

### ABSTRACT

This research work presents the development of an improved ad-hoc on-demand distance vector routing protocol (IE-AODV) for mobile ad-hoc network using modified route search algorithm to improve network lifetime and throughput. The major challenging issues in Mobile Ad-hoc Networks (MANETs) are low network lifetime, low throughput and intermediate bottleneck node in the network usually due to packet overhead. The problem of selecting energy efficient route with limited bottlenecks at intermediate nodes was modeled as the knapsack problem. The efficiency of a route discovery mechanism critically affects the scalability of a routing protocol. The route search algorithm used is the Location Aided Routing (LAR) protocol. A modified LAR protocol using a Time-to-Live (TTL) threshold value was used to locate nodes and to define packet hop limit as it did not require any frequent route update as compared to topology based routing algorithm. Simulation was carried out in NS2 environment. Simulation was carried out to evaluate the performance of the developed protocol IE-AODV. The result of IE-AODV was compared with the existing energy aware routing protocol based on current processing state of node (E-AODV) from the work of Mohammed *et al.*, 2016. Results obtained showed that IE-AODV performed better than E-AODV by 4.94% when network lifetime was tested against node mobility and 2.30%

when network lifetime was tested against number of nodes. IE-AODV also showed improvement over E-AODV by 2.91% when throughput was tested against simulation time and 3.75% when throughput was tested against node mobility.

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**Dissertation Title:** Development of a modified video watermarking scheme for enhanced robustness and imperceptibility using redundancy removal algorithm, discrete orthonormal stock well transform and alpha blending technique

### **ABSTRACT**

In this modern era of fast growth of internet; tampering, increase distribution and illegal manipulation of multimedia data have become trending problems. These problems are mostly reported in video media. Digital watermarking was introduced to address these problems. The purpose of digital watermarking is to embed secret information called watermark into the original media that is robust against various attacks and upholds the perceptual quality of the media. In video watermarking there exists inherent redundancy in frames which renders the video vulnerable to more attacks as compared with other media. Frame attacks have been one of the major problems in video watermarking amongst others, due to these redundancies. This research work developed a modified video watermarking scheme that is robust against frame attack, geometric attacks and noise attacks and also improved the imperceptibility of the scheme. The robust video watermarking scheme was achieved by developing a Redundancy Removal Algorithm (RRA) that mitigates these redundancies by comparing the video frames to identify and remove redundant ones. Furthermore, the Discrete Wavelet Transform (DWT) technique used was replaced with Discrete Orthonormal Stockwell Transform (DOST) for more efficient representation. In addition, Alpha Blending technique was adopted for embedding and extraction

of the watermark. The scheme was subjected to various attacks to evaluate its performance. Simulation was done on MATLAB R2016a using Image Processing Toolbox. Results obtained from simulation showed that the developed watermarking scheme achieved imperceptibility improvement of Normalized Correlation (NC) values of 3.28% and 9.50% for cover and watermarked frames respectively when compared with the standard watermarking scheme. Additionally, the developed watermarking scheme achieved an improvement in terms of robustness with Peak Signal to Noise Ratio (PSNR) improvement of 59.90%, 72.63%, 25.13%, 15.75%, 23.97% and 22.08% when subjected to frame dropping, frame swapping, salt & pepper, Gaussian, rotation and cropping attacks respectively. Also when comparing the developed scheme with the standard watermarking algorithm, the developed scheme achieved an improvement in terms of Mean Square Error (MSE) of 64.76%, 61.70%, 52.79%, 34.47%, 38.22% and 41.98% when subjected to frame dropping, frame swapping, salt & pepper, Gaussian, rotation and cropping attacks respectively.

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**Dissertation Title:** Development of an improved robust image watermarking algorithm using discrete orthonormal stockwell transformation technique

### ABSTRACT

An effective way for image copyright protection is digital image watermarking. This refers to a process of embedding code or some watermark information into digital image without affecting its visual quality. In this research work, image watermarking algorithm was developed to mitigate both signal processing manipulations and geometric attacks on watermarked image. The novelty in this work was achieved by the replacement of traditional transformation algorithms used in image watermarking standards such as: Discrete Wavelet Transform (DWT), Discrete Cosine Transform (DCT) with Discrete Orthonormal Stockwell Transform (DOST) for more efficient image decomposition and energy de-correlation. In addition watermark embedding was

achieved using Arithmetic Progression Technique (AP) to eliminate the need for scaling factor.

The developed watermarking algorithm was implemented using MATLAB R2015b and its performance was evaluated by comparison with traditional watermarking scheme based on Peak Signal to Noise Ratio (PSNR) and Structural Similarity Index Measurement (SSIM) using three images (Lena, Baboon and Barbara). It was observed from the results obtained that the developed watermarking algorithm applied on these three images produced respective robustness improvement of 0.5%, 5.4%, and 3.9% and respective imperceptibility improvement of 3.3%, 2.8%, and 3.5% over existing watermarking algorithm for the same three images of Lena, Baboon and Barbara.

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**Dissertation Title:** Enhancing selective mapping technique for peak-to-average power ratio reduction in orthogonal frequency division multiplexing system using normalised hilbert matrix

## ABSTRACT

This research work presents enhancement of Selective Mapping (SLM) technique for Peak-to-Average Power Ratio (PAPR) reduction in Orthogonal Frequency Division Multiplexing (OFDM) using normalized Hilbert matrix. The major challenging issues in OFDM transmission system is high PAPR, which distorts transmitted data and reduces power efficiency of amplifier used within OFDM transceiver. SLM is an attractive technique for PAPR reduction, whose large number of candidates signals representing original OFDM information are generated and the one with minimum PAPR is then selected for transmission. The performance of SLM in terms of PAPR reduction is largely affected by the magnitude of Phase Rotation Vectors (PRV) used to generate the candidates signals. PRV with large magnitude when used to multiply input data lead to escalation of amplitudes of signals when summed up together, causing the signals to exhibit peak

power. Signals with peak power affect the power amplifier efficiency. In this work, four normalization schemes were used to enhance SLM technique using Hilbert matrix. Computer simulations were carried out using MATLAB 2016Ra. The performance of the enhanced SLM (eSLM) was then compared with that of SLM technique with Hilbert matrix using Complementary Cumulative Density Function (CCDF) and Bit Error Rate (BER) as performance metrics. Amongst all possible CCDF values generated from the simulation results, CCDF of  $10^{-2}$  was found to be the most suitable available lowest value to be used due to power and power processing issues. With this value the eSLM had a better PAPR reduction when compared to SLM technique using Hilbert matrix with percentage improvement of 36.0%, 14.2%, 14.0%, and 14.0% for both Eigenvectors and eigenvalues, Inverse of matrix order, Determinant, and Euclidean normalization schemes, respectively. In addition 9.6% SNR improvement was achieved using inverse of matrix order normalization at BER of  $10^{-3}$  compared to SLM using Hilbert matrix.

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**Dissertation Title:** Development of an improved vertical handover decision algorithm for macro-femto cells in long term evolution network

### **ABSTRACT**

This research work presents the development of an improved vertical handover decision algorithm for macro and femto cells in long term evolution networks. A key design feature for vertical handover decision algorithms is to guarantee seamless handover process between varying wireless access technologies without degrading the Quality of Service (QoS) and Quality of Experience (QoE) of the users. There are unwanted scenarios in vertical handover schemes, where due to poor handover process, frequent handovers occur resulting in wastage of network resources, handover failures, and subsequent dissatisfaction of the users. Despite a number of efforts made to mitigate this problem of poor handover, network users still experience significant degradation in call quality

owning to the dissimilarities in access technologies available and the changing speed of the user. A vertical handover decision algorithm, which is based on the user's changing speed and network connection time, was developed in this research work by incorporating a dwell time into a proximity model prediction technique in order to make the handover decision more efficient. The developed algorithm was designed to establish communication link with either the macro or femto network depending on the changing speed of the user and the dwell time served as the expected network connection time the user should spend on either of the networks. The developed vertical handover decision scheme was implemented using a developed graphical user interface (GUI) in MATLAB R2015b and its performance was evaluated with the existing vertical handover algorithm (EVHA) based on the number of unnecessary handover and packet loss ratio. Results obtained showed that the developed vertical handover algorithm (DVHA) attained a 77.46% and 77.07% reduction in the number of unnecessary handover and packet loss ratio respectively.

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**Dissertation Title:** Development of a secure mobile agent in computer networks for mobile service protection using an identity based signature scheme

### **ABSTRACT**

A Mobile Agent is an extension to distributed computing paradigm which has provided alternatives for moving data across a network to improve the computing efficiency. Due to the autonomous nature of mobile agents, they are prone to several attacks, thereby raising security challenges. Mobile Agent (MA) security has become a serious challenge for researchers. Different approaches like Identity Based Encryption (IBE) have been developed by different authors and many cryptography methods have been proposed such as IBE. In IBE, the Public Key Infrastructure (PKI) needs to be built which is costly and difficult to implement, this shortcomings of IBE made Identity-Based Signature (IBS) to be attractive. The Identity-Based Signature (IBS) scheme is more secure and it is easy to implement. This study focus on development a secure MA using an IBS



scheme in computer network. The aim of the study is achieved by develop a mobile agent, which was built on the services (data bundle, airtime, and so on) rendered by the major GSM operator (MTN, GLO and AIRTEL) in Nigeria. The IBS scheme is use to secure the system. The security of MA was tested on computer network. The results show that the security objectives was 71% better than that in the blowfish scheme and reduced the total running time to approximately 69ms . The contribution of this study is twofold. Firstly, it presents a practical secure MA by using IBS scheme. This method is used in such a way that the entire scheme becomes efficient and feasible to deploy. Secondly, the development of a MA can be used by GSM operators for e-commerce and m-commerce to improve their service delivery to customers.

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**Dissertation Title:** Development of an improved user pairing, sub channeling, and power allocation algorithm for 5g noma system.

#### **ABSTRACT**

Due to increasing demand on telecommunications services, network suffers low speed and high latency. These seriously impact on the performance of the networks because there is a big burden on the existing multiplexing techniques such as Orthogonal Multiple Access (OMA) to deliver high speed data rates. Hence, the ever increasing demand for high speed and low latency data communications by mobile users define future features of networks to ease the burden on the existing multiple access techniques by significantly offering high data rates through multiplexing of multiple users over the same channel at same time and frequency using Non Orthogonal Multiple Access (NOMA) in 5G systems. The high speed sum rate of data in this kind of multiple access is another problem because it depends on efficient user pairing, subchanneling, and power allocation techniques used to avoid high rate of interference and decoding errors. These important conditions are difficult to meet because techniques are not perfects. These techniques used by previous researchers to resolve low speed and high latency introduced some problems such as high

speed sum rate, hence the need to improve these techniques. In this research work, therefore an improved user pairing, subchanneling, and power allocation algorithm that used the differences in channel conditions (that is, channel gain) of users and sub channeling to mitigate the effect of multi-user and inter user interferences in 5G NOMA systems to improve data sum rate, coverage probability, and Energy Efficiency was developed. A multiple users' downlink NOMA system with N subchannels and 32 users that were uniformly distributed in a circle of 300 meters diameter was considered. The developed algorithm was implemented in LTE system level simulator of MATLAB R2017a, which showed an average performance improvement of 7.0%, 19.3%, and 32.5% in terms of data sum rate, coverage probability, and Energy Efficiency (EE) over Hierarchical Pairing and Power Allocation (HPPA) algorithm of the work of Al- Abbasi & So (2016).

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**Dissertation Title:** Development of an improved adaptive hybrid technique to mitigate cross-tier interference in a femto-macroheterogeneous network.

### **ABSTRACT**

The deployment of femtocells presents an attractive solution for the improvement of mobile network's services, providing better data rates and coverage to indoor users. Since the deployment of femtocells amounts to a heterogeneous network where two layers utilize the available spectrum, issues of interference arise. The interference mitigation techniques in literature made use of a single or hybrid enhanced inter-cell interference coordination techniques to reduce interference in heterogeneous networks. These techniques mitigate interference at the expense of reducing the capacity or coverage of the interfering cell as well as the network as whole and also causing underutilization of the spectrum resources. A method used in this research to address this challenge investigated the positions of the user equipment and the installed Femto Base Stations and apply

the developed improved adaptive hybrid technique that combined Time domain technique using reduced power ABS and Power control techniques to mitigate the cross-tier interference between the Femto Base Station and the macro-user in the vicinity of the femtocell. This was done in order to achieve optimal and fair overall performance. The improved adaptive hybrid technique was implemented in a Graphical User Interface (GUI) using MATLAB R2018a. Only communication in the downlink direction was considered. Results obtained from simulation was compared with the results of Magaji *et al*, 2017 and it was found that the improved adaptive hybrid technique was able to improve femtocell user's total throughput by 15.20%, SINR by 11.50% and enhanced spectral efficiency by 50% with muting ratio of 0.5 without subjecting the macro users in the vicinity of the femtocell to severe interferenc

