Wireless Communications Research Group

Background/Synopsis of Research Activities

The current generation of the mobile system continues to transform the way people communicate and access information. The exponential growth of wireless data services driven by mobile Internet and smart devices has triggered the investigation of the 5G cellular network which is scheduled for deployment in the year 2020. Fifth generation wireless systems, commonly abbreviated as "5G", is the next step in the continuous innovation and evolution of the mobile industry. The 5G wireless networks will support 1,000-times gain in capacity compared to 4G networks, connections for at least 100 billion devices, and a 10 Gbps individual user experience with the capability of extremely low latency and response times. 5G will not only be about a new air interface with faster speeds, but it will provide low energy, low-cost hardware and will support massive number of devices for a very dense crowd of users. The above will be achieved by building the network with both new radio access technologies (RAT) and by evolving existing wireless technologies (e.g. LTE, HSPA, GSM and Wi-Fi). Therefore, the complex performance requirement for 5G can be multi folds; apart from aiming to achieve a faster data rates to support ultra high definition video and virtual reality applications, it should be able to provide latency of less than 1 millisecond to support real time mobile control and vehicle -to- vehicle applications. Energy per bit usage should be reduced by a factor of 1,000 to improve connected device battery life, zero switching time between different radio technologies to ensure seamless delivery of services. The modulation techniques used and Multiple Input Multiple Output (MIMO) technology are another areas used in 5G to increase the bandwidth and data rates. Availability of spectrum to support the very high data capacity in 5G is another important challenge. While a shift to 5G would be hugely impactful, the industry will need to overcome a series of challenges if these benefits are to be realized, particularly in terms of spectrum and network topology. The following are some research priorities that must be addressed if 5G will be a successful technology; research into spectrum provision for 5G technologies, new radio waveforms, new joint access/backhaul designs, integration of satellite into the wireless subsystem, new routing solutions for backhaul and core networks, new caching solutions for reducing service-level latency, and new low throughput solutions for sensor deployments.

Research Areas:
The research group performs multi-disciplinary research in the area of wireless communications networks:

1. Heterogeneous networks
2. Interference in communication networks
3. Spectrum resource management
4. Antennas and radiowave propagation
   - MIMO technology
5. Rural broadband
6. Ionospheric effects on GNSS signals

7. Propagation of radio signals through stochastic media
8. Machine learning in communication networks
   - Application of game theory to communication networks
9. Routing in communication networks
10. Computational algorithms.

Description of Notable Research findings /Outstanding Research findings

1. Sum-Rate Multiplicative Gain in D2D-Enabled Cellular Networks: A Game Theoretic Approach

In this research work, we considered the problem of optimisation of spectrum resource capacity through Device-to-Device (D2D) communication in a cellular network while protecting licensed users from interference. D2D communication functionality among mobile users is gaining tremendous attention as a means of meeting the demand for higher data rates and capacity in cellular networks. The challenge, however, is the problem of spectrum sharing and interference management in cellular networks with D2D users. We presented a hierarchical coalition game model to increase the overall spectrum resource capacity in a cellular network that allows D2D communication. The hierarchical game was divided into two sub-games and a D2D link can either access the network in an underlaid mode using the cellular sub-band allocation game or in the overlaid mode using the exclusive subband allocation game. These game models were used for coalition formation decisions that ensures that interference does not exceed an acceptable limit and guarantee an optimal rate for each user in the network. For each of the two sub-games developed, we proposed algorithms that detects sufficient conditions needed for stability in the coalitions formed. We presented simulation results to show that it is possible to increase the overall capacity of a cellular network, more than twice, with D2D communication without reducing the performance of licensed user communication within the cellular network by using our model.

2. Development of VHF and UHF Spectrum Optimization for Digital Services in Selected States of Nigeria

This research work is on efficient broadcast spectrum utilization for the accommodation of new digital services. The spectrum occupied by broadcast television services, especially the UHF spectrum band, has an excellent propagation characteristics that make it particularly attractive to newer technologies. There has been worldwide campaign on the spectrum that could be freed up as digital dividend from transition of analogue television to digital television. In this research work, simulation work was done using appropriate propagation model, to quantify the exact digital dividend that can be expected from this transition in Nigeria. This is particularly useful for spectrum planning purposes so that allocation of this scarce resource can be planned ahead of time. The research also considered a few digital services competing for the use of this spectrum and proposed a scheme for the allocation of this spectrum without causing harmful interference to digital television services.

Team members and their speciality

Name	Role	Speciality	Department
Dr. A.O. Gbenga-Ilori	Design of Coexistence mechanisms in Heterogeneous networks, Interference management in communication networks, Spectrum resource management, and game theoretic approach to optimising communication networks.	Communication Networks	Electrical and Electronics Engineering
Engr. H. Muhammed	Antenna designs for communication networks	Antennas	Electrical and Electronics Engineering
Dr. A.O. Akala	Study of Ionospheric effects on Satellite signals, Propagation of radio signals through stochastic media	Radiowave Propagation	Physics
Engr M.A.K. Adelabu	Radiowave propagation, Electromagnetic Compatibility (EMC) issues in communication.	Radiowave Propagation	Electrical and Electronics Engineering
Dr. O.P. Popoola	Machine learning in communication networks, Application of game theory to communication networks	Pattern recognition and machine learning	Sytems Engineering
Dr. K.A. Abdulsalam	Routing in communication networks, Computational algorithms, machine learning	Computer and network engineering	Electrical and Electronics Engineering
Dr. Chika Yinka-Banjo	Routing in communication networks and computational algorithms	Artificial intelligence and robotics	Computer Science
Dr. G.M. Sobamowo	Computational Algorithms	Computational Algorithms	Mechanical Engineering

Dr. Chika Yinka-Banjo

Engr. M.A.K. Adelabu

Dr. A.O. Gbenga-Ilori

Dr. K.A. Abdulsalam

Dr. A.O. Akala

Dr. G.M. Sobamowo

Dr. O.P. Popoola

Engr. Hisham Muhammed

Curriculum Vitae of Team members with Selected Publications

Abiodun Omowunmi GBENGA-ILORI

SURNAME: GBENGA-ILORI

OTHER NAMES: ABIODUN OMOWUNMI

DATE OF BIRTH: 6TH JANUARY, 1973 **NATIONALITY:** NIGERIAN

ACADEMIC QUALIFICATIONS WITH DATES:

- Ph.D. (ELECTRICAL ENGINEERING) – February, 2011
  Thesis Title: *DEVELOPMENT OF VHF AND UHF SPECTRUM OPTIMISATION FOR DIGITAL SERVICES IN SELECTED STATES OF NIGERIA*
- M.Eng. (COMMUNICATIONS ENGINEERING) – November, 2000
- B.Sc. (ELECRTICAL AND ELECTRONIC ENGINEERING) – December, 1996

PRESENT EMPLOYMENT

- DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING,
  UNIVERSITY OF LAGOS,
  POSITION: Senior Lecturer DURATION: OCTOBER 2012 - TILL DATE

MAIN FIELD OF RESEARCH

Frequency Spectrum Management, Interference Issues in Communication Networks, Radio Propagation Modelling for Broadcast Services, Game theory for analysis of coexistence of devices in communication network, Interference in 5G networks.

MAIN ACHIEVEMENTS

Some important publications are listed below.

- Gbenga-Ilori, A.O. and Aydin S., "Channel Access in D2D Multiuser Networks: A Game Theoretical Approach", 20th International ITG Workshop on Smart Antennas *(WSA*) conference proceedings, March *2016, Munich*, Germany, pp. 71-75.
- Sanusi O.I, and Gbenga-Ilori A.O., " LTE and Future DTV Compatibility Study in the UHF band in Nigeria", International Journal of Scientific & Engineering Research, Volume 5, Issue 6, June-2014, pp 491-497.

- GBENGA-ILORI, A.O. AND SANUSI, O.I., "MAXIMIZING TV WHITE SPACE IN NIGERIA USING AN OPTIMIZED SFN AND k-SFN NETWORK DESIGN", International Journal of Science, Environment
  and Technology, Vol. 3, No 4, 2014, PP. 1489 – 1501 .
-

- GBENGA-ILORI, A.O. AND IBIYEMI, T.S., "EFFECT OF LAND COVER (CLUTTER) ON FIELD STRENGTH PREDICTION IN URBAN AREAS", JOURNAL OF ENGINEERING RESEARCH (JER), UNIVERSITY OF LAGOS, JER-14, NO. 4, LAST QUARTER (2009), PP. 44 – 56.

- BRUGGER, R. AND GBENGA-ILORI, A.O., "SPECTRUM USAGE AND REQUIREMENTS FOR FUTURE TERRESTRIAL BROADCAST APPLICATIONS" EBU TECHNICAL REVIEW, 2009 Q4, PP. 1– 17. **http://tech.ebu.ch/docs/techreview/trev_2009-Q4_Spectrum_Brugger.pdf**

- OBIYEMI, O.O, IBIYEMI, T.S., GBENGA-ILORI, A.O., AND OJO, J.S., "PATH LOSS MODEL FOR RADIOWAVE PROPAGATION AT VHF AND UHF BANDS USING ELECTRIC FIELD STRENGTH MEASUREMENTS OVER ILORIN MIDDLE BELT, NIGERIA", IEEE EXPLORE DIGITAL LIBRARY FOR CONFERENCE ON ADVANCES IN COMPUTATIONAL TOOLS FOR ENGINNERING APPLICATIONS (ACTEA), 2ND INTERNATIONAL CONFERENCE, LEBANON, 12TH - 15TH DECEMBER, 2012, PP 43 - 46.

- GBENGA-ILORI, A.O. AND OBIYEMI O., "OPTIMIZATION OF HATA PATH LOSS MODEL FOR BROADCAST COMMUNICATION SYSTEMS IN LAGOS STATE", PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON INNOVATIONS IN ENGINEERING AND TECHNOLOGY (IET 2011), 8^{TH} – 10^{TH} AUGUST, 2011, PP. 335 – 342.

SPECIALIZED TRAINING

- Postdoctoral training at the Ruhr University of Bochum, Germany. April 2014 to September 2015.

- 2012 ICTafrica YOUNG SCHOLARS TRAINING PROGRAMME ON ICT POLICY RESEARCH AND PRACTICE, HOSTED BY RESEARCH ICT AFRICA AND THE NUNIVERSITY OF MAURITIUS, PORT-LOUIS, MAURITIUS. 3rd to 7th September, 2012.

- SIX MONTHS Ph.D. RESEARCH VISIT, FREQUENCY MANAGEMENT DEPARTMENT, INSTITUTE FUR RUNDFUNKTECHNIK, MUNICH, GERMANY. 1^{ST} APRIL 2009 – 31^{ST} SEPTEMBER, 2009.

- SCHOOL ON RADIO USE FOR DIGITAL AND MULTIMEDIA COMMUNICATIONS, THE ABDUS SALAM INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS (ICTP), TRIESTE, ITALY. 11TH FEBRUARY - 1ST MARCH, 2002 (TRAINING BY THE UNITED NATIONS/ITALIAN GOVERNMENT)

- SEVENTH COURSE ON BASIC MICROPROCESSOR LABORATORY TECHNIQUES, THE ABDUS SALAM INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS (ICTP), TRIESTE, ITALY. 27TH OCTOBER - 23RD NOVEMBER, 2001 (TRAINING BY UNITED NATIONS/ITALIAN GOVERNMENT)

PROFESSIONAL BODIES
- REGISTERED MEMBER, COUNCIL OF REGISTERED ENGINEERS OF NIGERIA (COREN)
- MEMBER, NIGERIAN SOCIETY OF ENGINEERS (MNSE)
- ASSOCIATE MEMBER, THE INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEERS (IEEE).

GRANTS/FELLOWSHIP
- African-German Network of Excellence in Science Grant for Junior Researchers 2012
- Alexander von Humboldt (AvH) Postdoctoral Fellowship Award at the Ruhr University Bochum, Germany. 2014-2015.

DISTINCTION AND HONOUR
- NUC Best Doctoral Thesis Award scheme (NUDTAS) nomination for Engineering for the year 2010.

Hisham Abubakar MUHAMMED

NAME: **Hisham Abubakar MUHAMMED**
DATE OF BIRTH: 2nd May, 1969
NATIONALITY: Nigerian
MARITAL STATUS: Married
EDUCATION:
University of Lagos: M.Sc. (1998)
University of Maiduguri B.Sc. (1991)

ACADEMIC QUALIFICATIONS:

B.Eng. (Hon), 2nd CLASS (Upper Division) University of Maiduguri 1992
M.Sc. University of Lagos 1998

PUBLICATIONS:

1. A Matrix – vector – potential Analysis of Bi-elliptical Toroidal Helical Antenna (Progress in Electromagnetics Research and Symposium Proceedings, Kuala Lumpur, Malaysia, March 27 – 30, 2012)
2. Analysis of Circular Zig-zag Thin-Wire Antenna (Progress in Electromagnetics Research and Symposium Proceedings, Marrakesh, Morocco, March 20 – 23, 2011)

SPECIALISED TRAININGS:

ERICSSON'S Understanding the New Telecomm
ERICSSON'S AXE 10
ERICSSON'S RBS 2000 Site Maintenance
ERICSSON'S RBS 2000 Operations and Maintenance (O & M)
CISCO CERTIFIED NETWORK ASSOCIATED (CCNA)
Networking Basics
Router and Routings Basics
IT Essentails

LANGUAGES: Speaking Reading Writing
English : Excellent
Hausa : Excellent
Fulfulde Fluent : Very good

COUNTRIES OF WORK: Nigeria
EMPLOYMENT RECORD: ORGANIZATION
University of Lagos 2000 – DATE
Dornier International Logistics 1993 – 1999

Dr Andrew O. AKALA

Dr. C. Yinka-Banjo

Khadeejah Adebisi ABDULSALAM

NAME: Abdulsalam, Khadeejah Adebisi (nee Adigun)

PLACE & DATE OF BIRTH : Ibadan & 22nd February 1971

PRESENT ADDRESS:
Dept of Electrical & Electronics
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NATIONALITY AT BIRTH: Nigerian

EDUCATIONAL BACKGROUND

Secondary and Post-Secondary Education with Dates

University of Lagos, Akoka	2008– 2016
Obafemi Awolowo University, Ile-Ife	1999 – 2005
Obafemi Awolowo University, Ile-Ife	1990 – 1997

Academic and Professional Qualifications with Dates

- PhD
  2016
- MSc Computer Science 2005
- B.Sc Computer Engineering ***(2nd Class Upper Division)*** 1997

  - Corporate member, Nigeria Society of Engineers (NSE)
  - Member, Nigerian Computer Society (NCS)
    (Formerly Computer Association of Nigeria, COAN)
  - COREN (registered) R.10,184

STATEMENT OF EXPERIENCE

- Lecturer II — Dept of Electrical & Electronics
  (April 2009 till date) University of Lagos
  Akoka, Lagos
- Lecturer II: — Department of Computer Science
  (June 2005 to Nov 2005) Yaba College of Technology, Yaba
- Part time lecturer: — September 2004 to May 2005
  Department of Computer Science
  Yaba College of Technology, YABA
- Graduate Assistant:
  (1998 to 2004) — Department of Computer Sc. & Engineering
  Obafemi Awolowo University, Ile-Ife

  - Trainee Engineer:
    (NYSC 1997 – 1998) — The Nigerian Shippers Council, Abuja
  - Internee (1995) — Frontline Computers, Sango Ibadan

CURRENT RESEARCH

Computation Algorithm, Computer Engineering and Routing in Networks.

PUBLICATIONS

1. **Adigun, A A** 1997, Unpublished B.Sc Thesis: Design and Implementation of a Digital Calendar
2. **Adigun, A A** 2004, Unpublished M.Sc Thesis: Development of a Routing Technique for Ad-hoc Wireless Network
3. **Abdulsalam KA**, 2006, Towards a Balanced Society: The ICT Challenge: APWEN Conference Abuja 2006
4. **Abdulsalam KA**, 2006, Framework for Increasing Women Participation in Engineering Education in Nigeria APWEN Conference Abuja 2006
5. Bello S.A., Sanni M.L**.** and **AbdulSalam K.A.,** "Framework for the Utilization of ICT by Women in Cottage Enterprise" 2nd AICTTR International Conference. Nigeria, 2007.
6. **Abdulsalam KA,** Bello SA, Sanni ML, "An Efficient Routing Technique for an Adhoc Wireless Network", International Journal of Nigeria Computer Society Vol 15 No1, June 2008
7. O. Adegbenro, **K A Abdulsalam**, O A Alli & K A Ladokun, "In-Phase Synchronisation Of Two Different Chaotic Systems Using Active Control Approach" 4th Annual UNILAG Research Conference And Fair Proceedings, Jan 2009

Published Non- Refereed Conference Proceedings

Sanni M.L., **Abdulsalam K.A**., Aderounmu G.A. Bello S.A. and Eludiora S.I", Framework for Remote Experiment Design for Computer Engineering Undergraduates. IEEE/IET Conference. Nigeria 2007

6. Dr. G.M. Sobamowo

Michael Adedosu Kolawole ADELABU, FNSE, MIEEE, RE, FLI

Electrical and Electronics Engineering Department,
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- A COREN registered engineer with over twenty five years experience and proven knowledge of electronic circuits and telecommunication systems
- An environmental studies expert on energy use and the environment.

Academic

- M.Sc Electronics (Telecommunications), Wroclaw University of Technology, Poland 1984
- PGD Comp Science , University of Lagos 1991
- PhD Electrical Engineering, University of Lagos -*in view* 2016

Current Research Interests

- Evaluation of Mobile Networks Propagation Characteristics and Development of Path Loss Models
- Development Renewable Energy systems and Application in Telecommunication Networks

Professional Experience

- University of Lagos, Faculty of Engineering 1993 – date
  - Lecturer in Dept of Electrical and Electronics Engineering , with research focus on telecommunication networks, and electromagnetic compatibility.

OTHER PROFESSIONAL SERVICES

- . He has conducted research and carried out studies on telecommunication networks, electromagnetic compatibility and energy utilization and optimization in telecommunication networks. These include:
  - Environmental Impact Assessment/ Environmental Evaluation Studies involving Electromagnetic/Radio Frequency Radiation Measurement on Vmobile BTS/BSCs in South West Region
  - ICT-Africa – Survey of ICT usage in Africa (Nigeria)
- He is a Faculty Member (Energy) at Leadership for Environment and Development, Anglophone West Africa (LEAD-AWA)

CONFERENCES AND PUBLICATIONS

Engr. Adelabu participated in several national and international conferences, seminars and workshops, several of which he presented papers. To his credit are over twenty five paper contributions to learned journals and conferences, seminars and workshops. He also edited or co-edited two conference proceedings and a collection of professional lectures delivered under the auspices of Nigerian Society of Engineers (Lagos Branch) on themes that address national development.

OTHER ACTIVITIES

Engr. Adelabu has served or is currently serving as External Examiner or assessor to several academic institutions and professional bodies – Nigerian Society of Engineers, Council for Regulation of Engineering and West African Examination Council.

He also served or is currently serving on several statutory or Ad-Hoc committees or Boards of the University.

References :

1. Hojeong K. (2009). "Internet Connection", Retrieved May 2016 from: http://www.edb.utexas.edu/minliu/multimedia/PDFfolder/InternetConnections.pdf.

2. FCC Report (2015). "FCC Finds U.S. Broadband Deployment Not Keeping Pace", Retrieved in May 2016 from: https://apps.fcc.gov/edocs_public/attachmatch/DOC-331760A1.pdf.

3. Koutroumpis, P. (2009). The Economic Impact of Broadband on Growth: A Simultaneous Approach. ITU Telecommunications Policy Report No. 33, 471-485.

4. FCC Report (2014). "Types of Broadband Connections", Retrieved in May 2016 from: https://www.fcc.gov/general/types-broadband-connections.

5. GSMA (2014). “GSMA M4D Impact: Country Overview – Nigeria” Retrieved in April 2016 from:http://draftcontent.gsmaintelligence.com/AR/assets/4161587/GSMA_M4D_Impact_County_Overview_Nigeria.pdf.
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8. Ogbodo, D. (2016). “/ Danbatta: Why FG Can’t Achieve 30% National Broadband Target by 2018”, Retrieved in April 2016 from: http://www.thisdaylive.com/index.php/2016/04/03/11724/ Danbatta: Why FG Can’t Achieve 30% National Broadband Target by 2018.
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11. Alliance for Affordable Internet (2014). “Nigeria: How Africa’s Largest Economy is Prioritising Affordable Internet”, Retrieved in May 2016 from: https://a4ai.org/wp-content/uploads/2014/07/Nigeria-Case-Study_FINAL.pdf#
12. Ibikunle, F. et.al. (2013). "Broadband Wireless Access Deployment Approach to Rural Communities." Journal of Computer Networks 1.3 pp. 38-45.
13 Informa Telecoms and Media (2012). “Telecommunication Research Agenda”, Retrieved in March 2016 from: http://www.informatandm.com/wp-content/uploads/2012/04/iDirect-White-Paper_online.pdf
14. Loong Y. et.al. (2014). “Recent Advances in Radio Resource Management for Heterogeneous LTE/LTE-A Networks “, IEEE Communication Surveys and Tutorials, Vol. 16, No. 4, 2014.
15. Research ICT Africa,(2012). “The Nigerian National Broadband Plan 2013-2018”, Retrieved in March 2016 from: http://www.researchictafrica.net/countries/nigeria/Nigeria_National_Broadband_Plan_2013-2018.pdf