

**THE 13TH INTERNATIONAL CONFERENCE
ON ADVANCED TECHNOLOGIES FOR
COMMUNICATIONS (ATC)**

ATC 2020

*October 08 - 10, 2020
Nha Trang, Vietnam*



Table of Contents

Message from the ATC 2020 General Chairs	ix
Message from the Rector, TCU	x
Message from the REV President	xi
Executive Committee	xii
Technical Program Committee	xiii
Additional Reviewers	xix
Keynote Abstracts	xx
Invited Talk Abstracts	xxiii

S1: Networks

- *Fiber wireless and optical wireless communications using high-speed photonic devices*

Toshimasa Umezawa (National Institute of Information and Communication Technology, Japan), Tien Dat Pham (National Institute of Information and Communications Technology, Japan), Atsushi Kanno (National Institute of Information and Communications Technology, Japan), Naokatsu Yamamoto (National Institute of Information and Communications Technology, Japan) 1

- *A Survey on Prediction of PQoS Using Machine Learning on Wi-Fi Networks*

Maghsoud Morshedi (University of Oslo & EyeNetworks AS, Norway), Josef Noll (University of Oslo, Norway) 5

- *Performance Enhancement of Satellite FSO/QKD Systems using HAP-based Relaying and ARQ*

Nam Nguyen (Posts and Telecommunications Institute of Technology, Vietnam), Hang Phan (Hanoi University of Industry, Vietnam), Hien Pham (Posts and Telecommunications Institute of Technology, Vietnam), Vuong Mai (KAIST, Korea (South)), Ngoc Dang (Posts and Telecommunications Institute of Technology, Vietnam) 12

- *Improving the feature set in IoT intrusion detection problem based on FP-Growth Algorithm*

Le Thi Hong Van (Academy of Cryptography Techniques, Vietnam), Pham Van Huong (Academy of Cryptography Techniques, Vietnam), Le Duc Thuan (Academy of Cryptography Techniques, Vietnam, Vietnam), Minh Nguyen (Academy of Cryptography Techniques, Vietnam) 18

- *Performance analysis and optimization of hybrid fiber/FSO dual-polarization 16-QAM data link under different weather conditions*

Kiem Nguyen Hong (Le Quy Don Technical University, Vietnam), Quang Nguyen-The (Le Quy Don Technical University, Vietnam), Binh Nguyen Duc (Le Quy Don Technical University, Vietnam), Hung Nguyen Tan (Danang Uni. of Science & Technology, Vietnam), Van Dien Nguyen (Danang Uni. of Science & Technology, Vietnam), Tuan Nguyen-Van (Danang University of Science and Technology (DUT), Vietnam), Phuong Vuong Quang (Hue University, Vietnam), Dong-Nhat Nguyen (Czech Technical University in Prague, Czech Republic) 24

• *Multilevel Modulation Coding for Four-Level Holographic Data Storage Systems*

Chi Dinh Nguyen (Phenikaa University, Vietnam), Pham Xuan Nghia (Le Quy Don Technical University, Vietnam), Cuong Chinh Duong (Phenikaa University, Vietnam), Nguyen Cong Luong (Phenikaa University, Vietnam) 30

• *On the Capacity of MRT/MRC Diversity Technique in Full-Duplex Relay System with Hardware Impairments over Rayleigh Fading Environments*

Ba Cao Nguyen (Telecommunications University, Vietnam), Xuan Hung Le (Telecommunications University, Vietnam), Xuan Nam Tran (Le Quy Don Technical University, Vietnam), Dung Le The (Chungbuk National University, Korea (South)) 35

S2: IC Design and Verification

• *New Methods for Anomaly Detection: Run Rules Multivariate Coefficient of Variation Control Charts*

Phuong Hanh Tran (Institute of Artificial Intelligence and Data Science, Dong A University, Vietnam & HEC Liège - Management School of the University of Liège, Belgium), Athanasios C. Rakitzis (University of Aegean, Greece), Nguyen Huu Du (Institute of Artificial Intelligence and Data Science, Dong A University, Danang, Vietnam), Quoc Thong Nguyen (HEC Liège Management School of the University of Liège & Dong A University, Belgium), Phuong Hien Tran (Institute of Artificial Intelligence and Data Science, Dong A University, Da Nang & Danang University of Economics, Vietnam), Kim Phuc Tran (ENSAIT & GEMTEX Laboratory, France), Cédric Heuchenne (HEC Liège - Management School of the University of Liège, Belgium) 40

• *7.6 uW Ambient Energy Harvesting Rectenna from LTE Mobile phone Signal for IoT Applications*

Linh Thuy Nguyen (Le Quy Don Technical University, Vietnam), Yasuo Sato (The University of Electro-Communications, Japan), Koichiro Ishibashi (The University of Electro-Communications, Japan) 45

• *A thermal distribution, lifetime reliability prediction and spare TSV insertion platform for stacking 3D-ICs*

Khanh N. Dang (Vietnam National University, Hanoi, Vietnam), Akram Ben Ahmed (Keio University, Japan), Fakhrol Zaman Rokhani (University Putra Malaysia, Malaysia), Abderazek Ben Abdallah (The University of Aizu, Japan), Xuan-Tu Tran (Vietnam National University, Hanoi, Vietnam) 50

• *An Improved Wide-Band Referenceless CDR with UP Pulse Selector for Frequency Acquisition*

Ha Pham Manh (Vietnam Telecommunications Authority, Vietnam), Tho Nguyen Huu (Le Quy Don Technical University, Vietnam), Thanh Nguyen (Le Quy Don Technical University, Vietnam), Quang Nguyen-The (Le Quy Don Technical University, Vietnam) 56

• *Integrated silicon optical switch for high-speed network-on-chip*

Ho Duc Tam Linh (Danang University of Science and Technology & Hue University of Sciences, Vietnam), Nguyen Van Quang (Hue University of Sciences, Vietnam), Dao Duy Tu (Hue University of Sciences, Vietnam), Nguyen Van An (Hue University of Sciences, Vietnam), Vuong Quang Phuoc (Hue University of Sciences, Vietnam) 61

• *GaN HEMT thermal characteristics evaluation using an integrated approach based on the combined use of first-principles and device simulations*

Maryia Baranova (Belarusian State University of Informatics and Radioelectronics, Belarus), Dzmitry Hvazdouski (Belarusian State University of Informatics and Radioelectronics, Belarus), Vladislav Volcheck (Belarusian State University of Informatics and Radioelectronics, Belarus), Viktor R. Stempitsky (Belarusian

S3: Communications

- *Orchestration of Wired and Wireless Systems for Future Mobile Transport Network*

Tien Dat Pham (National Institute of Information and Communications Technology, Japan), Atsushi Kanno (National Institute of Information and Communications Technology, Japan), Naokatsu Yamamoto (National Institute of Information and Communications Technology, Japan), Tetsuya Kawanishi (Waseda University & National Institute of Information and Communications Technology, Japan) 70

- *An Initial Acquisition Scheme Combined with Carrier Recovery for Modified Walsh-Hadamard Code Division Multiplexing*

Toshiharu Kojima (The University of Electro-Communications, Japan), Yota Yamamura (The University of Electro-Communications, Japan) 74

- *An Improved AFC Scheme for Modified Walsh-Hadamard Code Division Multiplexing*

Anna Himeno (The University of Electro-Communications, Japan), Toshiharu Kojima (The University of Electro-Communications, Japan) 79

- *A Comparison of Three-node Two-way PLC Channel Models*

Angie Ann Gie Liong (Curtin University Malaysia, Malaysia), Lenin Gopal (Curtin University Malaysia, Malaysia), Filbert H. Juwono (Curtin University Malaysia, Malaysia), Choo Wee Raymond Chiong (Curtin University, Malaysia), Yue Rong (Curtin University, Australia) 84

- *Secrecy Throughput Analysis of Energy Scavenging Overlay Networks with Artificial Noise*

Pham Thi Dan Ngoc (PTITHCM, Vietnam), Bao Ho-Quoc (Ho Chi Minh City University of Technology, Vietnam), Khuong Ho-Van (HoChiMinh City University of Technology, Vietnam), Thiem Do-Dac (Thu Dau Mot University, Vietnam), Phong Nguyen - Huu (Broadcast Research & Application Center (BRAC), Vietnam Television (VTV), Vietnam), Son Vo Que (HoChiMinh City University of Technology, Vietnam), Pham Ngoc Son (Ho Chi Minh City University of Technology and Education, Vietnam), Lien Pham Hong (University of Technical Education, Vietnam) 90

- *An Analysis of the Coded MIMO-OFDMA System Performance by Using the Spatial Wideband GBSM Channel Modeling Methods*

Nguyen Thu Nga (Hanoi University of Science and Technology, Vietnam), Nguyen Thi Ha (Hanoi University of Science and Technology, Vietnam), Nguyen Anh Bang (Hanoi University of Science and Technology, Vietnam), Nguyen Van Duc (Ha Noi University of Science and Technology, Vietnam), Nguyen Tien Hoa (Hanoi University of Science and Technology, Vietnam) 95

- *OLED-Based Visible Light Communication System Using Universal Filtered Multi-Carrier*

Khanh Nghi Vinh (HoChiMinh City University of Technology, Vietnam), Thai Pham Quang (HoChiMinh City University of Technology, Vietnam), Thanh Dinh Vu (HoChiMinh City University of Technology, Vietnam), Khuong Ho-Van (HoChiMinh City University of Technology, Vietnam), Tien Dat Pham (National Institute of Information and Communications Technology, Japan), Hung Nguyen Tan (Danang Uni. of Science & Technology, Vietnam) 101

- *Secrecy Performance Analysis for MIMO Relay System with Transmit/Receive Antenna Selection under Imperfect CSI*

Chu Tien Dung (Telecommunications University, Vietnam), Xuan Hung Le (Telecommunications University, Vietnam), Hoang Tran Manh (Telecommunications University, Vietnam, Vietnam), Hoang Van Toan (Telecommunications University, Vietnam), Dung Le The (Chungbuk National University, Korea (South)) 106

S4: Microwave Engineering & Antennas

- *TE Plane Wave Diffraction by Window Aperture on a Thick Conducting Wall*

Khanh Nguyen (Chuo University & Graduate School of Science and Engineering, Japan), Hiroshi Shirai (Chuo University, Japan) 111

- *High Gain Folded Loop-based Multilayer Antenna at 2.4 GHz Band for Far-Field RFID Reader*

Thanh Huong Nguyen (Hanoi University of Science and Technology & MICA, Vietnam), Do Hanh Ngan Bui (Université de Grenoble-Alpes, France), Tan Phu Vuong (Grenoble INP, France) 116

- *Genetic Programming for automated Synthesizing 3D Artificial Magnetic Conductor*

Khac Son Nguyen (Hanoi University of Science and Technology, Vietnam), Thuan Bui Bach (Hanoi University of Science and Technology, Vietnam), Bui Manh Cuong (Hanoi University of Science and Technology, Vietnam), Hoa Phuong Tran Thi (Hanoi University of Science and Technology, Vietnam), Nguyen Khac Kiem (Hanoi University of Science and Technology, Vietnam), Son Xuat Ta (Hanoi University of Science and Technology, Vietnam), Chien Ngoc Dao (Hanoi University of Science and Technology, Vietnam) 121

- *A Reflectarray Antenna Using Crosses and Square Rings for 5G Millimeter-Wave Application*

Hoang Dang Cuong (Le Quy Don Technical University, Vietnam), Minh Thuy Le (School of Electrical Engineering, Hanoi University of Science and Technology, Vietnam), Nguyen Quoc Dinh (Le Quy Don Technical University, Vietnam) 126

- *A Sequentially Rotated Array of Polarization-Conversion Patch Antenna Using Metasurface*

Kieu Trang Pham-Thi (Hanoi University of Science and Technology, Vietnam), Son Xuat Ta (Hanoi University of Science and Technology, Vietnam), Huu Truong Le (Hanoi University of Science and Technology, Vietnam), Nguyen Khac Kiem (Hanoi University of Science and Technology, Vietnam), Chien Ngoc Dao (Hanoi University of Science and Technology, Vietnam) 131

- *Caustics and Beam Steering Calculations of Negative Refractive Index Lens Antenna by the Ray Tracing Method*

Phan Van Hung (Le Quy Don Technical University, Vietnam), Nguyen Quoc Dinh (Le Quy Don Technical University, Vietnam), Dang Tien Dung (Telecommunications University, Vietnam), Yoshihide Yamada (Malaysia-Japan International Institute of Technology, Universiti Teknologi Malaysia) 136

- *Ambient RF Energy Harvesting System Based on Wide Angle Metamaterial Absorber for Battery-Less Wireless Sensors*

Quang Minh Dinh (School of Electrical Engineering, Hanoi University of Science and Technology, Vietnam), Minh Thuy Le (School of Electrical Engineering, Hanoi University of Science and Technology, Vietnam) 140

- *A Dual-Polarized Wideband Element Antenna for Base Station Application*

Tran Thi Lan (University of Transport and Communications, Vietnam & Yokohama National University, Japan), Lam Phi (University of Transport and Communications, Vietnam), Do Toan (Viettel High Technology Industries Corporation, Vietnam), Duc Nhat Nguyen (Viettel High Technology Industries Corporation, Vietnam), Hoang Truyen (Viettel High Technology Industries Corporation, Vietnam), Minh Thuy Le (School of Electrical Engineering, Hanoi University of Science and Technology, Vietnam) 145

S5: Signal Processing

- *A Novel Three Steps Method for Forest Parameters Extraction Using PolInSAR Images*

Cuong Thieu Huu (Le Quy Don Technical University, Vietnam), MinhNghia Pham (Le Quy Don Technical University, Vietnam) 149

- *New H.266/VVC Based Multiple Description Coding for Robust Video Transmission over Error-Prone Networks*

Dinh Trieu Duong (VNU, Vietnam) 155

- *Optimal Polarization Channel Method for Estimating Forest Height from PolInSAR Images*

Cuong Thieu Huu (Le Quy Don Technical University, Vietnam), MinhNghia Pham (Le Quy Don Technical University, Vietnam) 160

- *An Implementation of a Robust Visual Object Tracking System*

An Hoang Nguyen (International University, Vietnam), Linh Mai (International University, Vietnam, Vietnam), Hung Ngoc Do (International University, Vietnam) 166

- *Enhancing Quality for VVC Compressed Videos with Multi-Frame Quality Enhancement Model*

Xiem Hoang (VNU-UET, Vietnam), Huu-Hung Nguyen (Le Quy Don Technical University, Vietnam) 172

- *Micro-Doppler-Radar-Based UAV Detection Using Inception-Residual Neural Network*

Hai Le (Le Quy Don Technical University, Vietnam), Sang Van Doan (Vietnam Naval Academy, Vietnam), Phong Le (Le Quy Don Technical University, Vietnam), Huu-Hung Nguyen (Le Quy Don Technical University, Vietnam), Thien Huynh-The (Kumoh National Institute of Technology, Korea (South)), Le-Ha Khanh (Le Quy Don Technical University, Vietnam), Van-Phuc Hoang (Le Quy Don Technical University, Vietnam) 177

- *An Efficient Iteration Procedure for the Cluster Newton Method in Inverse Parameter Identification of Pharmacokinetics*

Tran Quang-Huy (Ha Noi Pedagogical University No2, Vietnam), Yen Nguyen Hoang (Hanoi National University of Education, Vietnam), Van Tu Duong (NTT Hi-Tech Institute – Nguyen Tat Thanh University, Vietnam), Tien-Anh Nguyen (Le Quy Don Technical University, Vietnam), Nguyen Canh Minh (University of Transport, Vietnam), Tran Duc-Tan (Phenikaa University, Vietnam) 182

- *Vision based steering angle estimation for autonomous vehicles*

Khanh Du Nguyen Tu (Hanoi University of Science and Technology, Vietnam), Dung Nguyen (Hanoi University of Science and Technology, Vietnam), Thanh-Hai Tran (Hanoi University of Science and Technology, Vietnam) 187

S6: Electronics & Communication Systems

- *An Early Termination Technique of Polar Codes for IR-HARQ Scheme*

Krittayaporn Mueadkhunthod (King Mongkut's Institute of Technology Ladkrabang, Thailand), Watid Phakphisut (King Mongkut's Institute of Technology Ladkrabang, Thailand), Lin Myint (King Mongkut's Institute of Technology Ladkrabang, Thailand), Pornchai Supnithi (King Mongkut's Institute of Technology Ladkrabang, Thailand) 193

- *Design of Partition Decoding for Polar Codes in 5G New Radio*
-

Anusorn Wongsra (King Mongkut's Institute of Technology Ladkrabang, Thailand), Watid Phakphisut (King Mongkut's Institute of Technology Ladkrabang, Thailand), Lin Myint (King Mongkut's Institute of Technology Ladkrabang, Thailand), Pornchai Supnithi (King Mongkut's Institute of Technology Ladkrabang, Thailand) 199

• *Efficiency Comparison of Cooperative Inductive Power Transfer Systems*

QuocTrinh Vo (Nara Institute of Science and Technology, Japan), Quang-Thang Duong (Nara Institute of Science and Technology, Japan), Minoru Okada (Nara Institute of Science and Technology, Japan) 205

• *Fast Multiplication in Binary Field on ARMv8 Processors*

Luc Pham Van (Posts and Telecommunications Institute of Technology, Vietnam), Dang Hai Hoang (Ministry of Information and Communications & Post and Telecommunication Institute of Technology, Vietnam) 210

• *3D Hand Pose Estimation Using Hand PointNet on Egocentric Datasets*

Le Hung (Tan Trao University, Vietnam), Van-Nam Hoang (Hanoi University of Science and Technology, Vietnam), Hai Vu (International Research Institute MICA, Hanoi University of Science and Technology, Vietnam), Thi-Lan Le (MICA, HUST, Vietnam), Thanh-Hai Tran (Hanoi University of Science and Technology, Vietnam), Viet-Vu Vu (Information Technology Institute - Vietnam National University, Hanoi, Vietnam) 215

• *Predicting heart failure using deep neural network*

Minh Tuan Le (International University, Vietnam), Minh-Thanh Vo (International University, Vietnam), Linh Mai (International University, Vietnam), Vu Truong Son Dao (International University, Vietnam) 221

• *Design, Fabrication Transmitter Modulator at S band for MicroSatellite with the direct RF input*

Ha Thi Bui (VietNam Space Center & VietNam National Satellite Center, Vietnam), Duong Bach Gia (VNU University of Engineering and Technology, Vietnam), Chinh Doan Tran (Vietnam National University - Hanoi, Vietnam) 226

• *A Design of DSP, CPU architecture on FPGA for secure routers*

Bao Bui Quoc (Ho Chi Minh City University of Technology, Vietnam), Phu Nguyen (Ho Chi Minh City University of Technology, Vietnam), Hoang Trang (Ho Chi Minh City University of Technology) 231

• *Design a Simulation Model of Multi-radio Mobile Node in MANET*

Anh Ngoc Le (Electric Power University, Vietnam), Van Minh Le (Vinh University, Vietnam) 237

Author index.....241

Papers by title.....250

Design a Simulation Model of Multi-radio Mobile Node in MANET

Anh Ngoc Le
Faculty of Electronics and Telecommunications
Electric Power University
 Hanoi, Vietnam
 anhngoc@epu.edu.vn

Van Minh Le
School of Engineering and Technology,
Vinh University
 Nghe An, Vietnam
 minhhdhvinh@gmail.com

Abstract— In this paper, we present a solution to design a simulation model for mobile node with multiple radio interfaces in mobile ad-hoc wireless networks (MANET). This solution extends the mobile node architecture in NS2 network simulator to allow analysis and evaluation of the performance of multi-channel mobile ad-hoc wireless networks. Simulation results show that the effectiveness of multi-radio mobile node model. Network performance with new mobile node architecture is greatly improved as the number of wireless interfaces increased.

Keywords— mobile adhoc networks, routing, multichannel, simulation

I. INTRODUCTION

Wireless ad hoc networks or Mobile Ad Hoc Networks (MANET) are one of the wireless access network models that has been widely used in many fields of military, health, education, transportation, aviation, shipping, research expedition [1]. The basic feature of MANET is that the mobile nodes communicate equally with each other through a wireless environment, without a pre-existing infrastructure. Each mobile node can act as both a server and a router. MANET's topology dynamically varies with the movement of the node. Therefore, the routing table at each node must also be updated regularly depending on the network state (Figure 1).

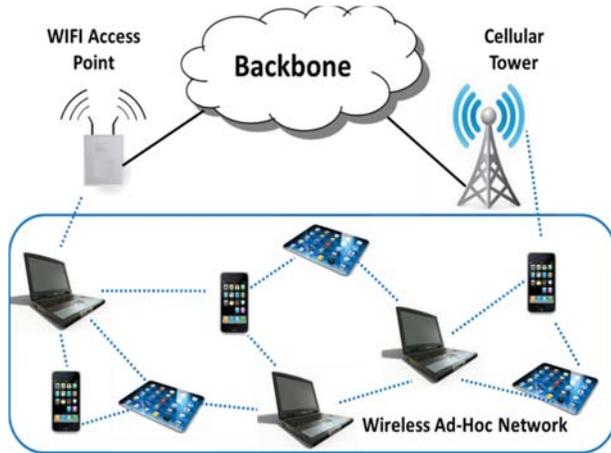
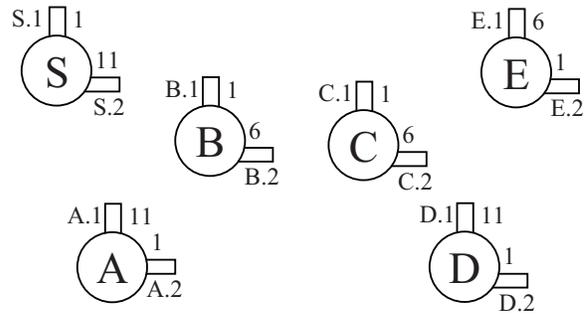


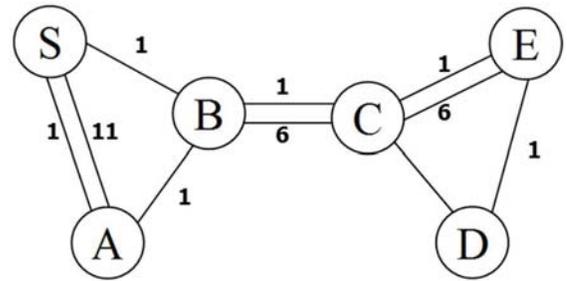
Figure 1. Wireless ad hoc network.

The principle of multi-hop communication in MANET has caused a serious decrease in throughput due to intra-flow interference and inter-flow interference. Accordingly, all mobile nodes have a radio interface that establishes the same frequency channel, because the characteristics of wireless nodes can only communicate with each other on the same frequency channel, which leads to performance of MANET is reduced [2]. To solve this problem, the solution of using multiple radio interfaces at mobile nodes and assigning non-

overlapping channels to those interfaces will allow to increase the capacity of the MANET network [3,4]. In practical deployment of MANET networks, the IEEE 802.11 family of standards is widely used. The IEEE 802.11 standard allows non-overlapping channels in the 2.4 GHz and 5 GHz bands. For example, the 802.11b/g standard operates in the 2.4GHz band with 3 non-overlapping channels: 1, 6, 11; The 802.11a standard operates in the 5GHz band with 12 non-overlapping channels. This allows the use of multiple IEEE 802.11 radio interfaces at mobile nodes for MANET to increase network capacity. Figure 2a illustrates a multi-channel MANET network with 02 radio communications at network nodes. These interfaces are assigned with non-overlapping channels 1, 6, 11. The result of this channel assignment creates a new network topology as a multi-graph that is more efficient due to the use of different channels on different links for simultaneous transmission (Figure 2b).



(a) Mobile nodes with 2 radios.



(b)MANET's topology as a multi-graph.

Figure 2. Multi-channel MANET.

Some methods can be applied to evaluate the performance of multi-channel MANET network by using simulation model, mathematical analysis model or empirical measurement. In the method of modeling and simulation of the MANET network, the studies mainly use the current popular network simulation software such as NS2, OMNeT++ or OPNET. Many researchers [1,5,6] used NS2 simulator to

III. PERFORMANCE EVALUATION

A. Simulation parameters

A mobile ad hoc network with nodes randomly deployed on an area of 1000m x 1000m. Mobile nodes have the same number of wireless interfaces established with non-overlapping channels, the channel assignment scheme is the same for all nodes. UDP connections are established between 50 mobile nodes to 01 mobile node acting as a gateway at a rate of 20 packets per second. Radio interfaces follow the IEEE 802.11 b/g standard used in the simulation, these standards have 3 non-overlapping channels 1, 6 and 11, different interfaces are established by different non-overlapping channels. AODV routing protocol is used and improved in the direction that routing broadcast packets are sent on all wireless interfaces. Other simulation parameters are shown as Table 1.

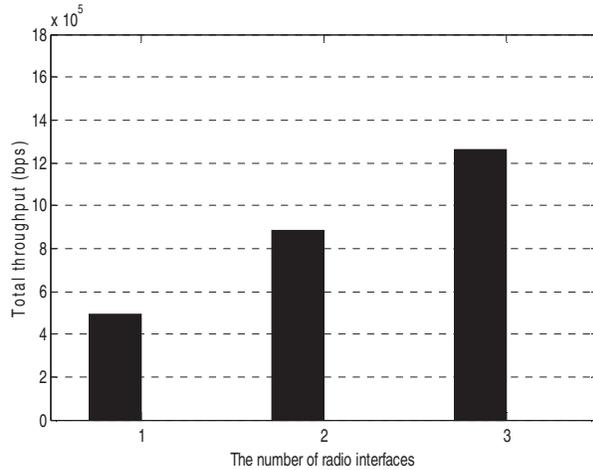


Figure 5. Throughput vs. the number of wireless interface at nodes in MANET

B. Simulation results

In order to evaluate the efficiency of the new mobile node architecture, the network performance parameters used for evaluation including throughput and delay.

- **Throughput:** This is defined as the amount of data that is transmitted through the network per unit time, (i.e., data bytes delivered to their destinations per second).
- **End-to-end delay of data packets:** This is defined as the delay between the time at which the data packet originated at the source and the time it reaches the destination.

The simulation scenario is similarly applied to mobile nodes with the number of wireless interfaces. Figure 5 shows that the network throughput of MANET is improved, when increasing the number of wireless interface at mobile nodes. With 2 radio interfaces assigned to 2 non-overlapping channels, the network throughput is doubled compared to using only one interface.

As shown in Figure 6, the end-to-end delay is significantly improved when increasing the number of wireless interfaces at each mobile node. The main reason is because of more route choices in multi-graph. In addition, the routes with high

channel diversity are preferred thereby reducing inter-flow and intra-flow interference.

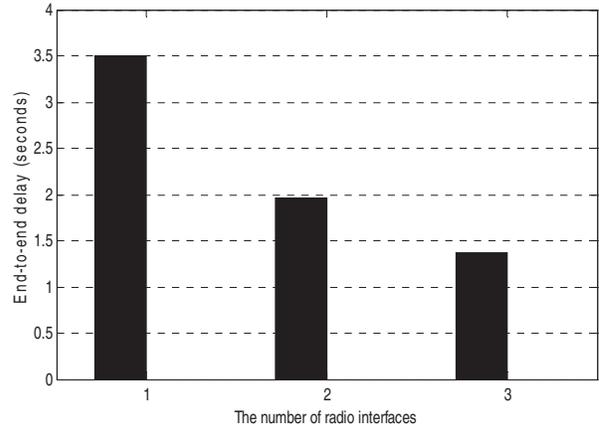


Figure 6. End-to-end delay vs. the number of wireless interface at nodes in MANET

IV. CONCLUSIONS

In this paper, we have presented a solution to design multi-radio mobile node for mobile ad hoc network in NS2 simulator. In addition, the paper also presented the solution to improve AODV routing protocol as well as with other routing protocols based on multi-radio mobile node architecture. The simulation results show the effectiveness of the multi-channel mobile ad-hoc networks. The performance of MANET with multi-radio mobile node architecture is significantly improved according to the number of interfaces and the number of non-overlapping channels assigned.

REFERENCES

- [1] C. K. Toh, A.N. Le and Y.Z. Cho, "Load balanced routing protocols for ad hoc mobile wireless networks," IEEE Communications Magazine, vol.47, No.8, pp. 78-84, 2009.
- [2] B. Muthuramalingam, S. Bhashyam, and A. Thangaraj, "Processing interference at the physical layer to enhance information flow in wireless networks," in Proc. IEEE 3rd Int. Conf. Commun. Syst. Netw. (COMSNETS), Jan. 2011, pp. 1-6.
- [3] Chandrakanth Chereddi, Pradeep Kyasanur, and Nitin H. Vaidya, "Design and implementation of a multi-channel multi-interface network," In Proc. 2nd International Workshop on Multi-hop Ad hoc Networks (REALMAN '06), 2006.
- [4] Mashraqi Aisha Mousa, Throughput Optimisation in Multi-Channel Wireless Mesh Networks. University of Leicester. Thesis. <https://hdl.handle.net/2381/40810>, 2017.
- [5] Ayush Pandey and Anuj Srivastava, Performance Evaluation of MANET through NS2 Simulation, International Journal of Electronic and Electrical Engineering, Volume 7, Number 1, pp. 25-30, 2014.
- [6] S. Mohapatra, P. Kanungo, Performance Analysis of AODV, DSR, OLSR and DSDV Routing Protocols using NS2 Simulator, Procedia Engineering, Volume 30, 2012.
- [7] The Network Simulator NS2. Available: <http://www.isi.edu/nsnam/ns>
- [8] K. Fall and K. Varadhan, Eds., *The ns Manual*, The VINT Project, UC Berkeley, LBL, USC/ISI, and Xerox PARC, Apr. 2002. available: <http://www.isi.edu/nsnam/ns/>.
- [9] C. E. Perkins, and E. M. Royer, *Ad hoc on-demand distance vector routing*, in Proc. of the 2nd IEEE workshop on Mobile Computing Systems and Applications, pp. 90-100, 1999.