A Comparison of Homogeneous vs Heterogeneous Choice of Routing Protocols in Integrated Wireless Networks

ISSN (e) 2520-7393
ISSN (p) 2521-5027
Received on 8th Aug, 2017
Revised on 5th Oct, 2017
www.estirj.com

Khalid Hussain Mohammadani[1]*, Hameedullah Kazi[2], Arshad Shaikh[2], Ibrahim Channa[3], Safi Faizullah[4]

[1,2]*Department of Computer Science ISRA University, Hyderabad, Pakistan.*
[3]*Department of Computer Science Quaid-e-Awam University of Engineering Sciences and Technology.*
[4]*Department of Computer Science, Islamic University of Madina, Saudi Arabia*

Abstract: Mobile Ad-hoc Networks (MANETs) are meant for establishing quick communication between nodes in a closed group present in a small geographical area. It is very likely that the nodes within a MANET may wish to communicate with nodes in some other MANET or wish to access the internet. Such communication is possible by deploying gateways within each MANET to allow access to the outside world. In a typical multi-MANET scenario, gateways belonging to these MANETs may be interconnected via some infrastructure oriented network (e.g.: wired mesh, radio links or GSM etc.) Such networks are termed as integrated wireless networks. In an integrated wireless network, all the component MANETs may be forced to use a common routing protocol or they may be set loose to opt for any routing protocol. We call the former "Homogeneous choice" and the later "Heterogeneous choice". This paper goals to evaluate the execution of two MANET routing protocols in such integrated/hybrid wireless network and try to answer the question whether a homogenous choice of routing protocol has any edge over the heterogeneous choice of the routing protocols.

Keywords: *Integrated wireless network, hybrid mobile ad-hoc network [1], wired-cum-wireless network [1], reactive, proactive and hybrid routing protocols.*

1. Introduction

The last two and a half decades have seen a significant increase in the use of mobile wireless communications [2].The presence of Wi-Fi has become a norm for any urban facility including homes and offices. Mobile phones have already become a need of everyday life. The introduction of 3G and 4G data communications over the GSM infrastructure has increased the use of wireless communication by leaps and bounds [3]. However, the need to pre-deploy infrastructure to establish communication has been identified as a big hurdle in many applications like wireless sensor network (WSN); and therefore, it is more desirable to the have an infrastructure-less ad-hoc network like MANETs. However, so far, these ad-hoc networks are like independent islands with no communication beyond their nodes.

More formally, the wireless cellular network is a network of portable mobile nodes in a larger geographical area which is divided into zones called cells having a designated fixed wireless transceiver called base transceiver station (BTS). Mobile nodes present in a cell communicate, via the BTS, with other mobile nodes present in that cell or present in some other cell [4]. As pre-installed infrastructure, the inter-BTS communication is carried out through a network of wired or wireless static links. This communication model is sometimes referred to as last-hop mobile wireless communication model [5], [6] due to the provision of mobility of nodes at the last hop only.

On the other hand, Mobile Ad-hoc Network (MANET) could be a community of wireless portable device, with no pre-installed or selected wireless infrastructure[7]. Nodes may communicate directly with the other nodes in their antenna ranges; however, the communication between distant nodes is achieved in a multi-hop fashion, by giving intermediate nodes the role of routers and make them forward data packets for the ongoing communication[8]. Since all nodes are mobile, establishing and maintaining communication routes, turns out to be a very difficult problem. Several routing protocols were designed and studied the literature, has pros and cons of their own.

Now, an Integrated Wireless Network can be considered as a hybrid of the two types above [9]. The combination is complementary and hence waives many of the limitations posed by each type. From the perspective of the mobile cellular networks, this will mean extending the range of a BTS to the non-coverage areas by allowing remote nodes to link up via a sequence of mobile intermediate nodes. From the ad-hoc network perspective, this would provide a mechanism to establish communication between nodes in two different MANETs. Figure 1, depicts such a network where nodes A and F are shown communicating which was otherwise not possible.

In this paper, we create scenarios of integrated wireless networks of varying complexities and study, through simulation, the performance of two leading routing protocols –viz. Ad-hoc on-demand distance vector plus (AODV+) is a reactive routing protocol and Distance-sequenced distance vector (DSDV) is a proactive routing

*Correspondence: khalid.mohammadani@gmail.com

protocol, under varying stress conditions. Further, we investigate for the answer to our research question that "Whether a homogenous choice of routing protocols for all the MANETs has an edge over a heterogeneous choice of routing protocols?"

Further, we distribute this paper into following sections. The second section presents an overview of the routing protocols we used in this study. The third section, we present a brief literature survey to highlight the findings of similar research efforts. We define the concept of homogeneous and heterogeneous choice or routing protocols and reiterate the research question in the fourth section. The fifth section describes the scenarios and the simulation environment. We discuss the findings and observations from the simulations in the sixth section, and the seventh section is last where we conclude the paper.

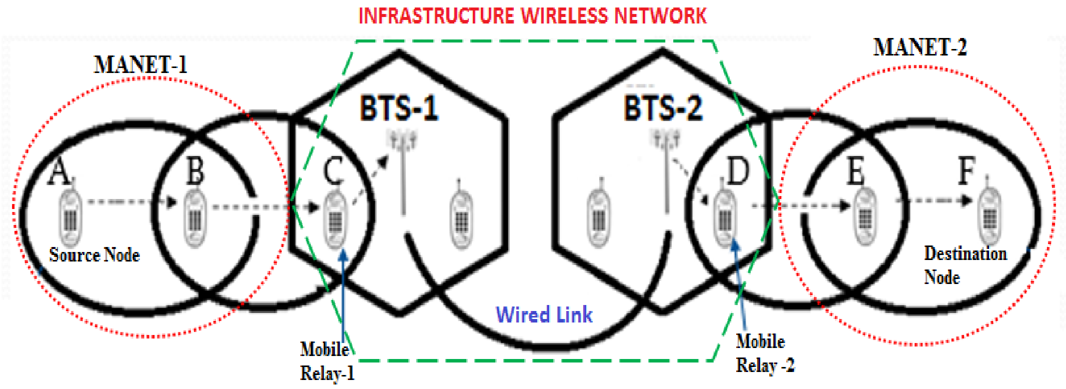

Figure 1. Integrated Wireless Network

2. Mobile Ad-hoc Network Routing Protocols

Routing protocols are utilized to discover a route from a source node to the target node. In MANETs routing may be a difficult task because of the dynamic topology. Depending upon the working, these protocols may be classified as proactive or reactive. A proactive protocol establishes and maintains routes between each pair of nodes all the time whether it is needed or not. Contrasting to this, a reactive routing protocol only creates route when it is needed. Below we will describe the two protocols we selected for this study.

2.1. Distance Sequenced Distance Vector (DSDV)

DSDV [10] is a proactive routing protocol that makes use of a way primarily based on the well-known Bellman-Ford algorithm. For every accessible target, nodes record in a very routing table the next-hop node at the side of several hops to succeed in the destination. DSDV routing requires each node to periodically share its routing table with the neighboring nodes. Upon receiving this information, nodes update their routing tables to drop longer routes in favors of shorter routes. A sequence range is additionally continued in every entry to avoid loops within the routes.

2.2 Ad-hoc On-demand Distance Vector Plus (AODV)

AODV+ [10] is a modified version of AODV which is a reactive routing protocol wherein a direction from source to the target node is created on-demand. It uses four kinds of management messages Rout e-Request-(RREQ), Route-Reply-(RREP), Route-Error-(RRER) and HELLO to discover, update and maintain the routing paths. To find a new route the source node floods RREQ packet, making each node register a reverse entry for this request temporarily. Once the target node collects the RREQ which sends back RREP packet via the reverse entries. Each node along this RREP packet constitutes the required path [8]. Established routes may break due to the mobility of the nodes, resulting in broken routes. Routing tables are altered for the link broken and RERR message is then used to have the source re-establish the route. AODV+ allows the use of gateways to root out of subnet packets via an external network. In AODV+, if the source intends to communicate with a node outside the MANET, a route is established with the gateway instead of the destination node.

3. Literature Review

For the last few years, researchers within the domain of Ad-hoc networks are focusing on the area of integrated wireless networks[11], [12],[13]. The main research issue in the study of the integrated wireless network is the discovery of end to end routes in the component MANETs [10], [14]. In the literature, some efforts are found studying the relative performances of QoS parameters [15], [16] in various types of scenarios while other attempts to design some new architectures of integrated wireless networks [17], [18]. In the following paragraphs, we will briefly highlight some of the important efforts found in the area.

It is worth mentioning the effort of [19] in which AODV+ was created as an extension of AODV to facilitate communication of ad-hoc wireless nodes with the infrastructure world using gateways. AODV+ employs the concept of IP subnets to distinguish between local and remote data traffic.

Adaptive QoS-Aware Ad-hoc On-demand Distance Vector (AQA-AODV)[20] is another modified version of AODV routing protocol, proposed as an improvement of traditional AODV to provide a better quality of the connection between MANET and the Internet. Further, they compared their protocol with AODV+ and QGWS routing protocols. Authors claimed that the AQA-AODV can reduce the network congestion without increasing routing overhead.

In [21] author compared AODV+ with DSDV routing protocols in a scenario that links a MANET with internet using stationary gateways. They measured average-throughput, PDR, and end-to-end-delay QoS parameters under various mobility speeds of nodes. They demonstrated that AODV+ scales well with large scenarios while DSDV's performance is comparable in smaller ones.

Mostly researchers focused on the homogeneous condition of MANET routing protocols (i.e. DSDV and AODV+) for isolate MANET and MANET-internet using stationary gateways[22][23][24] [25]. In this work, we work on homogeneously and heterogeneously combinations of both MANET routing protocols for a solution to our research question describe in section 4. We create the different complexity of integrated MANET with BS nodes. We generate different call stress for a voice call as data. Further, we describe our scenarios in section number 5.

4. A Research Question

In a multi-MANET, integrated scenario, it is generally understood that a single routing protocol should be used in all the component MANETS homogeneously to achieve end-to-end connectivity. In this paper, we deviate from this novice thinking and created scenarios in which the component MANETS were using different protocols arbitrarily. We call this a heterogeneous choice of routing protocols. Now in this paradigm, an interesting research question arises that: "Whether a homogenous choice of routing protocols for all the component MANETs has an edge over a heterogeneous choice of routing protocols?" In the next section, we will describe how we created scenarios with the homogeneous and heterogeneous choice of routing protocols and look for an answer to this question.

5. Scenario and Simulation

To pursue this study and to find the answer to our research question, we have taken a realistic scenario of the gas fields of Pakistan Petroleum Limited (PPL), located at Kandhkot at Kashmore district, Sindh, Pakistan, comprising of 6 sites distributed over an area of 60 km2. We assume that the mobile nodes at each site form a mobile ad-hoc network allowing a multi-hop communication between distant nodes. In order to provide an inter-site communication, a node at each site is designated as a gateway. We call this node a Base Station (BS). These BSs interconnect with each other via a full mesh of point-to-point radio links (i.e.: an infrastructure network). Mobile nodes in one MANET can establish communication with mobile nodes in another MANET by routing their packets to the BS which successively transmits the data to the BS in the destination MANET. The BS in the destination MANET routes the packet locally to the destination node.

We choose network simulator two (NS2), the famous discrete event simulator supporting wired-cum-wireless scenarios, to conduct this study and created simulation scenarios based upon the situation described above. To produce more weightage in our study we created scenarios of varying complexities comprising of 2, 4, and all 6 sites. Another dimension that we engaged in varying stress was the talk time/silence time ratio which we ranged from a low stress of 30/270 to a high stress of 120/180. We made each node of each component MANET to establish a uni-directional communication with a node in some other MANET.

First, we ran all these scenarios using a single protocol (either AODV+ or DSDV) homogeneously for all the integrated MANETs with BS. Then we move on to the heterogeneous case where we make half of the component integrated MANETs to use AODV+ and the remaining half to use DSDV. In table 1, we summarize our simulation parameters.

Table.1. Simulation Parameters

Parameters	Values
No. of Mobile Nodes	40, 80, 150
No. of BS Nodes	2, 4, 6
Simulation Area	9680 m × 6130 m
Antenna type	Omni Directional
Simulation time	600 secs
Traffic Type	CBR/UDP
Packet size	160 Bytes
Data rate	16 Kbps
Routing protocols	AODV+/DSDV/Heterogene ous
Call load	Call-30, Call-60, Call-120
(talk time / silence time)	(30/270), (60/240), (120/180)

6. Results and Discussion

After the simulation of all the scenarios described above, we looked for four QoS parameters to gauge the performances, -viz. Packet Delivery Ratio, End-to-end Delay, Throughput, and Network Routing Load. Below we give a brief definition of these parameters and discuss our observations:

5.1 Packet Delivery Ratio

It is one of the most recommended QoS parameters to observe the network's behavior. It is the quantitative relation of with success arriving of data packets by the target over the data packets sent by the source [26]. Figure 2 graphs the PDR is the call load for the three complexities of BS interconnections. It could be determined graph of figure 4 that each one the protocols (i.e.: AODV+, DSDV, and Heterogeneous) worked identically. Under high-stress situations, the execution is mostly affected because of the bottleneck within the network and more drop rate. The PDR of each one routing protocols reduces as call-load stress will increase.

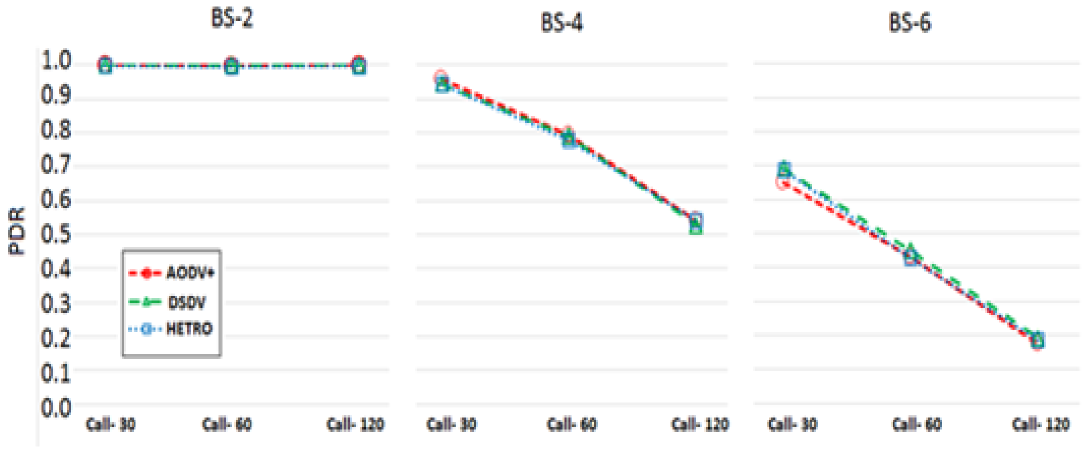

Figure 2. PDR vs the call load for the three complexities of BS interconnections

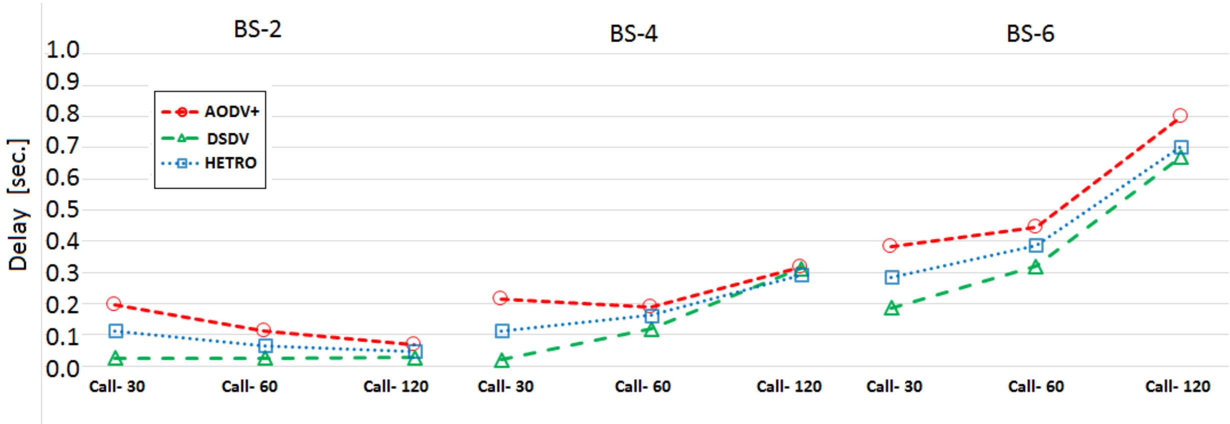

Figure. 3. Endo-to-end delay vs the call load for the three complexities of BS interconnections

A minor poverty of PDR in AODV+ can be observed because, the flooded route discovery packets expends some of the network bandwidth, which is missing in the case of DSDV. In the case of the heterogeneous choice of routing protocols, PDR seemed to be sandwich between that of AODV+ and DSDV, indicating an averaging effect of the two.

5.2 End to End Delay

A packet takes average time from sender to receiver nodes can be recognized as end-to-end delay[27]. As the graph in Figure 3, It could be located that the End-to-End Delay of the AODV+ stayed excessive, even as that of DSDV stayed little and that of the Heterogeneous situation stayed between the two in every one of the situations. Every one of the protocols demonstrates a steady ascent with the ascent in call stress because of a relating increment in blockage.

In 2 BS scenarios, DSDV displays a consistent delay whereas heterogeneous technique and AODV+ demonstrate an abatement in delay with an expansion in load. This is often as a result of in 2 BS situations the network turned into underdeveloped and in DSDV every packet took a similar quantity of time to achieve target because of established paths. Whereas in AODV+, the call-30 situation consists lower range of packets per link equated to call-60 and Call-120 situations and henceforth the delay in setting up a path for that connection has a higher contribution in keeping with packet within the call-30 situation compared to packets in call-60 and call-120 situations. In the heterogeneous technique, the end to end delay was found lying between that of AODV+ and DSDV homogeneous cases, indicative of an averaging effect.

5.3 Average Throughput

Average throughput is that the quantity of data delivered in an exceedingly unit of time averaged over the range of nodes[28]. In Figure 4, it is straightforward to examine that each one the cases (i.e. AODV+, DSDV, and Heterogeneous) acted correspondingly and delivered indistinguishable plots for the network throughput. The network might deliver more and more data beneath every protocol till some extent (BS-6, call-60), afterward, the throughput has begun declining. This is because of that reality that at this factor the point-to-point links among the BS-nodes get immersed and is not able to transport any more data.

In high-stress cases, AODV+ turned into observed acting beneath DSDV due to the fact AODV+ need to generate the routing packets for every new connection which devours some piece of the presented bandwidth.

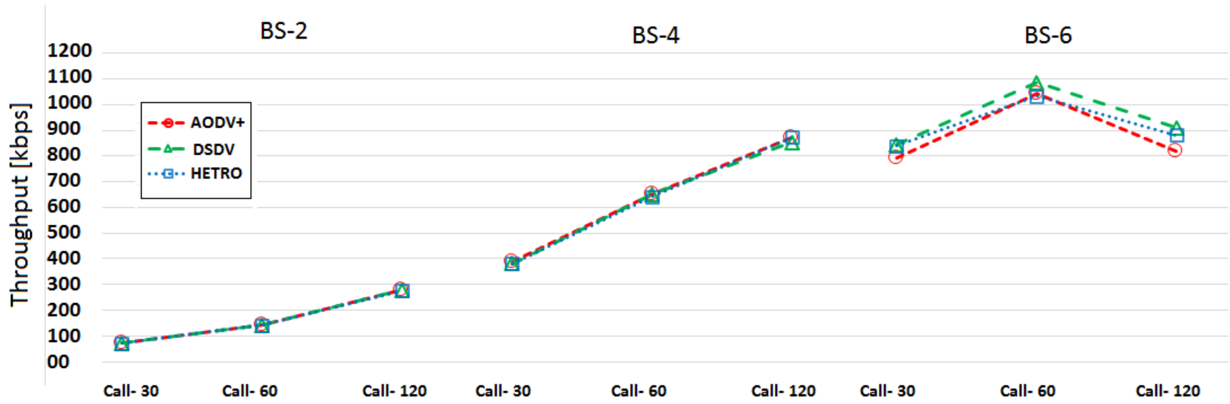

Figure 4. Average throughput vs the call load for the three complexities of BS interconnections

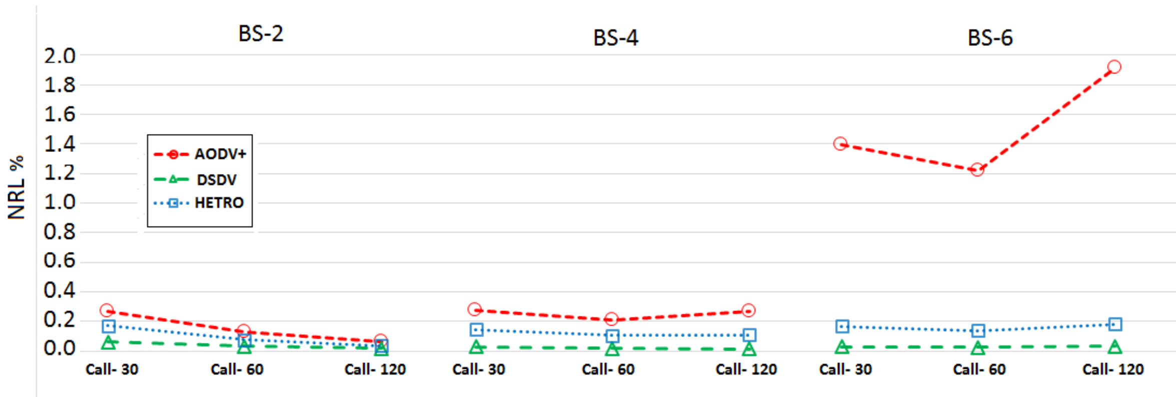

Figure 5. NRL vs the call load for the three complexities of BS interconnections

5.4 Normalized Routing Load (NRL)

Normalized routing load is the ratio of routing packet generated over the number of data packets[29]. From the graph in Figure 5, it is determined that NRL of DSDV remained reliably low, at the same time as that of AODV+ showed a large increase in NRL beneath stress cases. In the 6-BS situation, there is a lot of congestion that the flooded packets to set up the route get dropped inside the manner and therefore the source node floods the packets over and over.

In every one of the situations wherever routing isn't accomplished by congestion. Protocols show a reduction in NRL with the expansion in load. This can be as a result of the call-30 situation has lesser number of packets according to the connection as compared with call-60 and call-120 situation. Therefore, the routing load in setting up the route for that connection has a better contribution in line with packet within the call-30 situation in comparison to packets in call-60 and call-120 situations.

6. Conclusion

To conduct this analysis, a practical situation portraying an oil field having many teams of isolated mobile nodes (MANET) interconnected via a wired mesh network of BS nodes was planned. Numerous complexities of the network were reproduced different call stress conditions. These consist of a variable quantity of remoted MANET sites, numerous the variety of simultaneous calls and a desire among a homogenous (AODV+ or DSDV alone) and heterogeneous aggregate of the two routing protocols for element MANETs.

The simulated scenarios were observed for Packet Delivery Ratio, End-to-End delay, Average Throughput, and Network Routing Load. It was observed that both protocols behaved identically. In high-stress cases, the impact of flooding packet on the performance of AODV+ was seen.

Finally, the answer to our research question that whether a homogenous choice of routing protocol for component MANETS has an edge in performance over the heterogeneous choice: we observed no significant performance degradation (or improvements otherwise) in the heterogeneous case, and hence reject the mythical hypothesis that the homogeneous integrated wireless network performs better than heterogeneous network.

References

[1] Wilder Castellanos, J. C. Guerri, and Monica Chacon, “A hybrid gateway discovery algorithm for supporting QoS communications in heterogeneous networks,” *Rev. Fac. Ing. REDIN, Univ. Antioquia - Scopus Q4 - Colcienc. A1 Categ.*, no. 78, p. 9, 2016.

[2] K. H. Mohammadani, H. Kazi, I. Channa, and D. Vasan, “A Survey on Integrated Wireless Network Architectures,” *Int. J. Comput. Appl.*, vol. 79, no. October, pp. 4–9, 2013.

[3] P. López, "Michael and Blum , Jesse and Sharples , Sarah (2016) Unsupervised labelling of sequential data for location identification in indoor environments . Expert Systems with Applications . ISSN 0957-4174," 2016.

[4] P. KHANDNOR and T. ASERI, "Threshold distance-based cluster routing protocols for static and mobile wireless sensor networks," *Turkish J. Electr. Eng. Comput. Sci.*, vol. 25, pp. 1448–1459, 2017.

[5] J. A. García-Fernández, A. Jurado-Navas, M. Fernández-Navarro, and N. Sucevic, "Method Based on Confidence Radius to Adjust the Location of Mobile Terminals," *Wirel. Pers. Commun.*, vol. 94, no. 3, pp. 1123–1146, 2017.

[6] S. Abbasi, K. H. Mohammadani, Z. Hussain, J. H. Awan, and R. H. Shah, "Evolution of V2V Routing Protocols In Realistic Scenario of National Highway NH-5 Pakistan," *Sci. Int.*, vol. 28, no. 5, pp. 4711–4714, 2016.

[7] K. H. Mohammadani, S. Faizullah, A. Shaikh, N. N. Hussaini, R. A. Khan, and C. Technology, "Empirical Examination of TCP in MANET," *Eng. Sci. Technol. Int. Res. J.*, vol. 1, no. 2, pp. 22–27, 2017.

[8] S. Abbasi, K. H. Mohammadani, S. Shah, and R. H. Shah, "Performance Analysis of MANET Routing Protocols with UDP and TCP under VBR traffic," *SindhUniv. Res. Jour. (Sci. Ser.)*, vol. Vol. 47, no. 4, pp. 787–792, 2015.

[9] T. Le and Y. Liu, "On the capacity of hybrid wireless networks with opportunistic routing," *Eurasip J. Wirel. Commun. Netw.*, vol. 2010, no. 3, 2010.

[10] M. M. Joe and B. Ramakrishnan, "Review of vehicular ad hoc network communication models including WVANET (Web VANET) model and WVANET future research directions," *Wirel. Networks*, vol. 22, no. 7, pp. 2369–2386, 2016.

[11] T. Staub and M. Heissenb, "Ad-hoc and Hybrid Networks Performance Comparison of MANET Routing Protocols in Ad-hoc and Hybrid Networks Computer Science Project done by : assisted by :," 2004.

[12] S. Majumder and Asaduzzaman, "A hybrid gateway discovery method for mobile ad hoc networks," pp. 1–6, 2014.

[13] T. Qiu, N. Chen, K. Li, D. Qiao, and Z. Fu, "Ad Hoc Networks Heterogeneous ad hoc networks : Architectures , advances and challenges," *Ad Hoc Networks*, vol. 55, pp. 143–152, 2017.

[14] M. Altayeb and I. Mahgoub, "A Survey of Vehicular Ad hoc Networks Routing Protocols," *Int. J. Innov. Appl. Stud. ISSN*, vol. 3, no. 3, pp. 2028–9324, 2013.

[15] A. M. Atole, A. D. Asmar, N. R. Nemade, K. P. Tambe, and V. Deshpande, "Performance Analysis of Qos Parameters of WSN by Varying Density of the Network," *Indian J. Sci. Technol.*, vol. 9, no. 29, pp. 1–6, 2016.

[16] A. Shaikh, D. Vasan, and H. Mohammadani, Khalid, "Performance Analysis of MANET Routing Protocols – A Comparative Study," vol. 83, no. 7, pp. 1–29, 2013.

[17] K. Huang, C. Zhong, and G. Zhu, "Some new research trends in wirelessly powered communications," *IEEE Wirel. Commun.*, vol. 23, no. 2, pp. 19–27, 2016.

[18] y. Deng, L. WANG, M. Elkashlan, M. Direnzo, and J. Yuan, "Modeling and Analysis of Wireless Power Transfer in Heterogeneous Cellular Networks," *IEEE Trans. Commun.*, vol. PP, no. 99, p. 1, 2016.

[19] A. Hamidian, "A study of internet connectivity for mobile ad hoc networks in ns 2," Lund University, 2003.

[20] W. Castellanos, P. Arce, P. Acelas, and J. C. Guerri, "Route Recovery Algorithm for QoS-Aware Routing in MANETs," pp. 81–93, 2012.

[21] H. K. S. and R. Garg, "Performance Evaluation Of Gateway Discovery Routing Protocols In Manets," in *International Journal of Computer Science, Engineering and Applications (IJCSEA)*, 2012, vol. 2, no. 3, pp. 137–146.

[22] P. Ratanchandani and R. Kravets, "A hybrid approach to Internet connectivity for mobile ad hoc networks," *Wirel. Commun. Netw.*, vol. 3, no. C, pp. 1522–1527, 2003.

[23] P. M. Ruiz and A. F. Gomez-Skarmeta, "Adaptive gateway discovery mechanisms to enhance internet connectivity for mobile ad hoc networks," *Ad Hoc Sens. Wirel. Networks*, vol. 1, no. 1, pp. 159–177, 2005.

[24] Y. Chaba, R. B. Patel, and R. Gargi, "Efficient Multipath DYMO Routing Protocol with Gateway Selection for Hybrid MANETs," *Int. J. Comput. Theory Eng.*, vol. 4, no. 4, 2012.

[25] M. Tarique, "Performance Analysis of WiMax / WiFi System under Different Codecs," *Int. J. Comput. Appl. (0975 – 8887)*, vol. 18, no. 6, pp. 13–19, 2011.

[26] M. Chaugule and A. Desai, "Reliable Metrics for Wireless Mesh Network," pp. 932–938, 2016.

[27] N. N. HUSSAINI, H. KAZI, S. FAIZULLAH, A. SHAIKH, M, and H. MOHAMMADANI, K, "The Average End-to-End Delay and Average Through put Comparison of Multicast Routing Protocols in MANETs for Real-Time Streaming.," *Sindh Univ. Res. Journal-SURJ (Science Ser.*, vol. 49, no. 2, pp. 329–334, 2017.

[28] R. A. Khan *et al.*, "Enhancement of Transmission Efficiency in Wireless On-Body Medical Sensors," *Eng. Sci. Technol. Int. Res. J.*, vol. 1, no. 2, pp. 16–21, 2017.

[29] I. Ahmad, U. Ashraf, and A. Ghafoor, "A comparative QoS survey of mobile ad hoc network routing protocols," *J. Chinese Inst. Eng.*, vol. 5, no. 39, pp. 1–8, 2016.

About authors

Khalid Hussian Mohammadani is a Computer Science Professional with over five-year experience in teaching networking, programming in C, Web development and other CS and Telecommunication courses. His area of interest includes wireless sensor network, mobile ad-hoc network, image processing and blooming taxonomy technology. He worked as a trainer in two workshops of Network Simulator NS2 that held by Department of Telecommunication, Mehran University, Jamshoro, Sindh. He obtained his BS in Telecommunication from University of Sindh, Jamshoro, Sindh, Pakistan in 2008. He also received M. Phil. Degree in Computer Science from Isra University, Hyderabad, Sindh Pakistan in 2015. At present, he is pursuing Ph.D. in Computer science at Isra University Hyderabad, Sindh, Pakistan.

Prof. Dr. Hameedullah Kazi is a computer engineering professional with over 16 years of experience in software development, teaching, research, administration and leadership in academia. He draws experience from a diverse background of having worked in the American telecom sector and software development industry as well as serving in the academia in Pakistan. He obtained Bachelor of Engineering (Electronics) from Mehran University of Engineering & Technology, Jamshoro, Master of Science in Electrical & Computer Engineering from Purdue University, USA and Doctor of Philosophy in Computer Science from the Asian Institute of Technology in Thailand. He worked as a software engineer at Micro Data Base Systems, Inc., USA and as a consultant at Verizon Data Services, USA before joining Isra University. He has presented and published research papers at premier conferences and in journals of world-class repute. He serves as an editorial board and program committee member of various leading international conferences and journals. He also serves as an external examiner and member of the selection committee at several academic institutions. He is also a Higher Education Commission Approved Supervisor for Ph.D. He serves as the Management Representative at Isra University for ISO 9001:2008 Quality Management System.Certification. He is presently the Pro-Vice-Chancellor, Engineering & Management Sciences at Isra University, Hyderabad.

Prof. Arshad Shaikh is a computer science professional with over 20 years of experience in teaching and R&D. In addition to the core computer science, his areas of interest include topics from basic sciences and applied engineering. He obtained his Bachelors of Computer Science degree from the University of Karachi with a Gold Medal. He did his MS (Computer Science) from Rutgers, the state university of NJ, USA. He is presently associated with Isra University, Hyderabad.

Prof. Dr. Muhammad Ibrahim Channa did his BS in Computer Science from University of Sindh, Jamshoro, Pakistan, and MS in Information Technology from National University of Science and Technology, Islamabad, Pakistan. He did his Ph.D. in Information and Communication Technologies from Asian Institute of Technology, Thailand. His research interests comprise of security, trust and routing in Mobile Ad-Hoc Networks. Currently, he is working as a Professor, Department of Information Technology, Quaid-e-Awam University of Engineering, Science and Technology, Nawabshah, Pakistan.

Dr. Safi Faizullah received his Ph.D. in Computer Science from Rutgers University, New Brunswick, New Jersey, the USA in 2002. He also received MS and M. Phil. Degrees in Computer Science from Rutgers University, New Brunswick, New Jersey, USA in2000 and 2001, respectively. Dr. Faizullah also earned his BS and MS degrees in Information and Computer Science from KFUPM, Dhahran, KSA in 1991 and 1994, respectively. His research interests are in computer networks, mobile computing, wireless networks, distributed and enterprise systems. He is a Professor of Computer Science at Islamic University of Madina, Saudi Arabia.