Evolutionary Computation Techniques for Intelligent Computing in Commercial Mobile Adhoc Networks

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Ubiquitous smart devices and applications are constructing pavement for Mobile Adhoc Networks (MANETs) that allow the users to communicate without any physical infrastructure. The immense usage of pervasive computing devices have fuelled virtual environments which have exponentially enhanced the popularity of commercial MANET. In today's scenario, MANETs are used by each and every individual to perform even routine tasks. This extensive growth in number of users of mobile network has posed a gigantic challenge in catering needs of a huge set of varied users. To deliver Quality of Service (QoS) to users, there is a need to incorporate intelligent computing techniques in commercial MANETs. Emerging intelligent computing trends in commercial MANET are explored in this paper. It further explores the role of evolutionary computation approach in tackling commercial MANET challenges for improving its performance. Comparative analysis of evolutionary computation techniques for commercial MANET is presented in this paper.

Keywords: Computational Intelligence, Commercial MANET, Swarm Intelligence, Genetic Algorithms, Evolutionary Algorithms

1. INTRODUCTION

Mobile Adhoc Network (MANET) is a self organizing network comprising of mobile nodes that permit the users to communicate anywhere,anytime irrespective of their physical location Abielmona et al. [2016]. MANETs due to its inborn characteristics of instantaneous communication and mission precarious applications have engrossed substantial attention of researchers Neeti Maan [2012]. MANETs are infra-structureless networks made by autonomous mobile nodes connected through wireless links with no centralized administration. In such networks, all nodes are dynamically located and free to move independently in any direction Bento and Wille [2020]Kumar et al. [2018]. MANET uses data broadcasting for information transmission between nodes Elaiwat and Belal [2010]. The early work on MANET had been started in 1972, when the Defense Advanced Research Projects Agency funded Packet Radio Network (PRNET), which developed into the Survivable Adaptive Radio Networks (SURAN) project in the 1980s, which offer the packet-switched network to battlefield areas Chlamtac et al. [2003] Ramanathan and Redi [2005]. In the era of 1990, the idea to use MANET in the commercial sector was induced with the use of laptops and other portable communication devices Ankur O. Bang [2013]. Due to the commercialization of MANET in different sectors during the era of 2000 new routing protocols and cross-layer designs were proposed Conti et al. [2004]. Till 2010 MANET played an important role in revolutionizing society by proposing artificial intelligence techniques to secure the network from malicious attacks Herawan et al. [2014]. Subsequent years witness the integration of the innovative concept of machine learning, computational intelligence, and bio-inspired algorithms are used in commercial MANET to improve the network performance Sethi and Udgata [2010].

Today, we are moving to the age of ubiquitous computing in which a user uses different elec-

tronic platforms to access the required information whenever and wherever it is needed. Now a days, MANETs are used in a series of diverse areas like military operations, monitoring of weather conditions, disaster recovery, emergency operations, commercial applications, home automation, education, and entertainment.

The advancement in technology and advent of smart devices has forced users to use online platforms to accomplish even routine tasks. According to Data Reportal analysis "The trends specify that the number of users using digital platform has grown to more than 1 million users in last 12 months all over the world". Figure1 shows the growth in number of smartphone users has increased to 3.5 billion in 2020 and likely to reach at 3.8 billion till 2021.

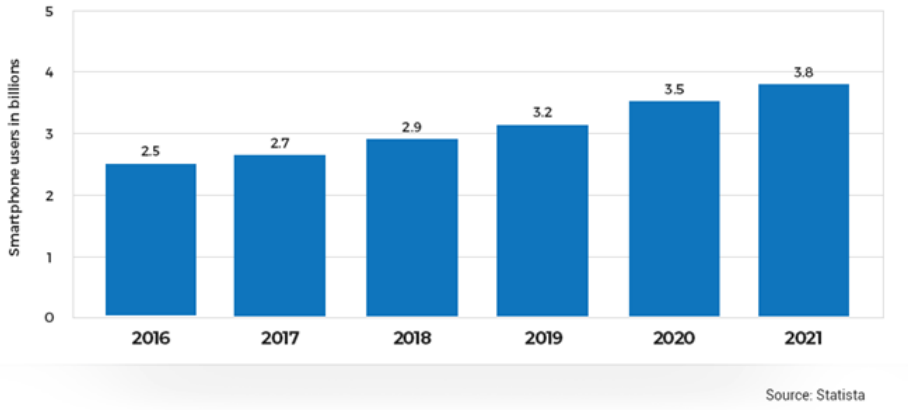

Figure 1. Number of smartphone users worldwide from 2016-2021 in billions

The extensive growth in the number of digital users and new applications has demonstrated that MANETs are progressively creating space in the native and commercial market Kulkarni, R. V., Forster, A., & Venayagamoorthy [2011]. The commercial businessman has shifted towards online applications to enhance the business opportunities and expand the reach to huge audience. This has also lead to exponential rise in the number of users of commercial MANET, so there

Figure 2. Exponential growth in users of commercial MANET

is a need to integrate intelligent computation through evolutionary algorithms in commercial MANETs to enhance its overall performance.

2. EMERGING INTELLIGENT COMPUTING TRENDS IN COMMERCIAL MANET

The sudden rise in the number of digital users urge to introduce intelligent computation in commercial MANETs to provide better services to a varied range of users. Computational intelligence is a new coinage in the disciplines of machine learning. It is the study and analysis of adaptive mechanisms that allow intelligent computation in multifaceted and varying environments. A computationally intelligent system deals with numerical data, consists of a module for pattern-recognition, and starts to reveal adaptive behavior, fault tolerance, speed, and error rates that estimate the performance of a human being. Computational intelligence through evolutionary algorithms can integrate elements of learning, adaptation, and fuzzy logic to create intelligent computing in MANET to improve quality of performance Kusyk et al. [2018] Taneja kavita [2003]. In accumulation to paradigms like reinforcement learning, computing based on neurons, and evolutionary computation, computational intelligence embraces techniques based on swarm intelligence, genetic algorithms, artificial immune systems, and fusion of two or more of the above-mentioned approaches Kulkarni, R. V., Forster, A., & Venayagamoorthy [2011] Shi et al. [2020]. Commercial MANET is also facing lots of challenges that can be addressed using paradigms of computational intelligence such as fuzzy logic, swarm intelligence, and evolutionary programming Dote and Ovaska [2001]. In order to improve the QoS in commercial MANETs, the integration of these intelligent computing trends in MANET is need of the hour Siddique N [2015].

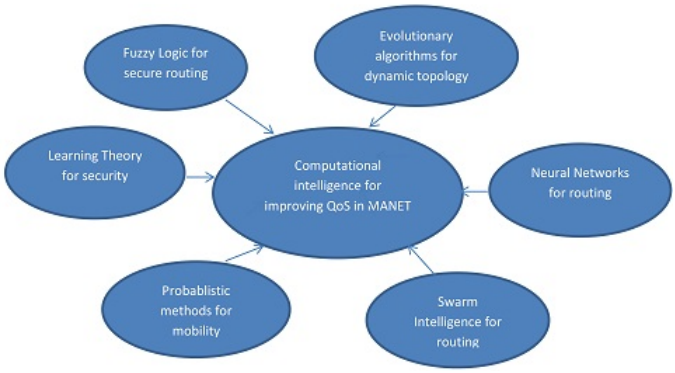

Figure 3. Computational Intelligence for improving QoS in MANET

3. LITERATURE REVIEW

Hussein and Saadawi [2003] discussed swarm intelligence based routing algorithm inspired from natural behavior of ants. The central idea of this approach is to work on optimization of more than one QoS parameters. The work done in this paper emphasized on fair distribution of energy in the dynamic network while considering mobility of nodes. The performance of algorithm is evaluated using OPNET simulator.

Wedde et al. [2005] proposed energy effective routing algorithm inspired from forging behavior of honeybees. The algorithm worked in reactive mode to consume less energy by utilizing less control packets. The performance of algorithm is compared with existing traditional routing protocols using network simulator.

Liu and Feng [2005] proposed robust routing algorithm that integrates swarm intelligence approach and multipath routing. Ant colony algorithm is used to disperse network traffic to deliver the best service.

Sapienza [2008] introduced evolutionary computation based model for optimizing QoS in MANET consistent with IEEE 802.11 standards. Intelligent techniques such as fuzzy systems in collaboration with associative memories and genetic algorithms are used in improving the implementation details of the network layer and MAC layer. The performance of the proposed model is determined with network simulator.
Sethi and Udgata [2010] suggested on-demand routing protocol that assimilates the ideas from ant colony optimization, local retransmissions and blocking expanding ring search to reduce routing costs and improve packet delivery ratio.
Gutiérrez-Reina et al. [2012] genetic algorithm based topological design of MANET is presented. The optimization in the topology of the network is achieved by considering the speed of mobile nodes and distance among static nodes. The vital idea of this methodology is to find an optimal position and speed of the node to enhance the network performance.
Reina et al. [2016] computational intelligence methodology using evolutionary algorithms for augmenting connectivity issues in disaster areas is proposed. The notion of this approach is to increase the reachability of the nodes by deploying auxiliary static nodes at an optimal position using a genetic algorithm.
Herawan et al. [2014] developed an intelligent routing protocol which is improved version of traditional Adhoc On Demand Distance Vector (AODV) protocol to discover the secure shortest pathway among nodes. This protocol is designed to prevent a black hole attack by assimilating two techniques, one is A* and another one is Floyds-Warshall's algorithm.
Vishnu Balan et al. [2015] proposed an intrusion detection system based on fuzzy logic to discover security attacks in the network. Major consideration of the approach is to identify black hole and grey hole attacks. This system uses node blocking mechanism to avoid malicious attacks within the network.The performance of the approach is evaluated with metrics such as throughput,packet loss and jitter.
Sharma and Agarwal [2017] suggested a hybrid approach combining the features of Automatic Neuro-Fuzzy Inference System (ANFIS) and the concept of kalman filteration to improve the QoS parameters within the network. The objective of the paper is to learn and determine the dynamic parametric values automatically.
Kumar et al. [2018] an improved version of Temporally Ordered Routing Algorithm (TORA) is presented by incorporating energy awareness factor into the protocol. Binary Particle Swarm Optimization (BPSO) approach is used to calculate route length and energy level, and then the shortest route with the highest energy level is suggested for data transfer.
Revathi [2020] proposed a hybrid intelligent algorithm to optimize QoS routing. This algorithm is based on two meta-heuristic techniques that are inspired by cuckoo search algorithm and differential evolution algorithm. Exploration of parameters is handled by the search algorithm and the updating approach is derived from differential evolution.

4. TACKLING CHALLENGES IN COMMERCIAL MANET THROUGH EVOLUTIONARY COMPUTATION

(1) Mobility: Mobility of connected devices is the most unpredictable challenge that hampers the overall performance of the network in light of the exponential expansion of commercial MANET application areas. Various evolutionary algorithms can be used to predict the stochastic behavior of mobile nodes Dorronsoro B, Ruiz P, Danoy G, Pigne Y and P [2014] Spears et al. [1996].

(2) Dynamic topology: Manet has a major challenge of dynamic topology because mobility of nodes is the most stochastic area that need to be addressed with evolutionary computation techniques. Research trends indicate that genetic algorithms and swarm intelligence algorithms are best suited to tame this challenge Gutiérrez-Reina et al. [2012] Reina et al. [2013].

(3) Low bandwidth: Wireless links have considerably lesser capacity than wired links. Due to the lower capacity of wireless links, they are more susceptible to external noise and interference. Moreover, connection establishment could be difficult due to low bandwidth. To address this challenge the existing algorithms can be combined with intelligent computation approaches Taneja et al. [2018].

(4) Link connectivity: Due to the extremely dynamic topology of MANETs, link connectivity is considered a highly cumbersome task. Handling frequent link failures, link re-establishment and failure detection are necessary to provide better network connectivity. In order to enhance the commercial MANET performance, the integration of intelligent computation and evolutionary programming in existing routing protocols are required Gutiérrez-Reina et al. [2012].

(5) Resource Constraint: Mobile nodes rely on resources like battery power and storage capacity for proper functioning within the network. These resources are scarce, so there is a need to conserve these resources wisely and effectively. To address this challenge there is a need to develop intelligent computation techniques to preserve these limited resources Mamatha and Sharma [2010].

(6) Routing: Routing between nodes is a challenging task in MANETs. The unavailability of perfect routing schemes makes it difficult to choose the optimum path. Existing routing protocols are not adequate to provide a secure shortest path due to mobility and dynamic topology. Due to these factors more robust intelligent computation based routing algorithms are needed to improve MANET performance Neeti Maan [2012].Literature study shows that nature inspired algorithms work best in finding optimal route in MANET Raghavendran et al. [2012].

(7) Security: The mobility of nodes indicates higher security threats to both network users and malicious invaders. Due to dynamic topology and lack of central management the intruders get easy access to the network and disrupt the network. With the expansion of commercial MANET application areas in varied fields, more secure protocols are needed to prevent malicious attacks Herawan et al. [2014] Revathi [2020]. Existing studies demonstrate that computational intelligence techniques work well in designing secure networks Sen [2015].

(8) Quality of Service (QoS): QoS is the capability of a wireless network to deliver the best service over different technologies. The persistently changing environment in MANET poses a huge challenge in providing QoS level. The parameters for measuring QoS such as transit delay, residual error rate,resilience, bandwidth, throughput diminishes, when multimedia data transfer takes place in the network. The QoS in commercial MANET can be improved by incorporating evolutionary computation based routing and security algorithms Kumar et al. [2018] Liu and Huang [2009].

(9) Scalability: Scalability is another vital issue in MANET. Due to the mobile nodes, the scale of the network alters repeatedly. Existing algorithms work well for small scale networks, as the scale of the network rises the performance of the network degrades. Improvement in terms of scalability is required for complex commercial MANETS Herawan et al. [2014].

Evolutionary algorithm	Proposed Approach	Challenge Addressed	Limitations	Tools used
Swarm Intelligence Hussein and Saadawi [2003]	Energy proficient routing algorithm based on ant colony is proposed	Routing	Not suitable for complex dynamic environments	OPNET
Swarm Intelligence Wedde et al. [2005]	Energy effective routing algorithm inspired from forging behavior of honeybees is proposed	Routing	Implementation is done with only 50 nodes	NS
Swarm Intelligence Liu and Feng [2005]	Multipath routing protocol based on ant colony is proposed to improve QoS	Routing	Congestion control and Routing overhead issues not considered	
Evolutionary Programming Sapienza [2008]	Evolutionary Programming based model to enhance QoS is proposed	QoS	Testing with typical MANET configuration is missing	Network Simulator (NS)
Swarm Intelligence Sethi and Udgata [2010]	Ant-based protocol using blocking expanding ring search is proposed to improve packet delivery ratio	Routing	Congestion control factor not considered.Performance is compared with only two algorithms (AODV,DSR)	(NS)
Genetic Algorithm Gutiérrez-Reina et al. [2012]	Proposed topology design technique based on distance between static nodes and speed of moveable nodes	Dynamic Topology	Application restricted to transport sector only (Railway scenario)	(NS)
Genetic Algorithm Reina et al. [2016]	Proposed placement of supplementary stationary nodes to enhance the reachability	Link Connectivity	27 % improvement achieved (Testing is done with disaster scenarios only)	NS
A* Search Algorithm Herawan et al. [2014]	Proposed a new routing protocol to discover the shortest secure path and prevent black hole attack	Routing	Only three performance metrics are considered	NS
Fuzzy Logic Vishnu Balan et al. [2015]	Proposed intrusion detection system based on fuzzy logic	Security	Route modification not considered	NS
Fuzzy Logic Sharma and Agarwal [2017]	Proposed intelligent framework to update parameter values using automatic neuro fuzzy inference system and kalman filteration	QoS	Testing is done with a very small number of nodes(10)	MATLAB
Swarm Intelligence, Kumar et al. [2018]	Proposed routing protocol based on route length and energy level	Routing	Performance is evaluated and compared with only one protocol (Temporally Ordered Routing Algorithm)	NS
Differential evolution algorithm Revathi [2020]	Hybrid algorithm with position updating mechanism inspired from cuckoo search algorithm is proposed	Routing	Modifications are required if extended for real-time networks	NS

Table I: COMPARATIVE ANALYSIS OF EVOLUTIONARY COMPUTATION TECHNIQUES FOR COMMERCIAL MANET

5. CONCLUSION AND FUTURE RESEARCH DIRECTIONS

The persistent availability of smart devices and innovative mobile applications , has generated a huge spike in mobile network users. In present scenario, mobile applications are one of the ideal preferences for businesses such as shopping, academia, industry, government, and entertainment. People are interested to perform their routine tasks with commercial manets while sittuing at home. This extensive surge in mobile network users imposes a massive challenge in providing QoS to diverse range of users in terms of link connectivity, increased throughput, and fast processing. To tame these issues , evolutionary computing algorithm for computing in commercial MANET is need of the hour. This paper presents the application of evolutionary algorithms to

address challenges in commercial MANETs. This paper explores the computational intelligence techniques to increase the performance of commercial MANET. The comparative analysis presented in the paper gives an insight into evolutionary computation based intelligent approaches along with their limitations in context with commercial MANET. The development of new evolutionary algorithms is required for improving existing routing protocols in terms of network life time,congestion control and energy efficiency while bearing in mind the adaptability factor in commercial MANETs.

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