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Low energy consumption in manet network

[1]Maral A. Mustafa, [2]Mohammed H. Rasheed,[3]Omar M. Salih
[1]Kirkuk Technical Institute, [2,3]Kirkuk Technical Collage, Northern Technical University, Kirkuk, Iraq
maralanwer@ntu.edu.iq[1], mohammed.rasheed@ntu.edu.iq[2] , omar.alsabaawi@ntu.edu.iq[3]

ABSTRACT

The aim of this paper is design and develop energy efficient MANET network in wireless networks. One of the most significant and effective protocol based on low energy consumption and number of Ad-hoc is MANET as remote directing convention source nodes forward in network simulator. Less number of nodes in the network would give low energy usage or consumption as the nodes in the network exceeds or increases that will also increase the energy consumption in the network. The designed MANET system is tried with 9, 12, 15 and 18 number of nodes in a system using network simulation-2 (NS-2). Henceforth source node needs to restart over and over which brings about low energy consumption use and use, ectiveness is less and packet space is additionally less and throughput is likewise less and more start to finish delay. Arrangement of this issue in MANET convention which is advanced as the node doesn't advance when demand arrived at their first it checked there is low energy consumption (battery lifetime) and until the node energy consumption is more noteworthy than the limit. Designed MANET examinations of the energy consumption and node energy consumption by maintaining a strategic distance from the low number of nodes in a network. By contrasting energy consumption and node it demonstrates that MANET is far superior to existing framework 802.11 protocol convention based on battery lifetime, energy consumption, throughput, and power transmission. We have performed a comparison between EEM and AODV routing protocol considering different measuring parameters.

Keywords: Wireless network, nodes, MANET, energy consumption, routing, packets

Corresponding Author:

Maral A. Mustafa
Kirkuk Technical Institute
maralanwer@ntu.edu.iq

1. Introduction

With the rapid development of network technologies, network scales continue to expand. Meanwhile, as the rapid innovation of Internet services, computer networks have been widely used in various fields, such as military, science, education, and business. People can communicate with each other and can get information from websites through the computer networks [1]. Computer networks profoundly impact people's learning, work and life. However, since the emerging network technologies such as Internet of Things and software-defined networking have been adopted in different areas, the computer networks gradually come out many limitations [2].

In the MANET architecture, network devices (such as switches, routers, etc.) are generally composed of control planes and forwarding planes [3]. The control planes are responsible for forwarding strategies based on gateway protocols and routing protocols. Forwarding planes comprise the entities to execute control logic from the control planes. The main responsibilities of the forwarding plane include data encapsulation, package de-encapsulation, and packet transmission [4]. However, the control planes and forwarding planes in traditional networks are all concentrated on the network devices. This characteristic makes users difficult to personalize the network according to the various requirements. The tight coupling of the control plane and the forwarding plane result in a series of problems, especially the user's hard to manage and adjust the network. [5].

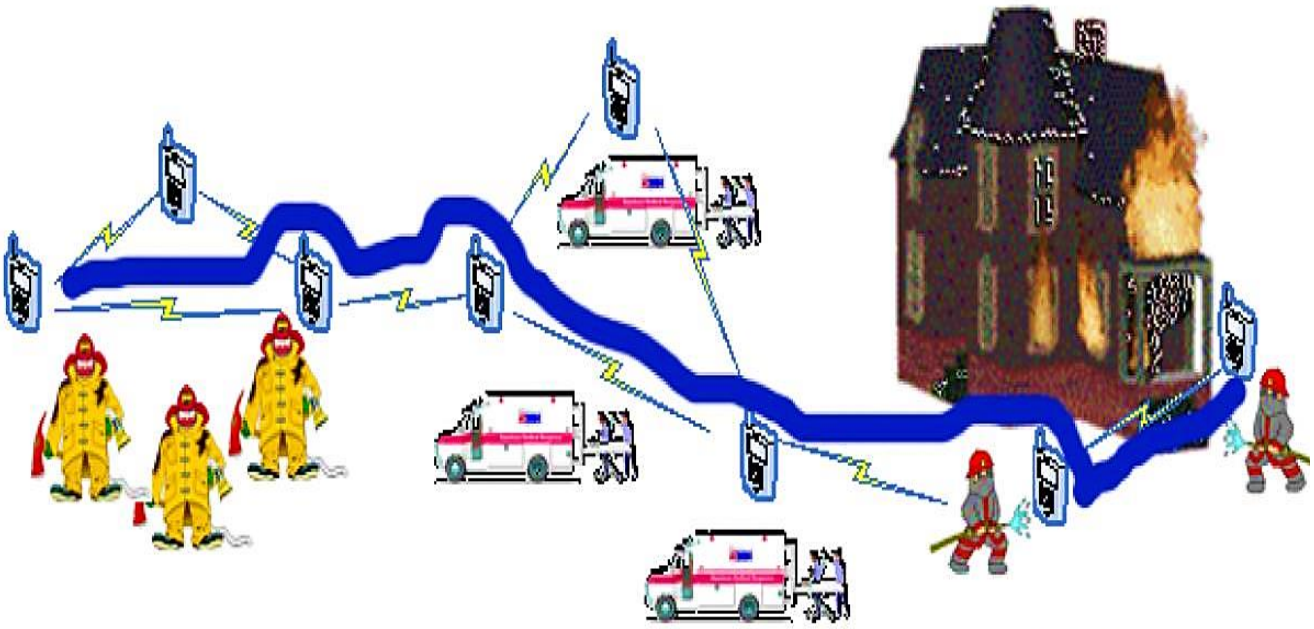

Figure 1. Application of Mobile Ad Hoc network in alarming the fire with efficieny. *Source* [1]

1.1. Problem Statement

There are many energy related issues in MANET network. The most widely recognized ones are:

- To identify the energy efficient routing protocol in Mobile Ad hoc Network known as MANET.
- To design and develop the proposed low energy consumption-based MANET system using network simulator-2 with all the measuring parameters for routing protocols.
- To evaluate and compare the proposed low energy consumption-based MANET system with the 802.11 protocol AODV rounting protocol.

1.2. Aim of Study

Today energy efficient MANET network is a need of industry. All network service providers need to install energy efficient MANETs to cover all areas. The self-organizing feature of MANETs indicates that no inherent communication network infrastructure is required. MANETs can quickly form temporary low energy consumption-based networks and establish network communications. In the case that the network infrastructures are seriously damaged by disasters, such as floods, earthquakes, and typhoons, MANETs become the proper method to establish network communications with low energy requirement.

However, the distributed network topology, the network node mobility and the wireless channel variation result in performance fluctuation of MANETs, and thus the network control becomes a key challenge. In addition, various node hardware and software configuration may introduce further network control and management complexity and low energy usage which is the main contribution of this study.

1.3. Mobile Ad-hoc (MANET) Network

MANETs are special kind of networks composed of many mobile terminals, which have wireless transceiver capabilities. This class of networks does not need to rely on network infrastructures to quickly implement networking and communications. Wireless links between different nodes can communicate directly or indirectly to complete the information exchange.

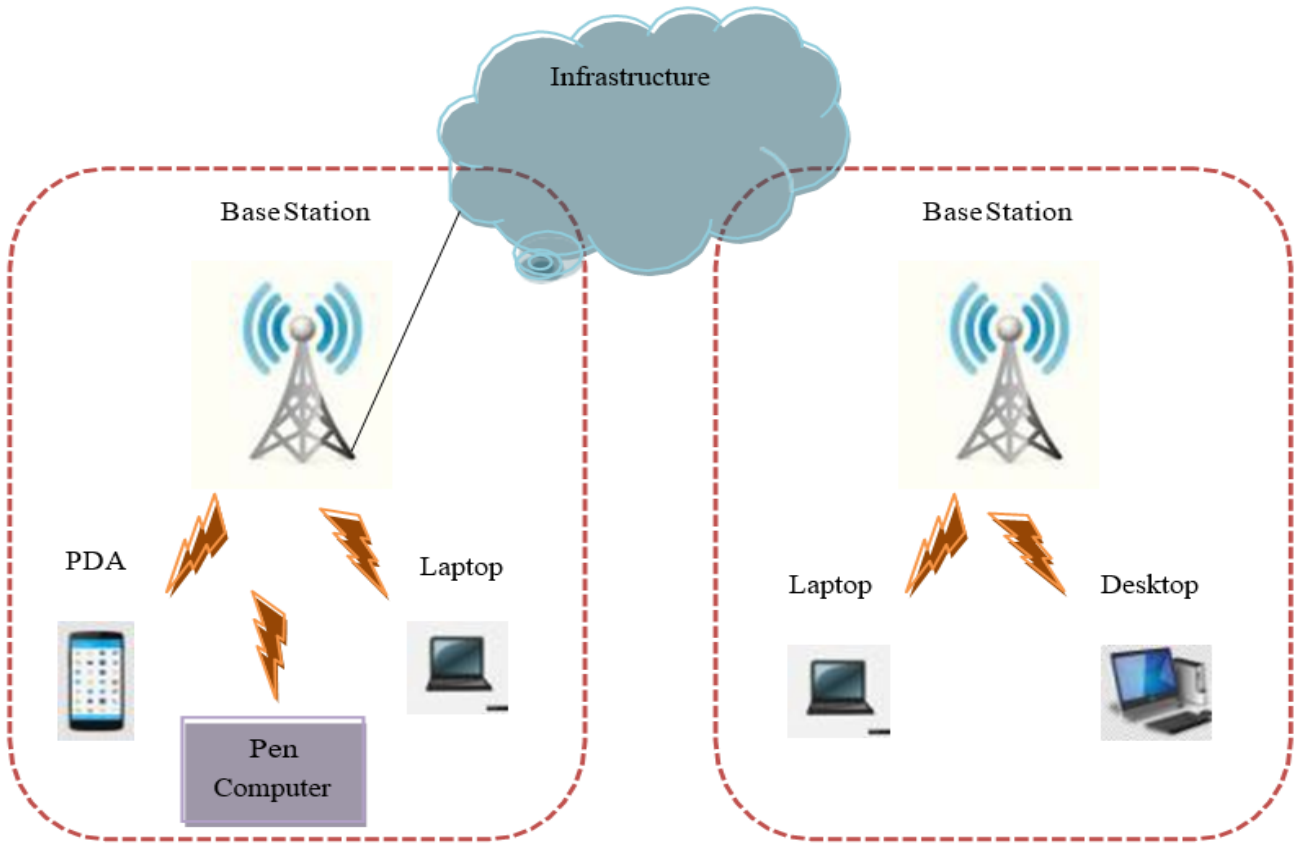

Figure 2. Architecture of Mobile Ad Hoc network with two different base stations. *Source* [2]

The main features of MANETs are provided below:

1- The variation of network topologies: Most of the wireless networks have been used in the mobile environment. Specifically, the mobile nodes in MANETs can cause the entire network topologies constantly to change. Thus, MANET routing protocols, security policies and other MANET technologies should adapt to the variation of topologies of MANETs.
2- The security of MANETs is very reliable: Comparing with the fixed telecommunication networks, nodes in MANETs can dynamically join and leave the networks at any time. Thus, the node mobility feature enables the MANETs is not vulnerable to be attacked, such as eavesdropping and intrusion. The MANET security is one of the important aspects in ad hoc network researches.
3- Self-organization: MANETs can automatically form self-organized networks without individuals' intervention. Meanwhile, node can automatically reorganize when MANETs encounter errors or node failures.
4- Multi-hop routing: Each node in MANETs is independent because of the limited communication distance, thus the communication between two non-neighbor nodes needs to implement multi-hop routing. In other words, if a node in outside of the effective range of communication needs to forward packets, this node must go through intermediate nodes to complete the routing path. This mechanism is called multi-hop routing.
5- Communication distance is unlimited: Since each node in MANETs is self-existent, there is no fixed centralized control, together with the energy restrictions of each independent terminal node, all these characteristics make the transmission power of each node in MANETs small, so that the network nodes in an isolated geographical position are able to communicate with each other.
6- Effective network time is unlimited: Since MANETs often build communications because of some temporary reasons, thus the existence time cycles of entire MANET environment are short, so MANETs can maintain stable wireless network environment for a long time.

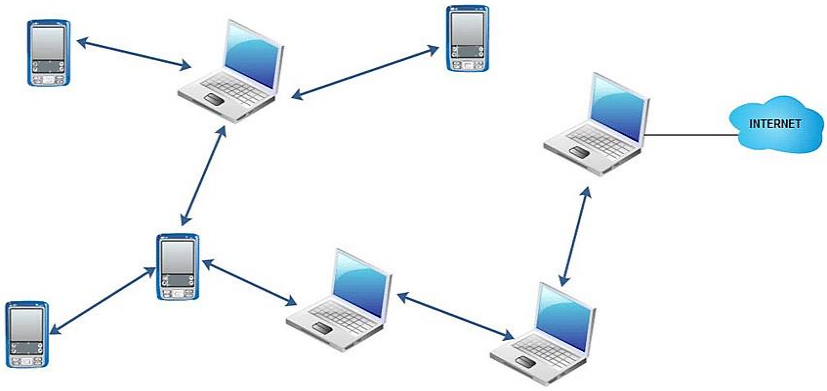

Figure 3: Example of MANET Network. *Source* [5]

1.3.1. Cellular Network

The multiple characteristics of cellular network given by: [6]

- Infrastructure-based.
- Single hop wireless links.
- Guaranteed bandwidth.
- Centralized routing.
- Seamless connectivity.
- High cost and time for deployment.
- High cost of network maintenance.
- Mobile hosts require low complexity.

1.3.2. Mobile Ad-hoc Network

The multiple characteristics of mobile Ad-hoc network given by: [6]

- Infrastructure-less.
- Multi hop wireless links.
- Shared radio channel.
- Distributed routing.
- Frequent path breaks due to mobility.
- Quick and cost-effective deployment.
- Self-organization and self-maintenance.
- Mobile hosts are required to make complex decisions.

2. Related work

2.1. Low energy wireless networks

In [7], the authors propose two mechanisms: watchdog and path rater, and use these as MANET protocol extension. Credible watchdog mechanisms need to assume that the nodes need to turn promiscuous mode, which has become a basic assumption of trusted based MANET routing protocols. Low energy consumption identifies misbehavior of nodes and monitors the received packets to get the trust value. Path rater rates the node according to the reliability of nodes. These two mechanisms can effectively find credible path. The results of the low energy consumption and path rate mechanism are all better than the Intrusion Detection System. However, in this paper [8], the authors only used the unicast MANETs and does not evaluate the performance of low energy consumption network techniques to other types of networks.

MANET protocol [9] provides a single path routing solution in a safety management environment with low energy consumption. It uses pre-defined encryption certificates to provide authentication and non-repudiation services, thus this mechanism ensures the end-to-end certification with low energy consumption. However, MANET protocol results in a large route discovery delay and overhead but provides the low energy consumption.

MANET Protocol [10] adds a simple packet acknowledgment mechanism, which includes PKT and ACK packets. The protocol uses Merkle Hash Tree method to implement the validation work of PKT packets efficiently [11]. After verification at the destination node, the node sends ACK message. Through these mechanisms, the protocol achieved good scalability.

MANET protocol [12] mainly considers the types network. Each node turns the promiscuous mode, and each node monitors the behaviors of its neighbors. This paper mainly focuses on two types of low energy consumption networks: black-hole networks and grey-hole networks. In this method, the indirect credibility value is obtained by calculating the average recommendation values of neighbors. The protocol uses a fully distributed algorithm, and only uses information within one hop, so this protocol has a very good scalability. However, this protocol requires each node to listen and save almost all its neighbors communication record, the memory overhead of the protocol is big. Meanwhile, the lack of trust maintenance largely affected the performance of the protocol.

MANET protocol [13-15] uses a historical behavior of nodes. The authors propose a credible mechanism mainly based on fuzzy logic prediction method for low energy consumption network. The protocol can find the shortest paths that nodes meet the minimum requirement of the node trust value. In order to maintain trust value, this protocol uses a routing update reporting mechanism, the amount of changing trust value exceeds the threshold will trigger the routing updates.

2.2. Protocols in MANET

After decades of development, mobile ad hoc networks have gradually developed a theoretical system. MANETs use inherent mechanisms to form complete and complex self-organized systems. There are some protocols that need to be followed as the network running: 1) each node in the networks has a criterion for the whole network; 2) each node has its own capacity to implement decisions; 3) each node determining their own behaviors will also affect the state of whole networks; 4) all nodes in the networks operate in the form of parallel

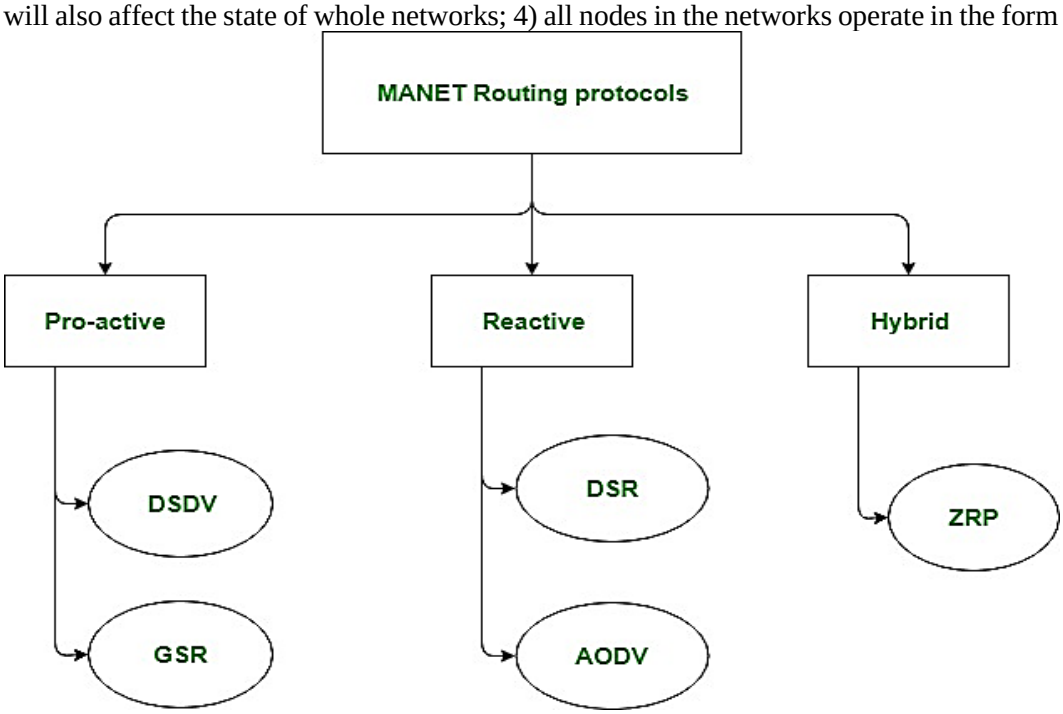

Figure 4: Taxonomy of MANET routing protocols. *Source* [13]

Mobile Ad Hoc applications are mainly related to its own characteristics. Compared with the conventional wireless network communication environments, MANET application fields mainly show its self-organization, rapid deployment, and dynamic topology features.

3. Methodology

3.1. Designing energy efficient MENET

In MANETs, each node is both host and router, exchanging information between the nodes aims to maintain the network topology and routing information with low energy consumption. The purpose of MANET routing protocols is to ensure that data packets can be safely and properly transmitted to the destination node with energy packet. However, the inherent characteristics of mobile ad hoc networks determine that MANETs are easy to be attacked by a variety of credible threats, which affect data packets correct forwarding. In general, the following aspects for designing low energy consumption-based MANET are given by.

3.1.1. Energy routing protocol technologies

The MANET routing protocols are one of important parts in ad hoc network researches. In terms of the routing, the prominent feature is dynamic and distributed network topologies, but this feature is a big challenge to design protocols in MANETs. The existing routing protocols of MANETs may not meet the real-time dynamic feature of ad hoc networks. Consequently, well-designed routing protocols are the arduous tasks for researchers to improve MANET performance.

3.1.2. Resource access control technology

In mobile ad hoc networks, each individual node has autonomous mobile features, while the communication range of each node is limited by its own energy and external conditions, so researchers have to design appropriate MAC protocols to resolve channel problems. For example, channel utilization needs to increase and the network end-to-end delay needs to reduce.

3.1.3. Energy Restriction

Each independent node in MANETs is often limited in energy. The limited energy feature has become one of the main design problems of MANETs. The energy consumption of mobile nodes makes the nodes' transmitting power decrease, which results the mobile nodes invalid and affects the network topologies, evenly may cause network paralysis. Therefore, designing MANET routing protocols must take into account the energy consumption of nodes.

3.1.4. MANET Security

Comparing with the traditional fixed communication networks, MANETs have the features of node mobility and open links. These features also make MANET safety cannot be well protected. MANETs are easier attacked by attackers, such as eavesdropping, masquerading and other malicious attacks. Meanwhile, nodes freely join or leave the networks make the security maintenance of ad hoc network become more difficult.

3.1.5. Energy resource management

Mobile Ad-hoc energy resource management is a very important and difficult technique. On the one hand, in order to guarantee the quality of service of data processing, we need to manage the radio resource efficiently; on the other hand, we have to solve the problem of rapid changing topology of MANETs. Moreover, since the mobile nodes' energy is limited, power management must be a holistic approach in order to obtain reasonable optimization results.

3.1.6. MANET topology management

Ad hoc networks have multi-hop and self-organization characteristics, so there are more potential problems in network management compared with the traditional fixed and centralized control network. For example, the positioning of mobile nodes has a lot of problems; in addition, how to quickly detect the dynamic changing in MANET topologies also needs to be solved. Meanwhile, ensuring rapid responses for the network services are also one of the MANET problems that needs to be solved in the future.

3.2. Algorithm for energy efficient MANET

The steps involved in energy optimization algorithm are:

Algorithm 1 Low Energy Consumption based MANET Node Calculation.

1: Initialization

if node *B* receives a MANET packet from its neighbor node *A*, and this packet does not be received by node *B*, then node *B* calculates the reverse low energy value in its routing table.

2: **end if**

3: **if** node *B* receives two different MANET packets from its neighbor nodes *C* and *D*, and the two MANET packets do not received by the node *B* before, then node *B* calculates the two reverse low energy values in its routing table.

4: **if** we only consider the low energy value factor, then node *B* selects the better energy value path, and discard another MANET packet.

5: **else**

6: **If** we consider the low energy and hop count factors, then node *B* selects the better energy value and minimum hop count path, and discard another MANET packet.

7: **end if**

8: **end if**

9: **end**

3.3. Architecture of energy efficient MANET

There are still some architectural problems that need to be solved in MANETs. Specifically, we mainly focus on the two problems of MANETs in our paper: one is the low energy consumption in MANETs, another is the node network topology management for MANETs. The bad behaviors of nodes bring a lot of problems, including data services cannot be sent correctly, bad nodes degrade MANET performance. How to add low energy consumption mechanisms in the routing protocols to distinguish and to detect the low energy consumption of nodes is important for MANET to enhance the network performance. Ensuring the reliable delivery of data services has become a major direction of the MANET researches. With further researches, in order to solve this problem, the concept of reliability and credibility of the route have been proposed.

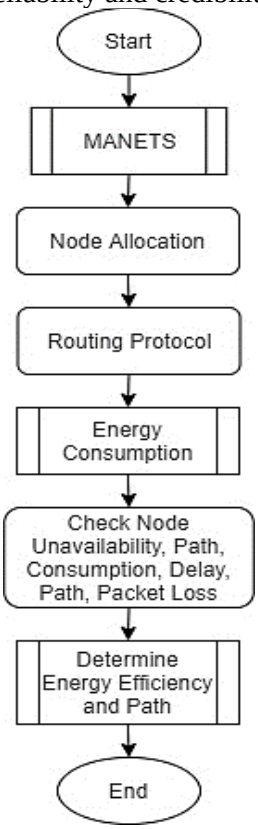

Figure 5. Flowchart of proposed approach for energy efficient MANET

3.4. Evaluation of energy efficient MANET

Evaluating the energy efficient MANET is a big task to do because each node has a certain amount of energy of battery lifetime and MANET intensively control and manage the entire network through developing the routing strategies, so the control node must have a whole network topology information. So, we need to design a message to obtain the entire network topology in MANET layer. The low energy consumption message can be designed by broadcasting node information to the entire network, and then control node can get the topology of the entire network.

Table 1. MANET routing protocols for low energy consumption

Parameters	Value
Number of nodes	Varies (1-18)
Mac Type comparison	802.11
Protocol	AODV, Energy Efficient MANET (EEM)
Communication Protocol	UDP
Application	Network-Simulator 2
Delay	2-3 ms
Simulation Time	Varies

In low energy consumption MANET, if choosing a fixed node as the control node, because of the node mobility, we cannot exclude a situation that the node maybe leaves the network at any time and comparing it with the 802.11 protocols for low energy consumption checking. Therefore, this situation brings a key issue that how to choose a terminal node as a controller for the whole network. One solution is that try to run a control program on each node. Although such programs are relatively simple, they also can bring some problems. For example, the control programs in two neighbor nodes may clash with each other, and how to choose one of the nodes (each node running the control program) as the controller; another solution is that automatically assigns the best status network node as the control node. The best status node means that the node has the highest forwarding ratio. We can factitiously select the best status node to serve as the controller. Finally, setting a standby control node is necessary because the standby node can quickly restore communication network if the precious control node is lost.

4. Results

Network simulator 2 has been used for this research work. The control and forwarding planes of network devices are generally designed and developed by the equipment providers. A large number of highly integrated network protocols are concentrated on this software, and the control planes and forwarding planes are all bundled in the network devices. Configuring and managing the networks are only achieved by people through a low energy consumption MANET network. MANET can individually configure a single network device, but low energy consumption MANET is hard for users to control the entire networks because the 802.11 protocol is not user-friendly and low energy consumption network with more nodes in network, which means that network need to remember a lot of nodes and parameters. The network has no other ways to configure and manage the network than typing the complex and right nodes. This control and forwarding plane tightly coupled way brings a series of problems in 802.11 network management and deployment, such as the complexity of network management and low efficiency of the network functions. Therefore, low energy consumption MANET came into our eyes. In recent years, low energy consumption MANET as a future alternative network has attracted more and more attentions.

The framework of MANET is a separated architecture that control and forwarding plane are decoupled from each other. Low energy consumption MANET operates through the standardized protocols using Network Simulator-2 to control and manage the network devices for low energy consumption-based network.

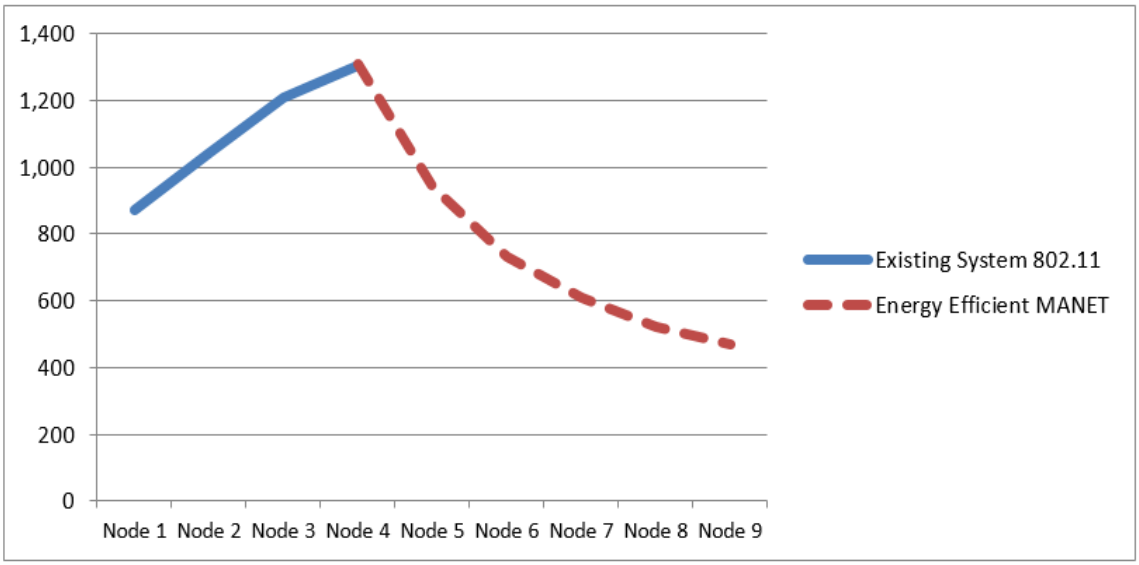

Figure 6. The power transmission and network energy consumption drastically decreased with 9 number of nodes using MANET in comparison with the existing system 802.11.

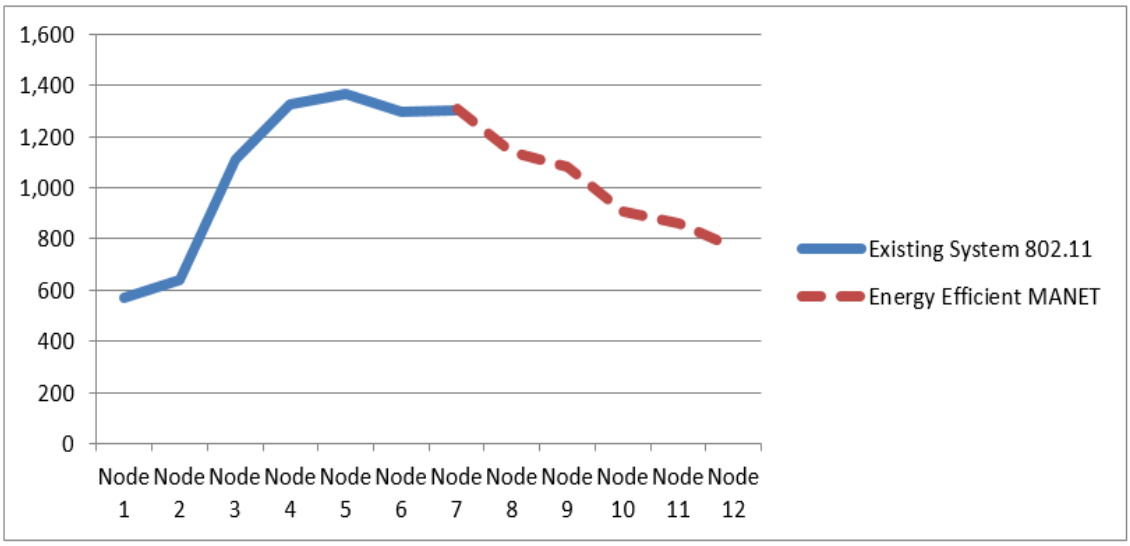

Figure 7. The power transmission and network energy consumption remained stable for some time than decreased with 12 number of nodes using MANET in comparison with the existing system 802.11.

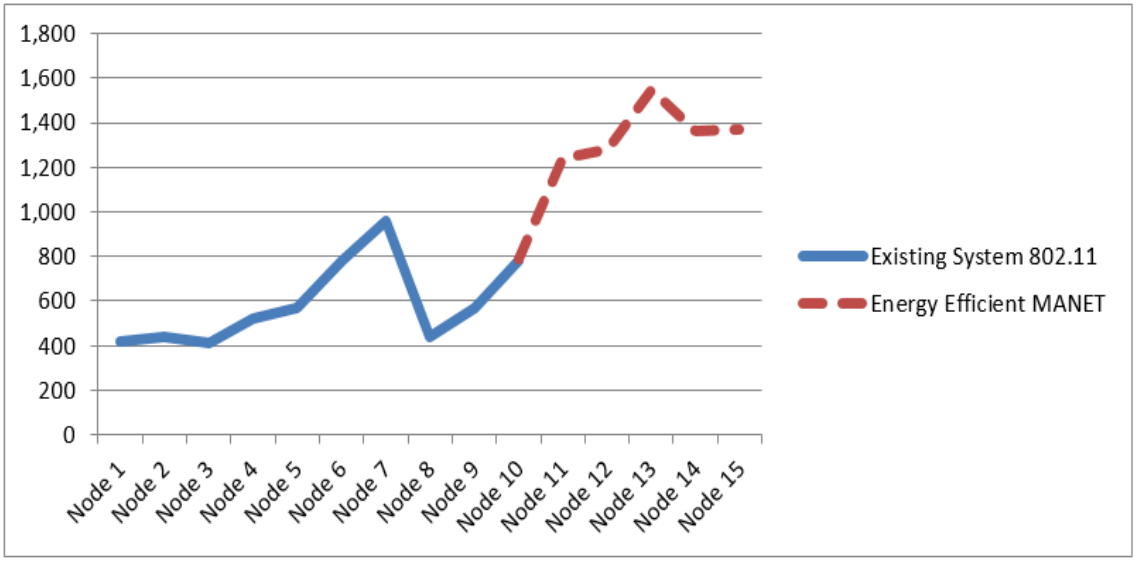

Figure 8. The power transmission and network energy consumption increased initially than decreased with 15 number of nodes using MANET in comparison with the existing system 802.11.

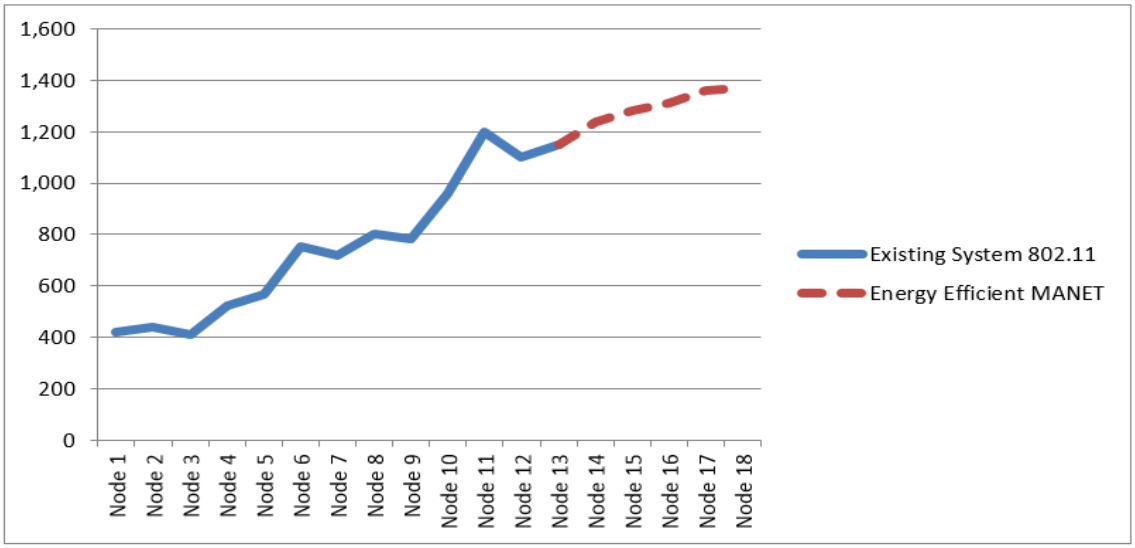

Figure 9 The power transmission and network energy consumption increased with 18 number of nodes using MANET in comparison with the existing system 802.11

Less number of nodes in the network would give low energy usage or consumption as the nodes in the network exceeds or increases that will also increase the energy consumption in the network. This paper presented an optimized Mobile Ad Hoc Network in comparison with AODV routing protocol with low energy consumption, which modifies broadcast mechanism of conventional existing network routing protocols.

Table 2. General analysis for proposed and exisiting MANET routing for nodes (1-9) on left while nodes (1-12) on right with different measuring parameters including energy consumption.

Parameter for Nodes (1-9)	AODV	EEM
Path Length	176.29	67.52
Congestion Cost	15.882	25.638
Unavailability	160	0
Delay	0.71	0.35
Packet Loss	0.1	0.34
Low Energy Consumption	126.76	94.286
Total Cost	352.99	93.859

Parameter for Nodes (1-12)	AODV	EEM
Path Length	194.29	130.03
Congestion Cost	2.1272	40.416
Unavailability	220	0
Delay	0.71	0.68
Packet Loss	0.08	0.69
Low Energy Consumption	129.58	22.794
Total Cost	417.22	171.86

Table 3. General analysis for proposed and exisiting MANET routing for nodes (1-15) on left while nodes (1-18) on right with different measuring parameters including energy consumption.

Parameter for Nodes (1-15)	AODV	EEM
Path Length	217.36	186.39
Congestion Cost	9.269	44.007
Unavailability	220	0
Delay	0.71	0.61
Packet Loss	0.07	0.62
Low Energy Consumption	130.99	31.148
Total Cost	447.41	231.66

Parameter for Nodes (1-18)	AODV	EEM
Path Length	247.45	217.22
Congestion Cost	16.943	37.1
Unavailability	170	0
Delay	0.65	0.74
Packet Loss	0.06	0.75
Low Energy Consumption	144.62	16.892
Total Cost		

			435.11	255.87	

5. Discussion

In this research work of low energy consumption based MANETs. Each node selects part of its neighbors as the multi-point relay nodes. When a node sends control packets to all its neighbors, only its first nodes forward control packets, and the other neighbor nodes are not able to forward the packets. Thus, the low energy consumption packet mechanism reduces the number of network packets forwarding, and it can effectively decrease the energy consumption. In discussion, proactive routing protocols exchange routing information periodically and maintain network topology and routing information, thus the route discovery delay is small with low energy consumption MANET. However, proactive protocols need a lot of packets, which means that the protocols enlarge the network overhead. So, the proactive protocols are not suitable for the situation that the network topologies always change. In order words, the network control information in this situation will exponentially increase, so that makes the network overhead increase significantly and development of low energy consumption MANET in this work.

6. Conclusion

In this paper, it is shown how energy is one of the important factors for MANET. We have proposed a low energy consuming MANET (EEM) in comparison with the AODV. Energy efficient routing protocol is proposed using Network Simulator-2. Less number of nodes in the network would give low energy usage or consumption as the nodes in the network exceeds or increases that will also increase the energy consumption in the network. The designed MANET system is tried with 9, 12, 15 and 18 number of nodes in a system using network simulation-2 (NS-2). The energy consumption in proposed MANET network and node energy consumption by maintaining a strategic distance from the low number of nodes in a network. By contrasting energy consumption and node it demonstrates that MANET is far superior to existing framework 802.11 protocol convention based on battery lifetime, energy consumption, throughput, and power transmission.

7. References

[1] V. Gupta, K. Kaur, and S. Kaur, "Developing small size low-cost software-defined networking switch using raspberry Pi," *Adv. Intell. Syst. Comput.*, vol. 638, pp. 147–152, 2018, doi: 10.1007/978-981-10-6005-2_16.

[2]. M. Henshaw, *Raj Kamal International Conference on Advanced Computing Networking and Informatics*. 2018.

[3]. D. Yang, H. Xia, E. Xu, D. Jing, and H. Zhang, "An energy-balanced geographic routing algorithm for mobile ad hoc networks," *Energies*, vol. 11, no. 9, pp. 1–16, 2018, doi: 10.3390/en11092219.

[4]. M. A. Jubair, S. H. Khaleefah, A. Budiyono, S. A. Mostafa, and A. Mustapha, "Performance evaluation of AODV and OLSR routing protocols in MANET environment," *Int. J. Adv. Sci. Eng. Inf. Technol.*, vol. 8, no. 4, pp. 1277–1283, 2018, doi: 10.18517/ijaseit.8.4.5028.

[5]. Pawan, R. K. Sharma, A. K. Sharma, and V. Jain, "Genetic algorithm-based routing protocol for energy efficient routing in MANETs," *Adv. Intell. Syst. Comput.*, vol. 638, pp. 33–40, 2018, doi: 10.1007/978-981-10-6005-2_4.

[6]. M. H. Hassan, S. A. Mostafa, A. Budiyono, A. Mustapha, and S. S. Gunasekaran, "A hybrid algorithm for improving the quality of service in MANET," *Int. J. Adv. Sci. Eng. Inf. Technol.*, vol. 8, no. 4, pp. 1218–1225, 2018, doi: 10.18517/ijaseit.8.4.5004.

[7]. S. S. Anjum, R. M. Noor, and M. H. Anisi, "Review on MANET Based Communication for Search and Rescue Operations," *Wirel. Pers. Commun.*, vol. 94, no. 1, pp. 31–52, 2017, doi: 10.1007/s11277-015-3155-y.

[8]. M. A. Jubair and R. C. Muniyandi, "NS2 Simulator to Evaluate the Effective of Nodes Number and Simulation Time on the Reactive Routing Protocols in MANET," *Int. J. Appl. Eng. Res.*, vol. 11, no. 23, pp. 11394–11399, 2016.

[9]. M. H. Hassan and R. C. Muniyandi, "An improved hybrid technique for energy and delay routing in mobile ad-hoc networks," *Int. J. Appl. Eng. Res.*, vol. 12, no. 1, pp. 134–139, 2017.

[10]. AL-Khaleefa, A.S.; Ahmad, M.R.; Muniyandi, R.C.; Malik, R.F.; Isa, A.A.M. Optimized Authentication for Wireless Body Area Network. J. Telecommun. Electron. Comput. Eng. 2018, 10, 137–142.
[11]. P. R and R. N, "An improved multipath MANET routing using link estimation and swarm intelligence," *Eurasip J. Wirel. Commun. Netw.*, vol. 2015, no. 1, 2015, doi: 10.1186/s13638-015-0385-3.
[12]. D. N. Kanellopoulos, "Recent progress on QoS scheduling for mobile ad hoc networks," *J. Organ. End User Comput.*, vol. 31, no. 3, pp. 37–66, 2019, doi: 10.4018/JOEUC.2019070103.
[13]. Goyal, P.; Parmar, V.; Rishi, R. MANET: Network Simulator-2, Application. Int. J. Comput. Eng. Manag. 2016, 11, 6.
[14] S. Rashid, A. Ahmed, I. Al Barazanchi, and Z. A. Jaaz, "Clustering algorithms subjected to K-mean and gaussian mixture model on multidimensional data set," *Period. Eng. Nat. Sci.*, vol. 7, no. 2, pp. 448–457, 2019.
[15] N. J. Qasim, S. M. Mohammed, A. S. Sosa, and I. Al Barazanchi, "Reactive protocols for unified user profiling for anomaly detection in mobile Ad Hoc networks," *Period. Eng. Nat. Sci.*, vol. 7, no. 2, pp. 843–852, 2019.