International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 12, December-2014

Investigating the Energy-Preservation Techhniques in Routing for MANET

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***Abstract*— The area of Mobile Adhoc Network (MANET) has been persistently attracted the attention of the global researchers from past decades. Literature archival has consistently witnessed the publications of research manuscript that exhibits some of the solutions towards enhancing the performance of MANET or to mitigate certain issues. Out of various issues in MANET e.g. routing issues, dynamic topology, security, channel capacity, restricted resources, it has been seen that dynamic topology is the root cause of majority of the problems. Owing to this, an excessive energy is drained out by the mobile nodes that giving rise to all the secondary problems. Hence, this paper presents a review of prior studies especially focusing on the standard routing techniques as well as some of the significant recent studies to understand the level of effectiveness in the prior techniques. Finally, the paper discusses about the research gaps that are yet to be solved among the research communities.**

Keywords: Mobile Adhoc Network, Routing Protocols, Energy Efficient routing,

I. INTRODUCTION

In the recent times communication has become very important for people to exchange information anytime from and to anywhere. As the rapid development in the field of networking and computing technology [1], computer communications become very much dependent in the field of mobile computing with very high profile links, which are very much energy efficient. A Mobile Adhoc Network consists of number of mobile nodes that are always in arbitrary movement and is characterized by decentralized and infrastructure free networking system. Owing to potential application of mobile adhoc network in the area of vehicular adhoc network, this area is also shrouded with various issues. The mobile adhoc network has inherent dynamic topology for which purpose there is an intermittent link breakage along with heavy consumptions of the channel capacity. This phenomenon also leads to frequent consumption of energy too from the mobile nodes. Another prominent issues in mobile adhoc network is to perform efficient routing [2][3]. Due to the fast proliferation of distributed computing environment, mobile network is growing very fast. Routing protocol in mobile adhoc network plays a critical role in establishing communication and networking system in the adhoc system. In last decade, there were various research attempts that have also focused on the understanding as well as investigating the effective routing protocols in mobile adhoc network. In this process, certain standards protocols have been evolved with potential features as well as constraints too [2]. The energy efficient routing may be the most important design criteria for MANETs, since mobile nodes will be powered by batteries with limited capacity. Power failure of a mobile node not only affects the node itself but also its ability to forward packets on behalf of others and thus the overall network [1][2]lifetime. A mobile node consumes its battery energy not only when it actively sends or receives packets, but also when it stays idle listening to the wireless medium for any possible communications requests from other nodes. Thus, energy-efficient routing protocols minimize either the active communication energy required to transmit and receive data packets or the energy during inactive periods. It was also seen that energy is the primary cause of various secondary issues in mobile adhoc network. The term 'energy' basically relates to battery lifetime of the nodes, where each node can have various physical and networking charecteristics. As the mobile nodes has to be in continuous mobility mode and also needs to participate in communication process, so a mobile node consistently drains it energy in both active and passive phase. Active phase is when the mobile node receives or transmits data packet and passive phase is when there is no transmission of data packet. However, a node will require being always in listening mode with other nodes to ensure that there is a less event of link breakage. Therefore, owing to energy issues, routing process is disturbed that potentially shoots up an issue of excessive available bandwidth in the network thereby causing delay as well as degrades the performance as well as throughput of the network. Although, there have been various set of research work that has focused only on energy issues, but still it is an open challenge in the area of mobile adhoc network.

This paper reviews and classifies numerous energy-efficient routing mechanisms proposed for MANETs. The paper attempts to investigates the prime reason for energy depletion followed by investigation of some of the standard techniques that are frequently being adopted by the various authors as well as researchers to perform either benchmarking or consider to perform enhancement. Hence, it is expected that outcome of this manuscript will assist the new reader to understand the effectiveness of energy efficient protocol. Section II discusses about the inherent issues in MANET followed by existing techniques adopted in MANET in Section III. Section IV discusses about the research issues and finally Section V makes some concluding remarks.

II. ISSUES IN MANET

The area of Mobile Ad-hoc network (MANET) is characterized by dynamic topology and decentralized networking system. In the existing system, the energy efficiency factor of the mobile node is found to be depicted by various definitions from various researchers. The energy factor of the mobile nodes is represented as a time when it detects the death of the first node. It is also depicted as a time until which value the mobile node stops operating in the normal operating condition. It is also defined as a time until the issues of network partitioning shoots up. However, similar issues do existing in wireless sensor network; however, the adverse effect is quite less compared to mobile adhoc network. In wireless sensor network, if one of the nodes undergoes failure it occasionally doesn't lead to the loss of sensing as well as doesn't disrupt much the entire network performance. But the same is not in the case of mobile adhoc network as it is more inclined towards invoking personal communication system in the presence of adverse effects of dynamic topology (which is absent in wireless sensor networks). In mobile adhoc network, it is critically important that mobile nodes are always in communication link with each other irrespective of the availability of the resources. Therefore, such sustainance features in mobile adhoc network calls for highly extensive network lifetime to ensure that it doesn't lead to network partitioning process. The issues of network partitioning in mobile adhoc network essentially leads to disruption of the communication session causing due to either node failures (due to energy dissipation) or owing to arbitrary movement of the mobile nodes. Although the existing routing protocols cannot control the dynamic behaviour of mobile nodes, but it can substantially conserve the energy required to perform routing. The other frequent issues of mobile adhoc networks are

- **Error in the channels**: The channel error in mobile adhoc network is caused due to burstiness and higher time correlational factor. Usually, adhoc network experiences channel errors owing to faulty routing procedure, interference, and bit distortion.
- **Hidden Terminal:** Hidden Terminal problem is another significant issue in mobile adhoc network that arises from the process of carrier sensing and packet sensing due to adoption of MAC protocols. In this process, the node is termed as hidden when it is not ready to hear the ongoing transmission that its neighbor nodes is receiving and therefore it doesn't defer from attempting to gain access. However, in doing so, it usually interferes with the reception at the destination.
- **Excessive bandwidth utilization:** It is said that wireless channel has lower bandwidth capacity as compared to wired channel. Moreover, owing to other significant issues like channel fading, interference condition, noise, traffic congestion, the issues of channel capacity exceed to a large extents. Certain application of multimedia streaming calls for excessive bandwidth consumption when the transmission is done in large scale mobile adhoc network.
- **Security Issues**: Owing to decentralization of the network, it is not possible to perform efficient authentication of the all the mobile nodes present in the network. Moreover, differentiating regular node, malicious node, selfish node, as well as erroneous node is still an unsolved problem in area of mobile adhoc network.

It should be noted that the energy consumed during sending a packet is the largest source of energy consumption of all modes. This is followed by the energy consumption during receiving a packet. Despite the fact that while in idle mode the node does not actually handle data communication operations, it has been found that the wireless interface consumes a considerable amount of energy Nevertheless. This amount approaches the amount that is consumed in the receive operation. Idle energy is a wasted energy that should be eliminated or reduced through energy-efficient schemes. Through energy consumption measurements studies, experiments have also been conducted to determine the power consumption patterns in the different active modes. In some experiments, the instantaneous power consumption per communication mode, e.g. send, receive, idle and sleep modes, has been measured. Some experiments went even further to include more details about the energy consumption pattern per subtype of the operation for example, the cases of unicast and broadcast are considered to have different costs.

III. EXISTING TECHNIQUES

The existing technique calls for using the routing protocol as the media of mitigating the energy issues in mobile adhoc network. In the past decade, various routing protocols have been designed that were used to address the issues of energy along with various other associated problems with energy efficiencies. A routing protocol is generally used during the transmission of packets from any source node to destination node. Several routing protocols have been proposed for such kind of mobile Ad-hoc network. It is said that effective design of the routing table is the critical success factor of the system and network performance in mobile adhoc network. As it lays the foundation of the decision variables of the communication system to ensure the effective communication does takes place in mobile adhoc network. An effective routing table not only ensure effective communication system, but also address the energy problems related to the dynamic topology of mobile adhoc network. Details of several routing protocols have listed in the below mentioned table. Table 1 highlights some of the effective and standard routing tables that were seen to be consistently being adopted by the research community for mitigating the problems related to energy issues in mobile adhoc network. Table 1 also highlights the advantages as well as the inherent limitation that characterized the existing routing protocols. This evaluation of the routing table is essentially important as in the upcoming studies, the routing tables mentioned in Table 1 are frequently chosen to perform benchmarking. Hence, it is very important to understand the potential features as well as associated limitations in order to assist the readers to understand the best routing protocol in the upcoming studies.

Table 1 Summary of existing techniques

Techniques	Advantages	Limitations
ZHLS [4]	Effective task distributed.	Network break-down can happen when the gateway failed
GSR , HSR ,DSDV [5]	Efficient for delay tolerant routing protocols in MANET and its applications.	Leads to additional overhead cost with adversely affected throughput
ZRP , AODV,DSR, LAR,TORA	Reduce wastage of bandwidth, Communication overhead has reduced	Large overlapping of routing zones. Incurs higher latency
Adaptive Cell Relay Routing, Protocol [7]	It can completely adjust itself with the minimized delay, varying node density, and targets for better scalability.	Not be suitable for dense networks (only applicable for sparse networks)
APR [8]	No QoS information is exchanged between the nodes, reducing protocol overhead	APR is not suitable for mobile Networks
QMPR [9]	QMPR avoids flooding To reduce the communication overhead	Cannot be used in MANET
Chen-Heinzelman [10]	Better service for Band width constraints	It does not give any QoS guarantees, as no bandwidth is reserved for a route
MAODV , AMRIS , BEMRP , DDM , ADMR , MCEDAR , CAMP, LGT and AMRIS , ACMP and CQMP , HQMRP , SPBM , MCEDAR , OMHF , Era Mobile	Up-to date information about network routes is always available, ensure better scalability , allows an ad-hoc group member to join/leave the multicast group dynamically, deploys geographic position of mobile nodes to furnish scalable membership scheme	The group leader continues flooding Group Hello messages even if no sender for the group exists. 1. Joining and rejoining of a node may take long time and waste much bandwidth since each node tries potential parent nodes arbitrarily. 2. The usage of periodic beacons consumes bandwidth
EELAR [12]	Control packet overhead is reduce	Loss of routes due to power shortage
ECNC_AODV[13]	Reduces energy Consumption and routing Overhead	Not Scalable to large network
PRISM [14]	Topology leakage is less. Hence increased security and privacy	It would require each node to store a complete network membership table which is expensive to store and maintain
RRR-AODV [15]	Reduces the number of control messages with the help of backup nodes to improve the efficiency of the network	Extra overhead due to back up nodes information gathering
OMNeT++ [16]	Effective for Collision Overhead	Not efficient for all type of MANET Environments
FCPP [17]	Reduces network Overhead by reducing flooding problem	For sparse system Information dissemination will be low

IV. RELATED WORK

Kim et al [18] have described a distributed power-aware routing protocol that finds the least power consuming paths between any two nodes in the network. The presented technique is based on priority based SPR algorithm to ensure an effective battery lifetime of the mobile nodes using shortest path routing. The author has discussed about this protocol as distributed energy aware routing protocol to select the best and shortest path with minimized energy consumption. However, the outcomes of the paper are not found to be benchmarked

Paroux et al [19] have presented Transhumance a middleware supporting peer-to-peer applications on pocket PC-based mobile ad hoc networks (MANETs). The study was targeted for small scale networks (20 mobile nodes) for providing services with a target to furnish higher layers with routes using OLSR protocol. However, the outcome was again found not to be benchmarked with the existing study although the work claimed to posse's energy efficiency along with security. Vassileva et al [20] have focused of this survey that how to maximize the useful lifetime of ad hoc wireless networks through energy-efficient routing.

Pilski et al. [21] have presented an approach for developing an algorithm for an energy efficient routing protocols in mobile ad hoc networks (MANETs) using genetic

algorithm. The authors have used heuristic based approach for identify the based energy efficient routing path using their self-designed simulator. Experimented over 16 mobile nodes, the study was performed for small scale mobile adhoc network where the outcome was evaluated using maximum number of transmitted message and remnant energy. However, there was no benchmarking of the discussed outcome.

Another work is similar direction was presented by Demeure et al [22] who have presented an energy aware middleware to support collaborative applications on small scale Mobile Adhoc Networks (MANET) made of handheld terminals. The authors have performed the experiment on the Transhumance middleware system also discussed by Paroux et al [19]. The experiment was carried out in real-time where the outcome of the study was evaluated using mean energy consumption. Although, the study is highly unique and exhibits more reliable outcomes in real-time, but the scope of the outcomes are required to be tested with other environments too.

Deb et al [23] proposed a new positioning framework by using only a handful of GPS enabled nodes. Lower dependence on specialized GPS hardware reduces the total cost of implementing the framework. The authors have presented an algorithm that performs selection of mobile node with higher energy efficiency. The outcome of the study was evaluated using total energy and hop counts with increasing number of nodes. The outcome is benchmarked with Location Aided-Routing (LAR) to exhibit better minimization of overhead, minimized cost, and energy efficient.

Awad et al [24] have demonstrated, the feasibility of efficient routing and service discovery in sensor networks using the Virtual Cord Protocol (VCP). Scalable and energy efficient data management is still a challenging topic in this domain. Mazhar [25] has presented an overview and comparison of the MANET security at routing layer by using the cryptographic and Artificial Immune System (AIS) approaches. The authors have designed an algorithm using swarm optimization technique (honey bee colony) that acts as a routing protocol to assists in fault-tolerant and efficient routing. The outcome of the study is evaluated using throughput, packet delivery ratio, hops, latency etc.

Emphasis on existing routing protocols was also laid in the study conducted by LIN et al [26] introduced unicast protocol, multicast protocol, geocast protocol, Mobicast protocol, and broadcast protocol. It is observed that carry-and-forward is the new and key consideration for designing all routing protocols in VANETs. With the consideration of multi-hop forwarding and carry-and-forward techniques, min-delay and delay-bounded routing protocols for VANETs are discussed in VANETs. Besides, the temporary network fragmentation problem and the broadcast storm problem are further considered for designing routing protocols in VANETs. Talwar et al [27] have stated the functioning of existing ACO based ad-hoc routing protocols as well as ad-hoc routing protocols for MANETs and the comparison tables with summery of every protocol is shown. Kumar et al [28] have proposed a model that reduces the routing overhead and path setup delay, and enhances the network lifetime. The authors have introduced a path maintenance algorithm using request, beacon reply, and error. The prime purpose of the algorithm is to ensure maintaining local routing table, path maintenance, packet forwarding, and control routing overhead using 94 mobile nodes.

Kalpana et al [29] have proposed a fuzzy logic technique for gossip based reliable broadcasting in Mobile Ad hoc Networks. In this technique, each node computes the node velocity, residual energy and node degree. The outcome of the study was evaluated using velocity, packet delivery ratio, delay, and energy with respect to speed of the mobile nodes. Ramesh et al [30] described a set of experiments conducted to analyze the performance of the Preemptive DSR routing protocol in a battlefield scenario. The authors have introduced a mathematical model to evaluate the discussed technique using Java. The outcomes of the study were evaluated using packet delivery fraction, routing load, and delay. Tiwari et al. [31] proposed a brief description of basic aspects of mobile ad hoc network and studied various power saving techniques in mobile ad hoc network & given a comparative analysis of these techniques. The work has jointly addressed the energy as well as the security issues in mobile adhoc network using cluster based routing protocol. The outcome of the study was evaluated using energy factor. Fahmy et al [32] illustrated and improved PEEBR algorithm is evaluated in terms of energy consumption efficiency and throughput compared to two state-of-art ad-hoc routing protocols (AODV and DSDV). The outcome of the study was tested using energy parameter from 10-30 mobile nodes in VC++ environment.

V. RESEARCH ISSUES

After reviewing the standard routing techniques as well as some of the significant studies done in this area, following research issues have being explored:

- **Few Benchmarked Studies**: Majority of the existing study's and their outcomes are not found to benchmarked for which reason, it becomes immensely challenging to understand the best energy efficient algorithm.
- **Scalability Issue**: The existing studies on energy efficiency deals with 50-70-100 mobile nodes, which are extremely less in number considered to the real-time applications in MANET. Hence, the outcome proving energy efficiency in low network doesn't necessary is scalable when the network is scaled larger.
- **Algorithm Efficiency**: Very few studies have been explored in the past decade where the energy efficient algorithms have actually underwent scrutiny of efficiency with respect to time and space complexity.
- **Narrowed Scope**: Majority of the energy efficient techniques have focused on selecting energy as a performance parameter, however, there are many other QoS parameters like Bandwidth, resources to be allocated are equally necessary. Adoption of QoS parameters are found quite less. The experimental scenario is highly specific to the simulation parameters as well as targeted applications.

VI. CONCLUSION

The area of Mobile Adhoc Network is shrouded with various issues from a long time. Although there are various research attempts, where some of them are significant considered as standard techniques are also found to posses constraints and limitations. This paper has essentially performed two types of investigation i) investigating the standard techniques and ii)

investigating few significant recent studies. After reviewing the outcomes, it can be seen that individual paper sounds well when local problems discussed in the paper's of authors are considered. However, when we tends to change the environmental variables, we found that there are actually few algorithms that fundamentally addresses the energy issues in mobile adhoc network. It was found that majority of the frequently adopted routing protocols are highly effective in one scenario, however, with change in scenario (or adoption of new performance parameters like bandwidth etc), the outcomes changes. The likelihood of adoption of such techniques are quite less as there are many upcoming trends of modern technology where mobile adhoc network will encounter further problems. Performance of the protocol varies according to the variation in the network parameters, as we know that in ad-hoc network properties continuously vary. Sometimes the mobility of the node of the network is high while sometimes energy of the node is our prime concern. So, we will choose the protocol in such a way that which perform best for that particular type of network. That's why we have surveyed many types of conventional protocols and their modification which includes energy efficiency. Energy efficiency is one of the main problems in a MANET, especially in designing a routing protocol. In this paper surveyed and classified conventional and energy efficient routing protocols. In many cases, it is complicated to compare them directly since each technique has a different objective with different assumptions and employs different means to achieve the objective. Our prime concern is energy efficiency and we have tried to discuss almost all possible approaches of energy efficient protocols.

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