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Energy Efficient Routing Protocol for Mobile Ad-hoc Networks

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Abstract

Mobile Ad Hoc Networks (MANETs) also called mesh networks are self-configuring networks of mobile devices connected by wireless links. MANETs are deployed in situations where there is no existing infrastructure, such as emergency search and rescue, military, etc. Each application has a different set of requirements. This paper considers energy routing protocols and workload balancing techniques for improving MANET routing protocols and energy efficiency. We give routing protocol that employs load balancing technique to the MANET routing protocols with node caching enhancement. For energy efficiency evaluation of the protocols with limited power supply, the primary objectives of MANET routing protocols are to maximize network throughput, to maximize energy efficiency, maximize network lifetime, and to minimize delay. The network throughput is usually measured by packet delivery ratio while the most significant contribution to energy consumption is measured by routing overhead which is the number or size of routing control packets. The simulation will be done using NS2 network simulator.

Keywords: *MANETs, routing protocols, mobile ad hoc networks, Ad-hoc On-demand Distance Vector, network simulations, node caching, energy efficiency.*

1. Introduction

Mobile ad hoc networks (MANETs) are composed of a collection of mobile nodes which can move freely and communicate with each other using a wireless physical medium. Therefore, dynamic topology, unstable links, limited energy capacity and absence of fixed infrastructure are special features for MANET when compared to wired networks. Wireless local area network based on IEEE 802.11 technology is the most prevalent infra-structured mobile network, where a mobile node communicates with a fixed base station, and thus a wireless link is limited to one hop between the node and the base station. MANET do not have centralized controllers, which makes it different from traditional wireless networks [1]. MANETs are infrastructure-less, self-organizing, rapidly deployable wireless networks MANETs find applications in several areas. Some of them are: military applications, collaborative and distributed computing, emergency operations, wireless mesh networks, wireless sensor network, and hybrid wireless network architectures [2].

The routing protocols proposed for MANETs are generally categorized as *table-driven* and *on-demand driven* based on the timing of when the routes are updated. With table-driven routing protocols, each node attempts to maintain consistent, up-to-date routing information to every other node in the network. This is done in response to changes in the network by having each node update its routing table and propagate the updates to its neighbouring nodes. Thus, it is *proactive* in the sense that when a packet needs to be forwarded the route is already known and can be immediately used. As is the case for wired networks, the routing table is constructed using either *link-state* or *distance vector* algorithms containing a list of all the destinations, the next hop, and the number of hops to each destination. Many routing protocols including *Destination-Sequenced Distance Vector (DSDV) [19]* and *Fisheye State Routing (FSR) [20]* protocol belong to this category, and they differ in the number of routing tables manipulated and the methods used to exchange and maintain routing tables.

With on-demand driven routing, routes are discovered only when a source node desires them. *Route discovery* and *route maintenance* are two main procedures: The route discovery process involves sending route-request packets from a source to its neighbour nodes, which then forward the request to their neighbours, and so on. Once the route-request reaches the destination node, it responds by unicasting a route-reply packet back to the source node via the neighbour from which it first received the route-request. When the route-request reaches an intermediate node that has a sufficiently up-to-date route, it stops forwarding and sends a route-reply message back to the source. Once the route is established, some form of route maintenance process maintains it in each node's internal data structure called a route-cache until the destination becomes inaccessible along the route. Note that each node learns the routing paths as time passes not only as a source or an intermediate node but also as an overhearing neighbor node. In contrast to table-driven routing protocols, not all up-to-date routes are maintained at every node. *Dynamic Source Routing* (DSR) and *Ad-Hoc On-Demand Distance Vector* (AODV) are examples of on-demand driven protocols.

The remainder of the paper is organized as follows: section 2 MANET characteristics .section 3 discuss the literature survey related to our paper. Section 4 discusses the detail description of proposed work and section 5 discusses the results. Finally, section 6 provides a conclusion.

2. MANET Characteristics

An area of wireless networking that has received tremendous attention lately in the mobile ad hoc network. It is typically compose of equal nodes that communicate over wireless links without the need for any central control or fixed infrastructure. In MANET each mobile terminal is an autonomous node which may function as both a host and router. In other words besides the processing ability as a host, the mobile nodes can also perform switching functions as a router. Since nodes in MANET can move in an arbitrarily fashion, the network topology may change rapidly and unpredictably. Connectivity among the terminals may vary with time.

Autonomous and infrastructure less-MANET is self-organized and independent of any established infrastructure and centralized network administration. Each node runs as a router and operates in distributed manner.

Multi-hop routing- As there is no dedicated router, every node functions as a router and aids in forwarding each other's packets to intended destination. Hence, information sharing among mobile nodes is made available.

Dynamic network topology- Since MANET nodes move randomly in the network, the topology of MANET changes frequently, leading to regular route changes, network partitions, and possibly packet losses

Variation on link and node capabilities- Each participating node may be equipped with different type of radio devices that have varying transmission and receiving capabilities, and possibly operate on multiple frequency bands Asymmetric links might be resulted due to this heterogeneity in the radio capabilities. Additionally, different software or hardware configuration might result in variability in processing capabilities. Thus, designing and standardization of MANET protocols and algorithms for this heterogeneous network are complicated as dynamic adaptation is required.

Bandwidth- constrained, variable capacity links: Wireless links will continue to have significantly lower capacity than their hardwired counterparts. In addition, the realized throughput of wireless communications--after accounting for the effects of multiple access, fading, noise, and interference conditions, etc.--is often much less than a radio's maximum transmission rate. One effect of the relatively low to moderate link capacities is that congestion is typically the norm rather than the exception, i.e. aggregate application demand will likely approach or exceed network capacity frequently. As the mobile network is often simply an extension of the fixed network infrastructure, mobile ad hoc users will demand similar services. These demands will continue to increase as multimedia computing and collaborative networking applications rise.

Dynamic topologies: Nodes are free to move arbitrarily; thus, the network topology--which is typically multihop--may change randomly and rapidly at unpredictable times, and may consist of both bidirectional and unidirectional links. One effect of the relatively low to moderate link capacities is that congestion is typically the norm rather than the exception, i.e. aggregate application demand will likely approach or exceed network capacity frequently. As the mobile network is often simply an extension of the fixed network infrastructure, mobile ad hoc users will demand similar services. These demands will continue to increase as multimedia computing and collaborative networking applications rise.

Energy-constrained operation- The processing power of node is restricted because the batteries carried by portable mobile devices have limited power supply. As a result, the services and applications that can be supported by each node are limited. Network protocols must be developed to be power-aware since each node is functioning as both an end system and a router.

*Network scalability***-** Many MANET applications may involve large networks with tens of thousands of nodes especially that can be found in tactical networks. Scalability is crucial to the successful deployment of MANET.

3. Literature Survey

The design of an energy efficient routing protocol for MANETs requires a detailed insight into routing and energy management strategies for MANETs. The characteristics of MANETs have led to the development of MANET specific routing protocols. A routing protocol is the mechanism by which user traffic is directed and transported through the network from a source node to a destination node [18]. Based on this definition the classification of routing protocols is given as follows.

Classification of Routing Protocols in MANETs

MANET routing protocols could be broadly classified into two major categories based on the routing information update mechanism [5]:

*1. Proactive Routing Protocols***:** Proactive protocols continuously learn the topology of the network by exchanging topological information among the network nodes. Thus, when there is a need for a route to a destination, such route information is available immediately. If the network topology changes too frequently, the cost of maintaining the network might be very high. If the network activity is low, the information about actual topology might even not be used. Ex: DSDV, WRP, CGSR, etc.

*2. Reactive Routing Protocols***:** The reactive routing protocols are based on some sort of query-reply dialog. Reactive protocols proceed for establishing route(s) to the destination only when the need arises. They do not need periodic transmission of topological information of the network. Ex: DSR, AODV, TORA, etc.

*3. Hybrid Routing Protocols***:** Often reactive or proactive feature of a particular routing protocol might not be enough; instead a mixture might yield better solution. Hence, in the recent days, several hybrid protocols are also described.

Proactive approaches introduce more overhead compared to reactive ones. This is because even when there are no changes in network topology, control messages are flooded in order to maintain a full knowledge of the network in each node [11]. In proactive routing protocols first packet latency is less when compared with on-demand protocols [11]. Proactive (Table-driven) protocols are inherently more energy consuming compared to Reactive (On-demand) ones, hence most of the proposals involve modifications to reactive protocols [5]. In Reactive protocols, AODV is found to be the most energy efficient routing protocol. Hence many researchers have their studies concentrated on making AODV routing protocol more energy efficient.

Ad hoc On-demand Distance Vector

AODV [5] is a reactive routing protocol instead of proactive. It minimizes the number of broadcasts by creating routes based on demand, which is not the case for DSDV. When any source node wants to send a packet to a destination, it broadcasts a route request (RREQ) packet. The neighbouring nodes in turn broadcast the packet to their neighbours and the process continues until the packet reaches the destination. During the process of forwarding the route request, intermediate nodes record the address of the neighbour from which the first copy of the broadcast packet is received. This record is stored in their route tables, which helps for establishing a reverse path. If additional copies of the same RREQ are later received, these packets are discarded. The reply is sent using the reverse path. For route maintenance, when a source node moves, it can reinitiate a route discovery process. If any intermediate node moves within a particular route, the neighbour of the drifted node can detect the link failure and sends a link failure notification to its upstream neighbour. This process continues until the failure notification reaches the source node. Based on the received information, the source might decide to re-initiate the route discovery phase.

Energy management in MANETs is the basis on which routing protocols are improved to attain energy efficiency. The choice of the routing protocol affects each of the dimensions along which energy is consumed, such as transmission, battery, and device and processor energy. These dimensions are discussed in detail in the remainder of the section. Along with these schemes there is also a description of the energy cost metrics which measure the amount of energy saved by using different path selection schemes.

Energy Management in MANETs

Energy is a scarce resource in ad hoc wireless networks and it is of paramount importance to use it efficiently when establishing communication patterns [3]. Energy Management is defined as the process of managing the sources and consumers of energy in a node or in a network as a whole for enhancing the lifetime of the network [2]. Energy Management can be classified into the following categories:

1. Transmission Power Management: The power consumed by the radio frequency (RF) module of a mobile node is determined by several factors such as the state of operation. The transmission power, and the technology used for the RF circuitry. The state of operation refers to the transmit, receive, and sleep modes of operation. The transmission power is determined by the reachability requirement of the network, the routing protocol and the MAC protocol employed. The RF hardware design must ensure minimum power consumption in all the three stages of operation.

2. Battery Energy Management: The battery management is aimed at extending the battery life of a node by taking advantage of its chemical properties, discharge patterns, and by the selection of a battery from a set of batteries that is available for redundancy.

3. Processor Power Management: The clock speed and the number of instructions executed per unit time are some of the processor parameters that affect power consumption. The CPU can be put into different power saving modes during low processing load conditions. The CPU power can be completely turned off if the machine is idle for a long time. In such cases, interrupts can be used to turn on the CPU upon detection of user interaction or other events.

4. Devices Power Management: Intelligent device management can reduce power consumption of a mobile node significantly. This can be done by the operating system (OS) by selectively powering down interface devices that are not used or by putting devices into different power-saving modes depending on their usage [2].

Energy Efficiency Metrics

A survey of the recent research in energy efficient routing protocols for ad hoc networks allows classifying the power efficient routing protocols into four categories based on their path selection scheme. The first set of protocols use the energy cost for transmission as the cost metric and aim to save energy consumption per packet. However, such protocols do not take the nodes' energy capacity into account. Thus, the energy consumption is not fair among nodes in the network. Minimum Total Transmission Power Routing (MTPR) [1] is an example protocol for this category. The second set of protocols use the remaining energy capacity as the cost metric, which means that the fairness of energy consumption becomes the main focus. But, these protocols cannot guarantee the energy consumption is minimized. The third set of protocols is similar to the second set, but use estimated node lifetime instead of node energy capacity as the route selection criteria. Therefore, these protocols still aim to fairly distribute energy consumption. In order to both conserve energy consumption and achieve consumption fairness, *Conditional Max-Min Battery Capacity Routing* (CMMBCR) [1] has been proposed to combine these two metrics. CMMBCR is an example of the fourth category of protocols, which use combined metrics to represent energy cost.

4. Proposed Work

The proposed work is aimed at developing energy efficient AODV routing protocol. In [6], Jin-Man Kim and Jong-Wook Jang propose an enhanced AODV routing protocol which is modified to improve the networks lifetime in MANET. One improvement for the AODV protocol is to maximize the networks lifetime by applying an Energy Mean Value algorithm which considerate node energy-aware. Increase in the number of applications which use Ad hoc network has led to an increase in the development of algorithms which consider energy efficiency as the cost metric. Till now, there is no existing standard of routing protocol for ad-hoc networks. The field is still new and much research work is still in progress. Though many routing algorithms have been proposed, there is not one that meets all the criteria. Many of the existing MANET routing incurs high routing overhead, high transmission delay and low throughput. This is mainly due to the fact that these algorithms are not adaptive or efficient enough to handle different network scenarios and conditions.

The modified route request uses a fixed threshold parameter *H*. The first route request is sent with the small threshold *H*. When a node *N* receives the route request, it compares the current time *T* with the time *T*(*N*) when the last data packet through N has been forwarded. If *T* ¡*H* >*T*(*N*), then *N* does not belong to the current node cache and, therefore, *N* will not propagate the route request. Otherwise, if *T* ¡*H* · *T*(*N*), then *N* is in the node cache and the route request is propagated as usual. Of course, the node cache cannot guarantee existence of paths between all source-destination pairs, therefore, if the route request with the small threshold *H* fails to find a route to destination, then a standard route request (which is not constrained by cache) is generated at the source.

Performance evaluation metrics

Six performance metrics parameter are used as, the generated packets, received packets, packet delivery ratio, total dropped packets, end-to-end delay and throughput. All metrics are measured quantitatively. Following are description of each metrics.

No.of Nodes	G P	R P	PDR	D P	E2E Delay
30	4312	4026	93.3673	60	333.692
21	4181	3839	91.8201	77	359.504
11	4389	3989	90.8863	80	317.528
6	4435	4015	90.5299	94	206.79

Table 1: Average of Scenario of result

Generated Packets: Total number of CBR packets sent by CBR sources. This is calculated by placing the condition "event== s" in awk script.

Received Packets: Total number of CBR packets received by CBR sources. This is calculated by placing the condition "event== r" in awk script.

Total Dropped Packets: Total number of dropped CBR packet by CBR sources. This is calculated by placing the condition "event==D" in awk script.

Packet Delivery Ratio: Packets delivery ratio is fraction of successfully delivered data packets to packets to packets generated by CBR sources. Packets delivery ratio describes how successfully protocol delivers packets from source to destination

5. Results

Analysis is based on above given scenarios that are for AODV protocol. Each scenario is run 6 times then find out the average of each run. Calculation is done through by finding average of every scenario with value of each scenario with AODV Table.1 respectively. Figure 1 Generating packet graph shows the graph as the network are vary with the number of nodes there is variation on the number of generation packet also take place. Figure 2 Receiving packet graph shows the graph as in the network are vary with the number of nodes there is variation in the number of receiving packet. The PDR graph shows the ratio of receiving packet/ generating packet. As the generating packet is only one and the receiving packet are large then the PDR shows graph which some how similar to receiving packet graph. In figure 3 Represent the Packet Delivery Ratio is increased as the no of nodes increased. Figure 4 graph of Delivery Ratio decrease with increase in number of nodes. Figure 5 graph of end to end delay increase with increase of nodes.

Facilities Required For Proposed Work

For this research work Network simulator-2 will be required.

The Network Simulator

The network simulator (ns) from Lawrence Berkeley National Laboratory is, thus far, the most popular simulator in the MANET research community. The ns simulator development began in 1989 and quickly gained the confidence of the network research community. The wireless extension to ns-2 (version 2 of ns simulator) simulator was provided by the Monarch Project. There were several ad hoc routing protocols (for example, DSR, AODV, etc.) implemented for ns-2. The ns-2 has an extensive collection of transport protocols and MAC protocols to support various wired, as well as wireless, protocols. The test cases were generated using built-in random generator in Network Simulator 2 (version NS-2.29). Our protocol evaluations are based on the simulation of 30 wireless nodes forming an ad hoc network, moving about over a 600m*X*600m rectangle. The simulation time was 150sec to evaluate general performances. At media access control (MAC) layer the 802.11 MAC protocol has been used.

6. Conclusion

A MANET consists of autonomous, self-organizing and self-operating nodes, each of which communicates directly with the nodes within its wireless range or indirectly with other nodes via a dynamically computed, multi-hop route. Due to its many advantages and different application areas, the field of MANETs is rapidly growing and changing. While there are still many challenges that need to be met, it is likely that MANETs will see wide-spread use within the next few years. In order to facilitate communication within an MANET, an efficient routing protocol is required to discover routes between mobile nodes. Energy efficiency is one of the main problems in an MANET, especially in designing a routing protocol. In this paper provides an overview of MANETs and discusses how energy is one of the most important constraints for these type of networks. A detailed study of the energy management strategies, energy cost metrics and AODV node cache energy efficient routing algorithms is provided.

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Figures

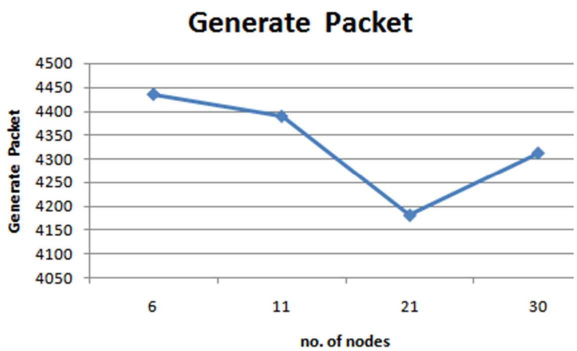

Figure1: Shows Generate packet v/s Number of nodes

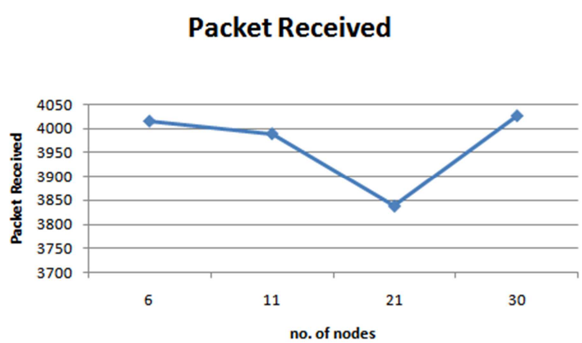

Figure 2: Shows Packet Received v/s Number of nodes

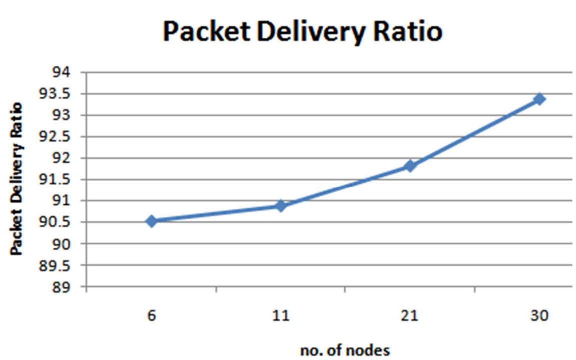

Figure 3: Shows Packet Delivery Ratio v/s Number of nodes

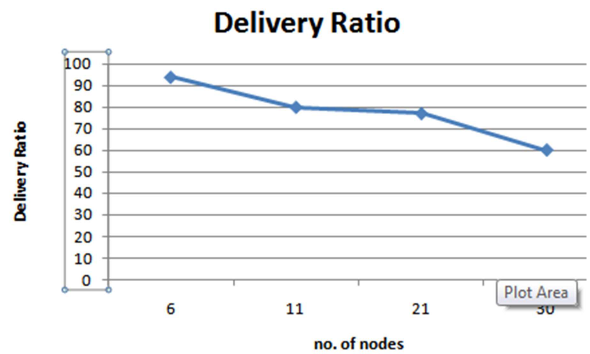

Figure 4: Shows Drop Packet v/s Number of nodes

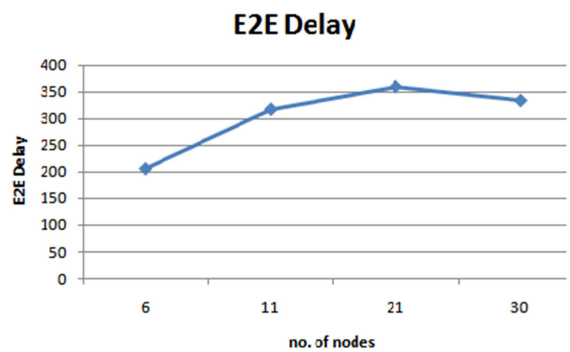

Figure 5: Shows E2E Delay v/s Number of nodes