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ADAPTIVE GOSSIP BASED PROTOCOL FOR ENERGY EFFICIENT MOBILE ADHOC NETWORK

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Abstract

In Gossip Sleep Protocol, network performance is enhanced based on energy resource. But energy conservation is achieved with the reduced throughput. In this paper, it has been proposed a new Protocol for Mobile Ad hoc Network to achieve reliability with energy conservation. Based on the probability (p) values, the value of sleep nodes is fixed initially. The probability value can be adaptively adjusted by Remote Activated Switch during the transmission process. The adaptiveness of gossiping probability is determined by the Packet Delivery Ratio. For performance comparison, we have taken Routing overhead, Packet Delivery Ratio, Number of dropped packets and Energy consumption with the increasing number of forwarding nodes. We used UDP based traffic models to analyze the performance of this protocol. We analyzed TCP based traffic models for average end to end delay. We have used the NS-2 simulator.

Keywords:

MANET Routing Protocol, Delivery Ratio, Energy Consumption, Reliability

1. INTRODUCTION

A mobile ad-hoc network is a collection of wireless mobile nodes dynamically forming a temporary network without the aid of any established infrastructure or centralized administration. The topology of the ad hoc network depends on the transmission power of the nodes and the location of the mobile nodes, which may change with time [1]. The primary objectives of MANET routing protocols are to maximize network throughput, to 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. A major challenge that a routing protocol designed for ad hoc wireless networks faces is resource constraints. Increasing the battery power may make the nodes bulky and less portable. The energy efficiency remains an important design consideration for these networks. In wireless networks, energy consumption is resulted by three main events other than the usual operation of transmission and reception. The first event is resulted due to overhear in which a node hears traffic not meant for it. The second event is collision. Collisions occur due to retransmissions and hence an increase in energy consumption. The third event which is the key idea of this paper is idle listening which corresponds to energy consumption. When a wireless interface is in an idle state that is neither transmitting nor receiving as per the Lucent's 915 MHz Wave LAN card - consumes 1.15W when idling, 1.2W while receiving and 1.6W while transmitting [2]. Measurements have shown that depending on the network loading situations, idle listening can consume up to 50-100% of the energy required for receiving.

In this paper, we proposed a protocol that reduces energy consumption due to idle listening by using an Adaptive Awake-Sleep algorithm for maintaining a common network-wide sleep schedule. Once synchronized, nodes can turn their interface off during the sleep section of the synchronized schedule, and they can communicate during the wake section of the schedule. By introducing sleep mode into the network, the total energy consumption of the network can be reduced and the network lifetime can be extended.

Contribution of the paper is twofold. First, it introduces a novel design of an Adaptive sleep mode by placing a RAS (Radio Activated Switch). It is placed on top of 802.11 MAC layer without requiring any change to the standard protocol. The second contribution is to apply this schedule synchronization mechanism for implementing an interface sleep-wake technique for significant reduction of the energy consumption due to idle listening.

The rest of the paper is organized as follows. In Section 2, we reviewed the literature on related topics of efficient protocol design in wireless ad hoc networks. In Section 3, we described Gossip based protocol. In section 4, the proposed protocol of Adaptive sleep-awake synchronization is explained. We described the Traffic pattern in Section 5. In Section 6 and 7, we evaluated and compared the performance of our protocol with and without adaptive scheme in the routing protocol of AODV.

2. RELATED WORK

One critical issue for almost all kinds of portable devices supported by battery powers is power saving. Without power, any mobile device will become useless. Battery power is a limited resource, and it is expected that battery technology is not likely to progress as fast as computing and communication technologies do. Hence, how to lengthen the lifetime of batteries is an important issue, especially for MANET, which is supported by batteries only.

Solutions addressing the power-saving issue in MANETs can generally be categorized as follows:

- Transmission power control: In wireless communication, transmission power has strong impact on bit error rate, transmission rate, and inter-radio interference. These are typically contradicting factors. In [3], power control is adopted to reduce interference and improve throughput on the MAC layer. How to determine transmission power of each mobile host so as to determine the best network topology, or known as topology control, is addressed in [4–6]. How to increase network throughput by power adjustment for packet radio networks is addressed in [7].

- Power-aware routing: Power-aware routing protocols were proposed based on various power cost functions [8–12]. In [8], when a mobile host's battery level is below a certain threshold, it will not forward packets for other hosts. In [11], five different metrics based on battery power consumption are proposed. Ref. [12] considers both hosts_ lifetime and a distance power metric. A hybrid environment consisting of battery-powered and outlet-plugged hosts is considered in [9]. Two distributed heuristic clustering approaches for two multi-casting are proposed in [10] to minimizing the transmission power.
- Low-power mode: More and more wireless devices can support low-power sleep modes. IEEE 802.11 [12] has a power-saving mode in which a radio only needs to be awake periodically. HIPERLAN allows a mobile host in power-saving mode to define its own active period. An active host may save powers by turning off its equalizer according to the transmission bit rate.

Comparisons are presented in [14] to study the power-saving mechanisms of IEEE 802.11 and HIPERLAN in ad hoc networks. Bluetooth [15] provides three different low-power modes: sniff, hold, and park. Other references include [16–22].

This paper studies the management of power saving (PS) modes for IEEE 802.11-based MANETs and thus falls into the last category of the above classification. We consider MANETs which are characterized by multi-hop communication, unpredictable mobility, no plug-in power, and no clock synchronization mechanism. In particular, the last characteristic would complicate the problem since a host has to predict when another host will wake up to receive packets. Thus, the protocol must be asynchronous. As far as we know, the power management problem for multi-hop MANETs has not been addressed seriously in the literature. Existing standards, such as IEEE 802.11 and HIPERLAN, do support PS modes, but assume that the MANET is fully connected. Bluetooth also has low-power modes, but is based on a master to slave architecture, so time synchronization is trivial. The works [19, 20] address the power saving problem, but assume the existence of access points. A lot of works have focused on multi-hop MANETs on issues such as power-aware routing, topology control, and transmission power control (as classified above), but how to design PS mode is left as an open problem.

3. GOSSIP ROUTING IN ADHOC NETWORKS

In Gossip, the packet retransmission is based on the outcome of coin tosses; the main objective of gossip is to minimize the number of retransmissions, while maintaining the main benefits of flooding. A message is normally transmitted as a broadcast rather than a unicast communication in adhoc networks. Since wireless resources are expensive, we use this physical-layer broadcasting feature of the radio transmission. In the gossiping protocol, we control the probability with which this physical-layer broadcast is sent [23].

The basic gossiping protocol is simple. A source sends a route request with probability 1. When a node first receives a route request, with probability p it broadcasts the request to its neighbors and with probability 1-p it discards the request; if the node receives the same route request again, it is discarded. Thus, a node broadcasts a given route request [26] at most once. Thus, in almost all executions of the algorithm, either scarcely any nodes receive the message, or most of them do. Ideally, we could make less number of executions where the gossip dies out relatively low while also keeping the gossip probability low, to reduce the message overhead [23].

As we mentioned earlier, the current ad hoc network routing protocols require all the nodes to be awake and keep listening. This wastes a lot of energy. Even if there is no traffic or heavy traffic (neighbor nodes are totally redundant for each other), the traditional ad hoc routing protocols necessitate all nodes to continue listening, thereby wasting the energy. Hence this reduces the lifetime of the nodes as well as the network's lifetime [26].The major objective as proposed in (GSP) is to achieve energy efficiency by putting some nodes in a sleep mode. The potential disadvantage of this approach is that packets may go through longer paths if the nodes sleeping are on the shortest paths [23] between source and destination nodes, resulting in more energy consumption in the network-wide communication. Also, paths will be broken more often due to mode change of the nodes. Therefore, more overhead is generated to overcome the path failures and this will consume some extra energy. In addition, sleeping of nodes results in decrease of the network throughput and increase of end to end delay.

4. NEW PROPOSED ENERGY AWARE GOSSIP PROTOCOL

In this paper, based on the GSP ad hoc routing, we proposed a new Protocol to achieve energy efficiency and reliability in wireless ad hoc networks to overcome the drawbacks. In this protocol, the nodes can be in active mode with probability 1-p or sleep mode with probability p which is fixed at the initial stage. A node (which wants to communicate) maintains a control variable called B which represents the current number of active neighbors. At each transmitting node the same process is initiated. The rest of the nodes will be in either p or 1-p state. The higher - B is the more power the node uses to send packets and thus the communication is more reliable. But higher the value of B will consume more amount of energy in joules in order to either forward or receive the packets. So, to reduce the amount of energy consumption the algorithm starts with every node in the network initializes B to one - means that a node initially broadcasts data packets only to its closest neighbor, thus requiring the least power. But to achieve the reliability, if needed, the intermediate nodes which fall on the path are triggered to the active mode. Now, the parameter of packet delivery ratio is computed and in the source node it is compared with threshold by means of feedback. Now, based on the time of feedback value arrived, we can estimate the shortest path. The time at which the feedback factor received is noted as T value. Other paths timing information through which we received the feedback factor are noted down. Perform the comparison with T and other computed time. This will used to determine the delayed response path and if so the nodes in that path are triggered into the sleep node. If the value of packet delivery ratio is greater than threshold value, the intermediate nodes are (which have been brought to active mode) triggered to sleep mode. The process repeats for every periodic interval.

But, due to the shortest path if the packet delivery ratio is not meeting the required threshold value, the other path, which gave somewhat greater delay compared to the shortest path time T, is taken into account. Through established path packets are transmitted. Now, the feedback of packet delivery ratio is computed. If it is above the threshold value, the nodes in the other path which yield greater delay are triggered to sleep mode. In this work, the threshold value is set as 0.5.

Based on RF tags technology, we can develop a switch that can be used to remotely activate a radio device while being in sleep state. In this way, nodes are woken up when necessary rather than getting active periodically to verify whether there is pending traffic.

The schematic representation of the switch, so-called RAS (Remote Activated Switch), is shown in Fig.1. Whenever, a node becomes idle, it enters a sleep state, i.e., the standard receiver/transmitter is turned off as well as part of the device electronics. Waking-up signals are received and demodulated [25] by the RAS, and then the signal information is passed to the logic circuit that detects the sequence. If the received sequence matches the device’s sequence, it turns on the standard receiver. Notice that the RAS receiver may be either totally passive (e.g., an amplitude demodulator) or supplied by the battery source through connection 1.

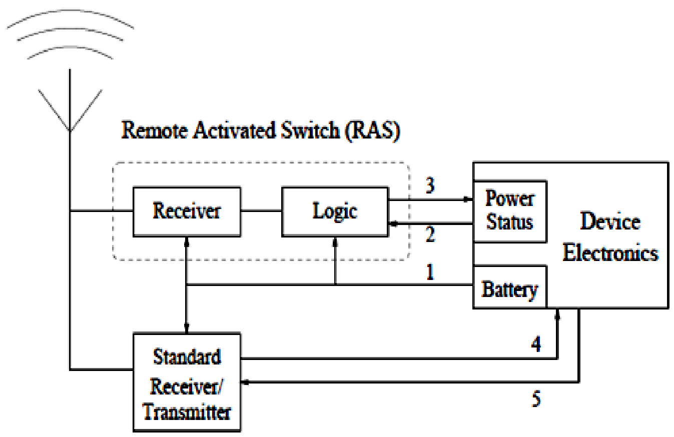

Fig.1. Scheme of the Communication Device Circuit

Two major challenges that one would encounter when designing power-saving protocols are: clock synchronization and the neighbor discovery. Clock synchronization in a multi-hop MANET is difficult since there is no central control and packet delays may vary due to unpredictable mobility and radio interference. PS modes are typically supported by letting low-power host’s wake up only in specific time. Without precise clocks, a host may not be able to know when other PS hosts will wake up to receive packets. Further, a host may not be aware of a PS host at its neighborhood since a PS host will reduce its transmitting and receiving activities. Such incorrect neighbor information may be detrimental to most current routing protocols because the route discovery procedure may incorrectly report that there is no route even when routes actually exist with some PS hosts in the middle

The major objective as proposed in this protocol is to achieve energy efficiency by putting more number of nodes in a sleep mode. The sleep nodes in the path of the packet transmissions are made to be active state by a triggering signal which will consume power from the RF signal itself. But we can achieve reliability, energy conservation and less delay compared to existing protocols. And in this protocol, once the threshold value is achieved the nodes are again driven to sleep mode which will conserve some extra amount of power compared to the existing power saving schemes.

5. TRAFFIC PERFORMANCE ANALYSIS

MANET performance is sensitive to mobility, scalability and traffic load, so to examine the different protocol performance while the amount of traffic and speed of nodes varies even plays a crucial role in efficient traffic routing. Now the important aspect is whether varying the network size, node speed and traffic load will improve the performance of the Protocols. So far Research studies on performance analysis of MANET routing protocols have shown distinctive results, based on the different network conditions such as traffic type, parameters, network size [24] and by using different simulators.

5.1 TRANSMISSION CONTROL PROTOCOL (TCP)

It represents to the transport layer of the OSI reference model. TCP uses a virtual connection. It means a logical connection is established before transmitting the data. TCP operates at a higher level with the end systems like Web browser and Web server. Applications of TCP include FTP, HTTP, streaming media and E-mail. TCP in data transmission uses requests for the lost packets and rearranges the out of order packets and minimizes the network congestion [27]. This makes TCP efficient in accurate packet deliver. But sometimes, this will result in long delays usually in seconds using requests for lost packets.

5.2 USER DEFINED PROTOCOL (UDP)

UDP is as simple message-based connectionless protocol. Connectionless protocols do not set up a dedicated end-to-end connection. Communication is achieved by transmitting information in one direction from source to destination without verifying the readiness or state of the receiver [27]. But, this approach leads to Unreliable, Not ordered and Datagramed approach. But UDP makes inefficient in accuracy. Since in MANET communication the radio range is small, this unreliable UDP provides high packet delivery ratio with small amount of delay.

6. SIMULATION RESULTS

NS2 is used to simulate the proposed algorithm and the channel capacity of mobile hosts is set to the same value: 2 Mbps. For the MAC layer protocol the distributed coordination function (DCF) of IEEE 802.11 (for wireless LANs) is used. It has the functionality to notify the network layer about link breakage. In the simulation, mobile nodes moved within a 600 meter x 400 meter region for 50 seconds simulation time. The number of mobile nodes is kept as 50. We assumed that each node moves independently with the same average speed of 20m/s. All nodes have the same transmission range of 250 meters. The simulated traffic is Constant Bit Rate (CBR). The pause time of the mobile node is kept as 10 sec. The traffic Scheduler is changed as TCP and the comparison is made.

Mobile ad hoc networks have several inherent characteristics (e.g. dynamic topology, time-varying and bandwidth constrained wireless channels, multi-hop routing, and distributed control and management).

To judge the merit of a routing protocol, one needs metrics—both qualitative and quantitative-- with which to measure its suitability [23] and performance. Specifically, this paper evaluates the performance comparison of AODV routing protocol with this proposed energy saving Adaptive Gossip Based Protocol and without adaptive technique based on the following performance metrics: Energy consumption, Average Drop and Packet delivery ratio with the increasing number of forwarding nodes.

6.1 ENERGY CONSUMPTION

Energy consumption is calculated by the ratio of the total energy consumed to the total number of nodes present in the deployed network. This metric unit is in joules. Energy consumption model for lucent IEEE 802.11i wavelan pc card with 2mbps Radio mode Energy Consumption (W) is listed as below.

Transmit 0.660, Receive 0.395, Idle 0.035 and for Sleep 0.008

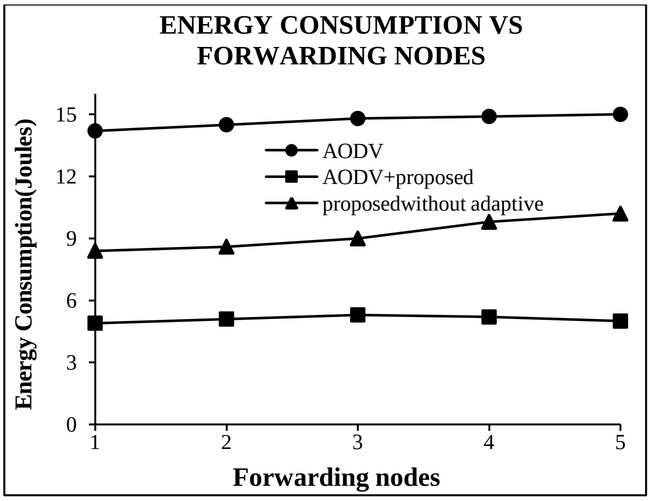

Fig.2. Energy Consumption Vs Number of forwarding nodes

Fig.2 gives the Energy consumption of protocols when the number of forwarding nodes is increased. From the Fig.2 we can see, the Energy consumption is less in the proposed scheme than other schemes. Even though number of forwarding node is increased due to sleep mode the energy consumption is constant and starts decreasing after some point in the forwarding nodes for the proposed scheme.

But in the proposed scheme without adaptive technique, the energy consumption is gradually increased due to packets taking the alternate path (presence of sleep nodes in the shortest path) to reach the destination. The routing protocol AODV consumes the maximum energy due to always awakening mode nodes in the path of the routing.

6.2 PACKET DELIVERY RATIO

Packet delivery ratio is calculated by dividing the number of packets received by the destination through the number of packets originated. It specifies the packet loss rate, which limits the maximum throughput of the network. The better the delivery ratio, the more complete and correct is the routing protocol. Fig.3 gives the Delivery Ratio of protocols when the number of forwarding nodes is increased for all the schemes. As we can see from the Fig.3, the Delivery Ratio is more in the case of proposed scheme than any other schemes.

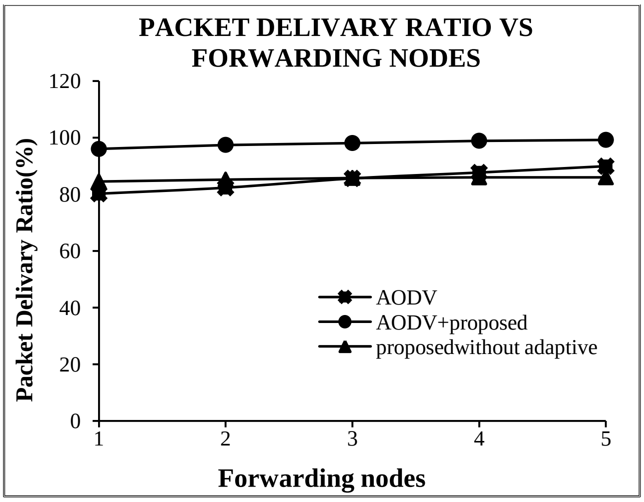

Fig.3. Delivery Ratio Vs Number of forwarding nodes

Due to the change of mode by trigger signal the proposed scheme has got good delivery ratio compared to other schemes. But in the proposed protocol without adaptive technique the packet delivery ratio will start decreasing and at one stage, the packet delivery ratio has very low value than the routing protocol of AODV because of the sleep mode behavior.

6.3 PACKETS DROP

Number of packets Drop is calculated based on the trace file generated by simulation. It calculates the number of packets dropped in percentage before the data packets reach the destination. This metric is calculated by ‘D’ -- packets were dropped when they transmitted by source before they reach the destination. This includes all possible drops caused by control and as well as data packets. But dropped data packets are alone taken for calculation and it is plotted. This metric is significant in understanding the packet delivery ratio. In the initial position, since the number of neighbor node is one, the drop will be the same for both the schemes (with and without). But when the number of forwarding node is increased due to the trigger signal used for the adaptive technique, the drop will be decreased in the proposed scheme as shown in the Fig.4.

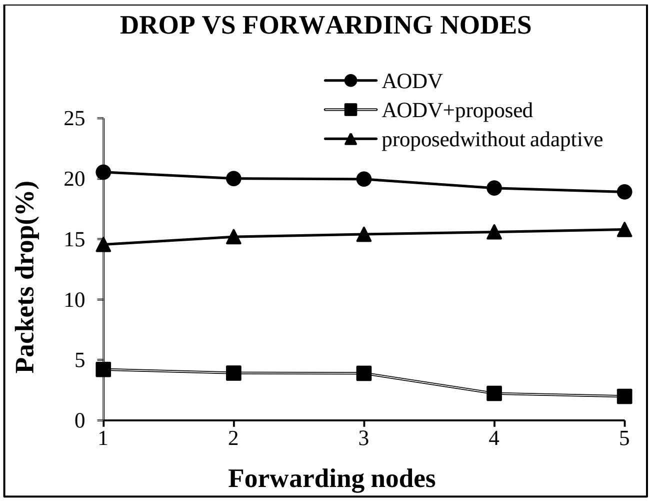

Fig.4. Drop Vs Number of forwarding nodes

In the proposed protocol without adaptive technique shows significant amount of packets dropped. The drop is due to sleep mode of nodes and the dynamic nature of nodes. The percentage of drop of AODV is high compared to the proposed protocols.

6.4 ROUTING OVERHEAD

As the network grows, various routing protocols perform differently. The amount of routing traffic increases as the network grows. An important measure of the scalability of the protocol, and thus the network, is its routing overhead. It is defined as the total number of routing packets transmitted over the network, expressed in bits per second.

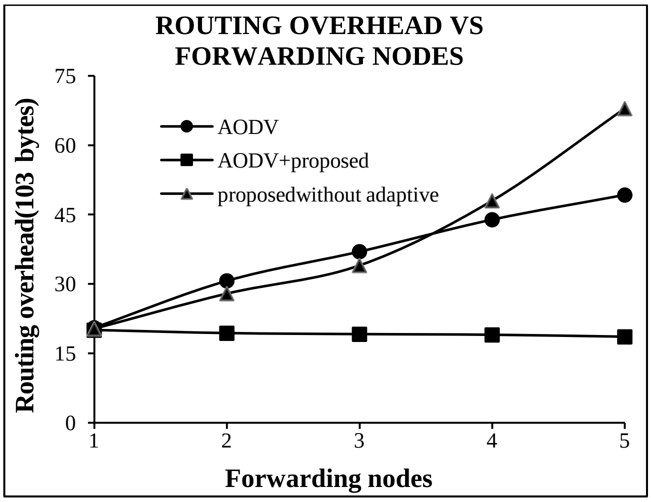

Fig.5. Routing overhead Vs Number of forwarding nodes

Fig.5 shows the performance of the three routing protocols in term of routing overhead over varying number of forwarding nodes. As shown from the fig, the routing overhead generated by each of the routing protocols increases almost linearly as the number of forwarding nodes increases. But in the proposed protocol the routing overhead is less compared to other two schemes.

7. COMPARISON OF TCP AND CBR TRAFFIC FLOW

7.1 AVERAGE END-TO-END DELAY

Average End-to-End delay (seconds) is the average time it takes a data packet to reach the destination. This metric is calculated by subtracting – time at which first packet was transmitted by source from – time at which first data packet arrived to destination. This includes all possible delays caused by buffering during route discovery latency, queuing at the interface queue, retransmission delays at the MAC, propagation and transfer times. This metric is significant in understanding the delay introduced by path discovery.

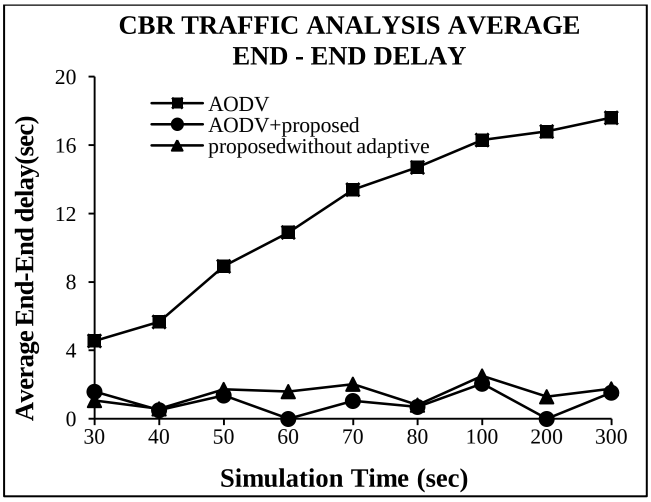

Fig.6. Average End to End Delay Vs Simulation Time for CBR Traffic

Traffic pattern analysis for this proposed protocol is analyzed with CBR and TCP. From the figs, we can realize that for TCP Traffic, the average end to end delay is increased but to achieve the guaranteed packet delivery ratio. But in the case of CBR, the average end to end delay is decreased with the moderate packet delivery ratio.

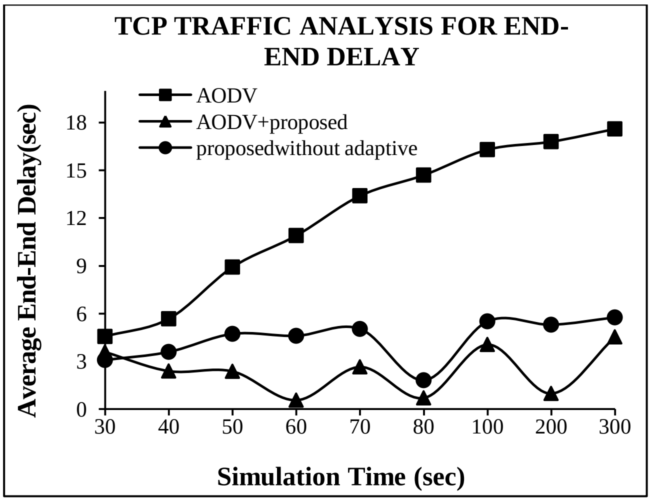

Fig.7. Average End to End Delay Vs Simulation Time for TCP Traffic

8. CONCLUSION

In this paper, we have proposed a new Energy Efficient and Reliable Gossip Routing Protocol. This protocol assures the increased delivery ratio, better reliability and low energy consumption for power managed routing. By simulation results, we have shown that the proposed protocol achieves good delivery ratio, less amount of Drop and less energy consumption. For further enhancement of this work, we plan to optimize the Queue for better performance.

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