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Evaluating The Effects of the Energy Management's Issues on the MANET's Performance Using Two Native Routing Protocols against a Power-Aware Routing Protocol

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ABSTRACT
A mobile ad-hoc network (MANET) is an infrastructure-less wireless network meaning that topology is dynamically created without any central authority such as a router, access point, etc. Its mobile nodes are battery-powered and constrained by limited battery power's lifetime; this issue makes a node's active state short due to unrealistic shutdown or restart. Increasing each node battery's lifetime is a challenging task in MANET; this is accomplished by designing and implementing a power-aware routing protocol which takes into account power optimization approaches; a technique being rarely implemented with native routing protocols. This paper conducts a performance evaluation of two native routing protocols available in MANET namely DSR, a reactive routing protocol and DSDV, a proactive routing protocol. The evaluation is conducted by comparing these two protocols with a prominent power-aware routing protocol available for MANET EPAR, to prove how it is advantageous to use a power-aware routing protocol to enhance MANET operation's performance. Four popular routing metrics are used for performance evaluation namely number of dropped packets, end-to-end delay, end-to-end packet delivery ratio, and the overall network lifetime. The simulation results carried out using the ns-2 simulator for all cases studied confirm that EPAR outperforms other protocols, DSDV performs mediumly whereas DSR almost works worse compared to other protocols.

Keywords:- MANETs, Routing Metrics, Power-Aware Routing Protocols, Performance Analysis, and simulation.

I. INTRODUCTION

An ad-hoc network [1] is an easily deployed wireless network as it is a self-organized network structure whereas a mobile ad-hoc network [2] is one type of ad-hoc networking which is the most popular wireless network thanks to its ability to increase flexibility and whose deployments is very easy as nodes freely join and leave the network, thus making a dynamic topology. The overall operations of an ad hoc network are constrained by various challenges. Battery constraints are the one of the most problems faced in MANET; this is due to limited battery power's lifetime causing an unexpected termination of individual nodes. To fill this gap, the energy management is needed to maintain and increase the duration of the network's connectivity, which in turn minimizes packet drops, end-to-end delays, thus, increasing packet delivery ratio to destination.

This approach is accomplished by controlling battery discharge, adjusting the transmission power, and scheduling of power sources, thus increasing the lifetime of a node; power-aware protocols are designed for this end. This paper aims at evaluating the advantages provided by routing taking into account network's lifetime. For this end, we conduct a performance evaluation of two types of native routing protocols namely DSR, a reactive routing protocol and DSDV, proactive routing protocol. These two routing protocols are evaluated against EPAR which is the prominent and popular power-aware routing protocol proposed for MANETs.

The paper is divided in the following parts: related work is presented in section II. Section III provides an overview of routing protocols. In section IV, we explain the methodology and experimentations used to compare the protocols. Results and discussions are presented in section V and section VI deals with the conclusion.

II. RELATED WORKS

Shivashankar et al. [4] dealt with the frequent MANET's problem of maximizing the MANET's lifetime, to this end; the EPAR protocol was proposed which was an extension to DSR protocol. The network lifetime and packet delivery parameters were used to evaluate three routing and power-aware protocols varying the network environment. The outcomes revealed that the throughput and energy consumption metrics were almost the same for the small networks, while DSR was not good in performance for medium network and large networks. EPAR outperformed other protocols in such networks where MTPR mediumly performed.

M. Ravi Kumar et al. [6] in their study, an energy performance comparison of FSR and DSDV routing protocols for the mobile ad-hoc network was presented. They stated that the type of routing protocol affects the energy consumption due to different routing overhead used for sending and receiving the data packets. Their experiments showed that FSR is efficient with most mobility scenarios, but source routing increases the overhead of routing in this protocol. On the other hand, DSDV is efficient with some mobility scenarios by eliminating source routing overhead of the FSR protocol. They again proved that in DSDV, discovery route process requires more overhead and actually is more expensive than in FSR. The overall results showed a better performance of FSR rather than DSDV except in static networks while DSDV uses hop-by-hop routing, FSR uses source routing with a longer header. The reason is that FSR uses caching mechanisms to reduce the discovery routes overhead. They also showed that FSR resulted in the least energy consumption for low-density networks and DSDV generated the higher volume of energy than the FSR in high-density networks. They both had a similar behavior in static networks. The reason for this behavior can be the less overhead in FSR due to the source routing mechanisms. Also, the results demonstrated that FSR performs better than DSDV in low and high loads. However, DSDV is found effective for low loads. Therefore, as an overall conclusion, routing protocols currently used in MANET may require some effort to minimize the energy cost of interfaces in the network.

Dongkyun Kim et al. [9] proposed the drain rate, a metric which, using the current nodes' traffic conditions is able to predict the lifetime of any participating node in the network. This metric was used in combination with the remaining power of each node's battery in deciding whether a node should be part or not of a selected route. To this end, they used an approach called Minimum Drain Rate (MDR) as route selection criterion. The MDR's main advantage was to prolong the lifetime of both connection and battery's lifetime. An extension to MDR called Conditional MDR (CMDR) was also proposed aiming at minimizing the total transmission power consumed by each packet referring to Conditional Max-Min Battery Capacity Routing (CMMBCR) algorithm. NS-2 results showed that CMDR was better than CMMBCR in performance and threshold selection criterion.

S. Muthuramalingam et al. [10] explained how some energy is consumed whenever a signal passes through a mobile node. They discussed in details how this signal's transmission causes the wastage of power while updating each node's positional information in a wireless network. Bandwidth is also wasted by sending control signals rather than using it effectively for data communication. To minimize this utilization, they proposed a modified algorithm that uses Weighted Clustering Algorithm (WCA) for cluster formation and mobility prediction for cluster maintenance which helps the effective utilization of power, minimum wastage of bandwidth and more stable clusters and further improving the QOS in MANETS. Weighted Clustering Algorithm itself is improved with the use of mobility prediction in the cluster maintenance phase. In short, they proposed an algorithm which reduces overhead in communication by predicting the mobility of node using linear autoregression and cluster formation.

Hussein et al. [12] were interested in clustering schemes. They explained that this type of algorithm provides various advantages especially in studying nodal mobility and large mobile terminals using throughput and delay as parameter values. They later revealed how the Flexible Weighted Clustering Algorithm based on Battery Power (FWCABP) is able to provide stability in the network as it never selects a node with low battery power as a cluster-head. The number of formed clusters, reaffiliation frequency, and the number of cluster changes parameters were used for this performance evaluation whose results showed that their algorithm outperformed the traditional ones and was able to adapt to various network's conditions.

III. ROUTING PROTOCOLS FOR MANET

3.1. Overview of routing protocols

Various routing protocols have been designed and implemented which have a goal to disseminate packets from source to destination. We distinguish three different types of routing protocols in MANET [3] namely table-driven (pro-active), on-demand (reactive) and hybrid routing protocols. A Proactive routing protocol maintains topological information in the form of a routing table at every participating node in the network, thus keeping routes between all nodes in the networks as opposed to an on-demand routing protocol which creates routes to destination nodes when required. Hybrid routing protocols, as the name suggests, combines the best features of both proactive and reactive routing protocols.

3.2. Power-aware routing protocols

Mobile nodes in MANET are constrained by limited power due to low-capacity of battery resources powering them during their overall active period. Various routing protocols are efficient in routing but do not take into account node and network's lifetime issues which sometimes cause early termination of any node, which in turn, adversely affects the overall network's performance. Power-aware routing protocols [1] are either proactive or reactive protocols which are designed in such a way to contain this problem by reducing energy consumed by packet processing including their transmission; to do so they take into account the power management issues in order to increase node's lifetime as well as the whole network's. EPAR is an example of such protocols.

3.3. Protocols description

3.3.1. Efficient Power Aware Routing (EPAR) protocol

EPAR [4] is a new on-demand, power-aware routing protocol with the capability to predict future battery lifetime, it does so to reduce the total energy consumed by packets traversing from source to destination by identifying node capacity using its remaining battery power also considering the energy used to forward packets over various links. The path is chosen based on the energy, the selection is done by computing the lowest hop energy allocated to each link. By doing so, it reduces the overall energy consumed, thus decreasing the end-to-end delay and increasing end-to-end packet delivery ratio. It is advantageous in large, highly dynamic networks as it prolongs network's lifetime.

3.3.2. Dynamic Source Routing (DSR) protocol

DSR [5] is a reactive routing protocol which is described by three main functions namely route discovery cycles for route finding, maintenance of active routes for the overall life-cycle of the network and source routing approaches. No periodic activities of any kind are available, but source routing is its main goal meaning that the entire route is in the message's header. Routes are maintained in the form of caching approaches; when a source needs to send packets to the destination it first searches the route into its caches, if not found, it then proceeds with the alternative approach by flooding route requests. The intermediate nodes can also forward route requests till they reach the destination which in turn sends route reply to the sender. Upon receiving the route reply, the sender caches it for future route requests and then uses an asymmetric link to transmit packets along the way. Concerned with power management issues, although, DSR is an efficient protocol, when the network size increases, consumed power and overhead proportionally augment, this is the main reason why DSR has been revised using various approach to overcoming these problems.

3.3.3. Destination-Sequenced Distance Vector routing (DSDV) protocol

DSDV is an excellent proactive routing scheme aiming at solving routing loop problems. Each node maintains a routing table with an entry of each node in the network such as destination address, destination's sequence number, next hop, hop-count, and install time. The topological information is distributed between all nodes thanks to the routing table having all routes to all participating nodes in the network. Each node maintains its sequence number used to allow loop-freedom and aiming at avoiding stale routes. Any change in topology is informed to all participating nodes thanks to the fact that each node sends its updates to its neighbor to keep the table up-to-date, that's why route discovery process in DSDV is very fast. When a route to the destination is not still valid, the protocol sets its hop count to infinity and then increments the sequence number of the affected nodes. For power management related issues, DSDV selects the best route by prioritizing the available ones based on the maximum allowable energy allocated to each route. On the other hand, it [6] is efficient with some mobility scenarios as it eliminates source routing overhead of the FSR protocol but in most the cases route discovery requires more overhead and it is actually more expensive.

IV. METHODOLOGY AND EXPERIMENTS

4.1. Network metrics

4.1.1. Dropped packets fraction

Dropped packets fraction is the total number of packets lost during the simulation. The lower is the value of packet loss means the better performance of the protocol. When network traffic increases, the number of dropped packets also increases. Packet retransmission approaches are used to ensure that these dropped packets are successfully transferred from source to destination. When the fraction of dropped packets is high, the network's performance is significantly affected. Packet loss can also occur due to many factors such as link failure, broken link due to node shutdown or restart which may be caused by the low battery power, if such link was an intermediate path of the route toward the destination, it is broken causing irreversible packet drops.

Dropped packets fraction = Number of packets sent – Number of packets received

4.1.2. End-to-end delay fraction

End-to-end delay ratio is the average time necessary for a packet reach to the destination. It may be caused by many factors such as router discovery cycle and queuing process used during data packet transmission. Only data packets that have been successfully delivered to the destination are counted. The performance of the protocol is determined by the value of end-to-end delay; the lower ratio means the higher is the performance of the protocol.

End-to-end delay ratio=∑ (packet-arrive time – packet-send time) / ∑ Number of connections

4.1.3. Packet delivery ratio

Packet delivery ratio is the fraction of the number of delivered data packets to the destination. This fraction illustrates the level of packet delivery. The greater value of packet delivery ratio means the higher performance of the protocol.

Packet delivery fraction=∑ Number of received packets / ∑ Number of sent packets

4.1.4. Network lifetime

Network lifetime is total duration from the start of the functional state of the network to the time when is fully inactive. When a system should be considered nonfunctional is, though, application-specific. It can be caused by many factors including the death of mobile nodes, network partitions, the loss of the overall coverage, etc. These problems unfavorably affect the performance of the network. One of the solutions of these problems is to increase battery's power.

4.2. Parameter values

Table 1: Network parameters

Number of nodes	0,10,20,30,40,50,60,70,80,90,100,110,120
Topology Size	500 x 500 m
Simulation Time	700 seconds
Packet Size	512 byte
Packet Rate	8 packets/second
Traffic Type	Variable Bit Rate (VBR)
Mobility Model	Random Way Point (RWP) Model
Channel Type	Wireless Channel
Antenna Model	Omni-Directional Antenna
Radio Propagation Model	Two-RayGround model
Mac Layer Protocol	IEEE 802.11
Maximum queue's length	50

V. RESULTS DISCUSSION

5.1. Dropped packets ratio

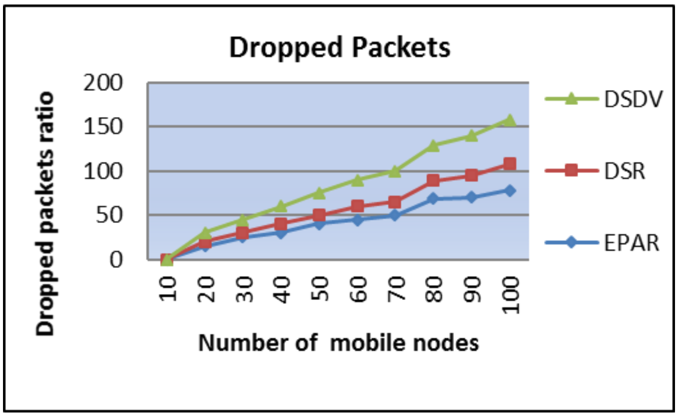

Figure 1: Number of nodes vs dropped packets ratio

As we can see on figure1, when varying the number of nodes, packet drop ratio increases proportionally to the number of mobile nodes for all the three protocols. For the overall simulation time, EPAR protocol outperforms other protocols as it maintains a lower-level, this is achieved thanks to its ability to maintain the power contained in each node's battery, thus, minimizing dropped packets which may be caused by intermediate node's shutdown due to low battery power, this consequently makes the route to the destination unavailable. The DSDV's performance is always bad in all cases; it worsens as we increase the number of participating nodes, it maintains almost an increasingly and steady dropped packet ratio. DSR maintains a medium level for the overall simulation time.

5.2. End-to-end delay

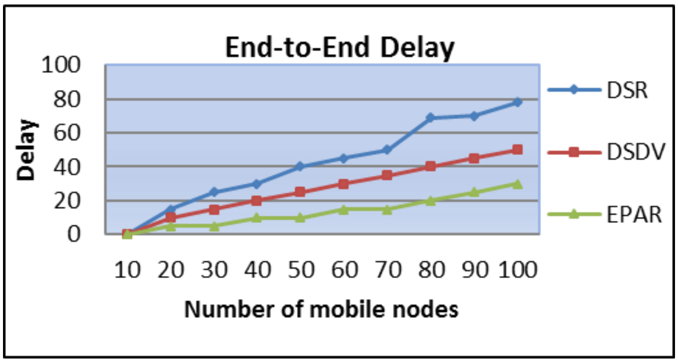

Figure 2: Number of mobile nodes vs end-to-end delay

Figure 2 shows us that again EPAR outperforms other protocols as its average end-to-end delay level is always lower than other protocols', all the three protocols maintain almost the same level when the number of mobile nodes is low (between 10 and 20), as we increase the number of nodes (above 20), DSR continually performs worse than other protocols due to the overhead and power consumption of nodes in the network which proportionally increases as number of nodes augments. But both DSR and DSDV maintain a progressively increasing end-to-end delay level as the size of the network grows. An interesting final observation for all protocols is that when the network becomes bigger, the end-to-end delay ratio proportionally increases.

5.3. End-to-end delivery ratio

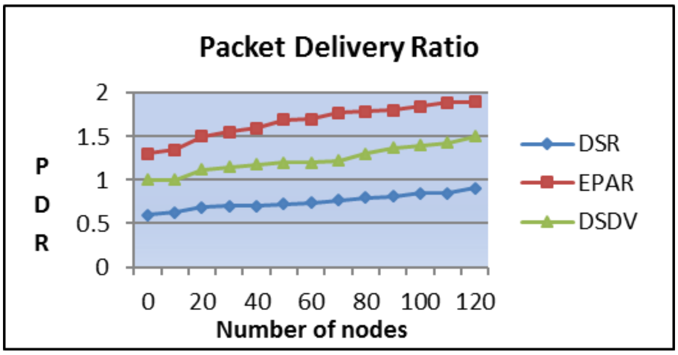

Figure 3: Number of nodes vs PDR

Concerned with packet delivery ratio, figure 3 reveals the weakness of DSR protocol compared to EPAR and DSDV, for the small, medium and large number of nodes, it maintains small packet delivery fraction with a minor change as the number of nodes increases. The bad performance of DSDV is due to the huge number of dropped packets and higher end-to-end delay as it is unable to maintain node's battery power in a high level when the network's size dynamically increases resulting in numerous nodes' unavailability. EPAR again has gotten a better performance as it maintains a high packet delivery ratio making it a better protocol for end-to-end packet delivery. DSDV maintains a middle level which slightly increases when the number of nodes augments; the same performance applies to all of the three protocols as when nodes range from 1 to 10, their packet delivery ratio is almost steady and starting to increase proportionally to the number of nodes.

5.4. Network lifetime

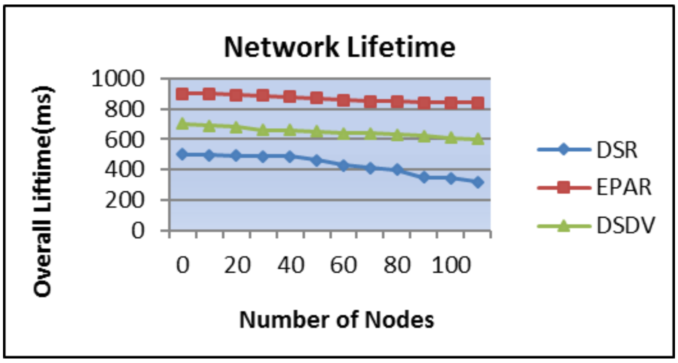

Figure 4: Number of nodes vs network lifetime

Figure 4 shows an interesting parameter, the network lifetime which reveals an overall performance of these three protocols. EPAR is again a better protocol, the main reason of this is that it performs an end-to-end delivery taking into account energy issues, as the result, mobile nodes which would be shouted down or restarted due to low battery power are minimized, this, thus, increases the network's lifetime. Another observation is that DSDV outperforms DSR by maintaining a middle level in performance. For all the three protocols, the network lifetime decreases progressively, oppositely and proportionally to the number of nodes, the raison d'être of this is that dropped packet and end-to-end delay ratios augment when the network's density increases affecting the overall network's performance.

V. CONCLUSION

This paper conducts a performance evaluation of two native routing protocols available in MANET namely DSR, a reactive routing protocol and DSDV, a proactive routing protocol, against EPAR, the most popular power-aware routing protocol available in MANET. For the small networks, these three protocols did not reveal any significant difference. For medium and large MANETs, EPAR outperforms other protocols due to its capability to maintain battery power at a high level for a long time. This proves how taking care of energy issues while routing is necessary. Whereas DSDV works mediumly in term of the overall network lifetime, packet end-to-end delivery, and end-to-end delay but when concerned with dropped packet fraction, it works worse as while increasing the number of mobile nodes; the number of lost packets proportionally augments. The overall findings show that DSR almost performs worse than other protocols for all the cases studied except when the performance evaluation is conducted with the dropped packets parameter where it performs mediumly for low, medium and large networks. All these results showed that taking into account of power consumption approaches is very important while routing as the overall performance of a network is constrained by node's unexpected shutdown and restart issues due to low battery power caused by poor power management of some routing protocols: for this, we propose that power management is taken into consideration while designing an efficient routing protocol.

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