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Extensive Performance Analysis of AODV and Modified AODV for Link Stability and Network Life time in MANET

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Abstract: Mobile Ad-hoc Network (MANET) is consisting of independent wireless mobile nodes which animatedly form a temporary network without use of any fixed infrastructure or centralized management. A major anxiety that affects such a network that characterized by dynamically changing topology is the performance, where routing with robustness performance is one of the key challenges in deploying MANET. In this work we concentrate on AODV routing protocol which is widely used in MANET, It is widely simulated in this paper by varying number of nodes in MANET for standard AODV routing protocol and modified AODV which will take forwarding decision based on two parameters that are energy of node and link expire time (LET) and scrutinize the impact on network stability. Routing protocols are analyzed against several performance metrics. Modified AODV employs a novel route discovery process that takes into account the links stability and the nodes residual energy to perform data routing.

Keywords: MANET, AODV, Energy Aware Routing, Link Stability, LET.

I. INTRODUCTION

Mobile Ad-hoc Networks (MANETs) are self configuring and self-healing wireless networks, where the mobile nodes communicate without the existence of infrastructure or centralized station [1]. Such networks are suitable for scenarios requiring rapid deployment such as battlefield, conference and disaster recovery. Each wireless node can directly communicate with all the nodes located within its transmission range. When the destination is beyond the source node coverage, multi-hop communication takes place to successfully relay the data traffic through a set of intermediate nodes that act as routers. Numerous protocols have been developed to enhance the routing efficiency in MANETs. Those protocols can be categorized into two approaches: topology-based and position-based routing. Topology based routing protocols use the links' information for packet transmission, whereas position-based approaches mainly focus on the nodes' location information, in order to route the data traffic. Specifically, topology routing is divided into reactive, proactive and hybrid protocols. The difference among these resides in the way the route, from source to destination, is determined. Reactive method discovers the route to the destination when needed while proactive method determines routes in advance and maintains information about all the possible paths in the network table. From network performance perspective, the impact of such difference can be observed mainly in terms of delay and routing overhead. Reactive scheme requires the path to be discovered before data packets can be exchanged between the communication peers. This introduces time delay for the first packet to be transmitted. On the other side, proactive scheme generates high routing overhead by maintaining routing information of unused paths. Hybrid scheme combines both schemes to achieve higher level of routing efficiency and network. AODV [2] and Optimized Link State Routing protocol (OLSR) [3] are examples of reactive and proactive schemes. Furthermore, the routing operation in MANETs requires the mobile node to cooperate with each other to successfully route the traffic amongst the communication nodes. The nodes' availability is essential for the enforcement of such cooperation and impacts the status of all the incoming links to the node. There are two main factors that can cause link breakage in MANETs including:

a) Residual energy of Node (battery lifetime).
b) Node Mobility.

Due to the nature of MANET nodes as energy constraint devices, the amount of control messages introduced in the network dramatically affects the nodes' availability and consequently the network lifetime. Besides, the nodes' mobility is one of the main characteristics of MANETS that leads to frequent topology changes and to a subsequent increase in the probability of link failures and routes breakage. Consequently, link failures initiate a route maintenance process, which tries to either find alternative links or discover a new route. Such a process wastes bandwidth and battery lifetime resources, and affects the network's performance by introducing additional routing overhead and re-routing delay. Therefore, considering the nodes' mobility as well as the residual energy in the routing operation is essential for limiting the discovered routes to the most stable and durable one. In this paper we

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propose a new Route Discovery mechanism that uses the link lifetime and the nodes' residual energy in the discovery process. The key concept behind this route finding mechanism is to forward the Route Request (RREQ) messages over stable links by the nodes with sufficient residual energy and a good link lifetime among the nodes that involved in the route. The rest of the paper is organized as follows. The related work is reviewed in section 2. Section 3 defines the current problem and proposed routing protocols by considering the link lifetime and power. Section 4 presents our experimental results. In Section 5, we conclude this work.

II. RELATED WORK

There are several existing methods for estimating link lifetime in MANET. Some of these methods rely on the received signal's strength, while others make use of the location information of the nodes composing the link to predict the link expiration time. In addition, many routing algorithms use the link lifetime as well as the nodes' residual energy as routing metrics to allow the most stable and energy efficient route to be selected for data transmission.

2.1 Signal Strength-Based Routing Protocols:

In [4], the signal strength is used as a link quality metric that varies according to a predefined signal strength threshold. The link quality of a mobile node increases when its signal strength is above the threshold and decreases otherwise. Moreover, Signal Stability based Adaptive Routing has been proposed in [5], which classifies the links into groups according to the signal strength metric. During the path-discovery phase, each mobile node divides the connections between itself and its neighboring nodes into two groups, a strongly connected (SC) group and a weakly connected (WC) group.

2.2 Geographical Information Routing Protocols:

A method to predict the link and the route lifetime based on the nodes' location and movement information has been proposed in [6]. The routing concept introduced in [6] is to predict the Link Expiration Time (LET) at each hop of the route, which allows the prediction of the Route Expiration Time (RET). RET is defined as the minimum LET of the links composing the route. The link expiration time between two mobile nodes i(xi, yi) and j(xj, yj) is defined by the following equation:

$$LET = \frac{-(a+b)+\sqrt{(a^2+b^2)r^2-(ad-bc)}}{(a^2+c^2)} \qquad (1)$$

Where

$a = ViCos\theta i - VjCos\theta j$; $b = xi - xj$;
$c = ViSin\theta i - VjSin\theta j$; $d = yj - yj$;

Here, $\theta i, \theta j, Vi, Vj$ are moment direction and speed of the nodes i and j respectively.

2.3 Power Aware Routing Protocol

Minimum Battery Cost Routing (MBCR) has been proposed in [7]. MBCR routing protocol computes the sum of the remaining power of all nodes in a path and uses it as the criterion for selecting a path, but the method may choose a path in which there may exist mobile nodes with low power. Thus, these low power mobile nodes may cause path breakage. Min–Max Battery Cost Routing (MMBCR) has been proposed in [8] to addresses the problem in MBCR. In [9], I-AODV has been introduced to consider the situation where selfish nodes exist in the network. IAODV adds a term called FAME to record the probability of nodes that want to help relay data. In addition, I-AODV also takes the remaining power into account to prolong the network lifetime. As a result, I-AODV can select the nodes that have enough remaining power and high probability to help relay data to construct a path. Finally, most of the research works in the literature have addressed the link lifetime and the energy information as routing metrics to improve the route selection mechanism of the routing protocol. To the best of our knowledge, this is the first work that introduces the link lifetime and the nodes' residual energy to enhance the route discovery process that allows the routes that satisfy the link lifetime and the energy requirements to be discovered.

III. PROPOSED WORK

3.1 Problem Definition:

As previously mentioned, there are two important factors that cause the link breakage, which include: a- node moving out of the radio range of its neighboring node, b- node dying of energy exhaustion. For instance, In Fig. 3.1 we will take into account the effect of the link lifetime on the network. There are six nodes in the network, where node S is the source and node D is the destination. When node S broadcasts a RREQ, nodes 1 and 2 received this RREQ from node S. Accordingly, nodes 1 and 2 record node S on the routing table as a reverse path for S. After that, nodes 1 and 2 broadcast the RREQ packet as we assume they don't have a valid route to D. Node 3 and 4 received the RREQ sent from nodes 1 and 2 respectively. Accordingly, nodes 3 and 4 record nodes 1 and 2 respectively on the routing table as a reverse path for S. Then 3 and 4 broadcast the RREQ. Now node D received RREQ from node 3, in the same time node 3 received a duplicated RREQ from 4. Node 3 simply will discard the duplicated RREQ from node 4. Node D now prepares to reply with the RREP packet.

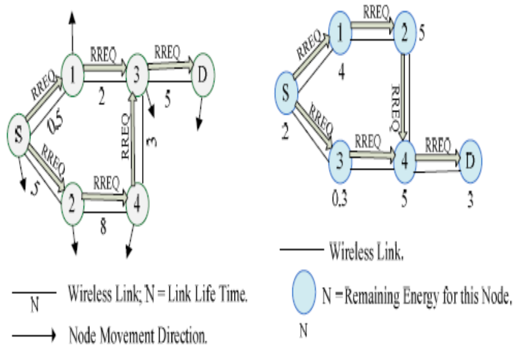

Figure 3.1. Link Lifetime Figure 3.2. Energy Level

Now we have the reverse path from D to S as (D, 3, 1, S). Node 3 will succeed to receive the RREP send by node D

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as there is a good link lifetime between them which is equal to 5. As well node 1 will succeed to receive the RREP send by node 3 as there is a good link lifetime between them which is equal to 2. But the problem will appear when node 1 tries to send the RREP to node S as the link might be broke or if node S succeeds to receive the RREP from node 1. Definitely the link will break after a few data send through this link due to the weak link between nodes S and 1 which is equal to 0.5 at the time of sending the RREQ. Moreover, in fig.3.2 we will take into account the effect of the node energy level on the network. If node S chose path S, 3, D to send date through it, then the path will break very soon as node 3 will consume the remaining energy after few data sent through this node due to low energy level of the node.

3.2 Link Stability and Energy Aware Routing Protocol (Modified AODV)

In this paper, our focus is mainly in showing how to improve the route discovery process whenever a source node attempts to communicate with another node for which it has no routing information. We get the link lifetime between any two nodes using equation 1. When the link lifetime between any two nodes equal 1, that imply after 1 second the link between those two nodes will breaks.

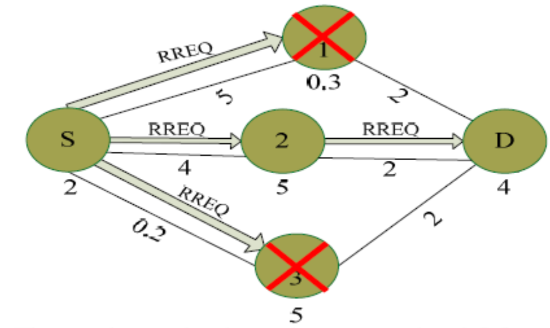
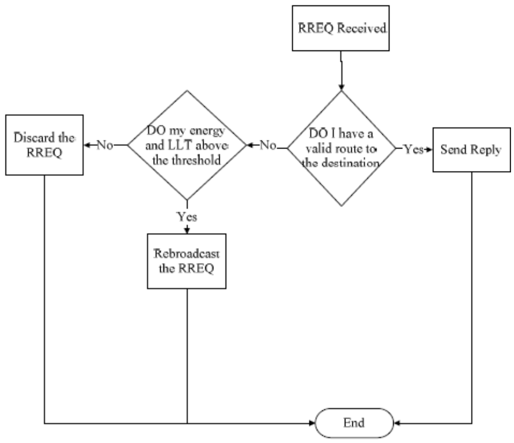


Figure 3.3. Link Lifetime +Energy

Our protocol satisfies a pure reactive-routing protocol rule. In Modified AODV, when there is data to transmit, the source node broadcast a RREQ, the neighboring nodes decides whether to forward the RREQ based on its remaining battery as well as the expiration time of the link with the RREQ sender. In essence, simplicity, together with effectiveness, is one of the major goals of our work. Our Modified AODV is different from all previous work in a way that on receiving a RREQ at any node, it can decides immediately whether to forward the RREQ or not based on its remaining battery as well as the expiration time of the link with the RREQ sender, rather than all nodes forward any RREQ and give the destination a chance to select one RREQ that contain nodes having a good link lifetime among them in case of link lifetime used as metric or that contain nodes having a good power level in case of power used as metric. Hence in Modified AODV the question rose up, why the node forward a RREQ while the link lifetime with the RREQ sender going to break and can't reach the RREQ sender to send back a RREP or the node energy level is very low and this node going to die soon. In addition, sending any RREQ will incur more overhead and at the end only one RREQ will select to create a path through it. For instance in Fig.3.3, when S tries to sends data to D with no data available for D in S routing table. S broadcast a RREQ packet and all its neighbors will receive this packet.

In conventional AODV, nodes 1, 2 and 3 will rebroadcast the RREQ if they don't have a valid route to D. However in our proposed scheme, Modified AODV node 1 will check the link lifetime with S. Node 1 find out that a link lifetime is good (more than 3second). Then it will go to check the second condition which is the energy level. Node 1 finds out that it has very low energy level. Simply according to our scheme it decides to discard the received RREQ.

The same thing will happen with node 3, as it has a good energy level (more than 4) but the link lifetime with node S is very weak and likely will broke after 0.2 second. So, node 3 will decides to discards the RREQ. In this example the only node allow to rebroadcast the RREQ is node 2 as it satisfied our requirement for energy level and the link lifetime.



Flowchart for LSEA Receiver Node

IV. Performance Analysis

In this section we evaluated the performance of our scheme by NS2 simulation [10]. In our simulations, the transmission range is set to 250 m. The evaluations are conducted with a total of 150 nodes that are randomly distributed in an area of 700m x 700m.

We use Random Waypoint to model node mobility. In each test, the simulation lasts for 500 seconds while the minimum speed of 5 and maximum speed of 25 were chosen.

The size of each Constant Bit Rate (CBR) packet is 1000 bytes and packets are generated at the fixed interval rate of 4 packets per second. 15 flows were configured to choose a random source and destination during the simulation.

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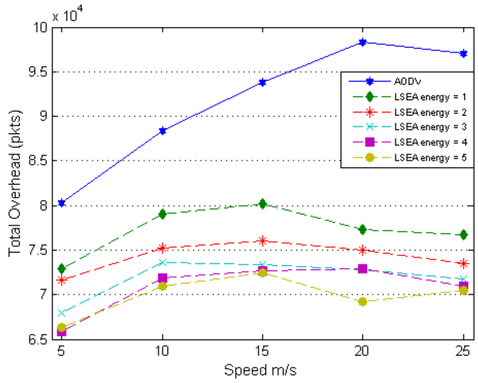

Fig 4.1: Overhead vs Speed. (Link Life Time =2)

4.1 Overhead

Fig.4.1 shows the overhead increases when mobility becomes high in AODV while stay in same level with Modified AODV. This is due to the reason that AODV sends RREQ without knowledge of which best neighbors shall rebroadcast the RREQ. MODIFIED AODV required, any node must check the link lifetime with RREQ sender as well as the energy level before forwarding any RREQ. This requirement reduces the forwarding RREQ and increase the path stability, since the path created by nodes having a good link lifetime among them as well as having a good energy level. Moreover when the threshold for energy level increases (1 to 5) the overhead decrease due to few nodes will satisfy this value if it's high.

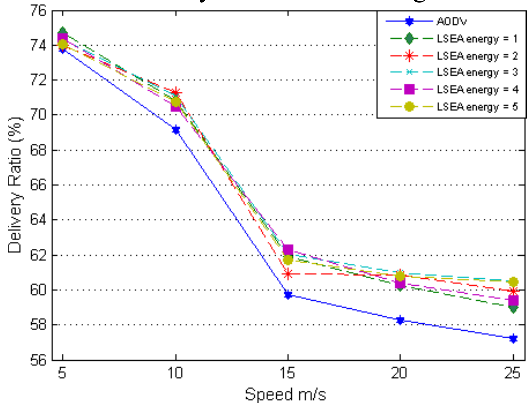

Fig 4.2: Delivery Ratio vs Speed. (Link Life Time =2)

4.2 Delivery Ratio

The results from fig.4.2 show that considering the combined effect of energy and mobility factors, MODIFIED AODV gives higher average packet delivery ration than AODV..

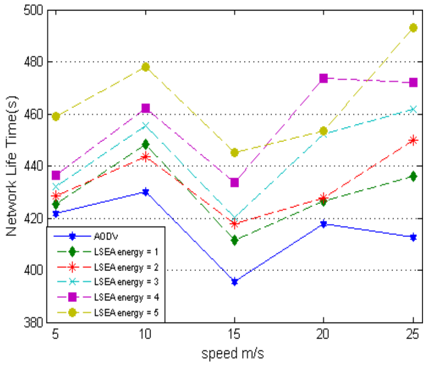

Fig 4.3: Network lifetime vs Speed. (Link Life Time =2)

Through this, it can be inferred that the paths found by MODIFIED AODV are stable and have higher network lifetime as compared to AODV, MODIFIED AODV considers paths with nodes having the highest residual energy and good link lifetime among those nodes. In AODV case, nodes are not capable to comply with our needs which are link lifetime and energy level that why they send a lot of unnecessary RREQ which leads nodes to die soon and hence, lower delivery ratio.

4.3 Network life time

Fig.4.3 shows the network lifetime increases when we increase the level of the energy threshold. When we increase the energy threshold (1 to 5) that mean we stop any node from forwarding the RREQ if its energy is below this level that lead to a lot of node stop forwarding the RREQ which lead to save energy that cause by sending the RREQ and in same time saving energy on the global view by saving other node energy as they not going to receive the RREQ. High stability of the paths leads to lesser control packets needed for path maintenance and lesser energy consumption

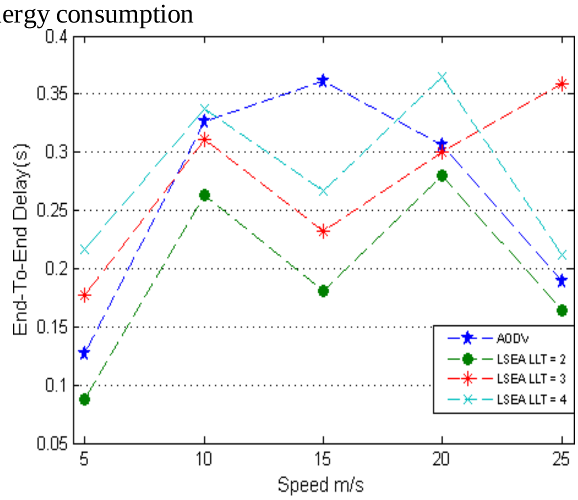

Fig 4.4: End-To-End Delay vs Speed. (Energy=3)

4.4 Delay

Finally, End-to-End Delay in fig.4.4 shows that the average end-to-end delay is better in the case of MODIFIED AODV compared to AODV due to the technique in MODIFIED AODV that always try to find a good node forwarder with respect to link lifetime and energy level. In addition, we notice the increasing in the delay when we increase the link lifetime threshold that because the difficulty in finding a good link lifetime and energy level in one node especially in high mobility. Moreover, packets are not always sent via minimum hop.

V. CONCLUSION

The above mentioned technique considers the stability of the network from all aspects. The lifetime of the network can be reduced primarily by two causes. First, the node moving out of the radio range can lead to link breakage. Second, the node can be drained of its energy leading to network partitioning. The metric used in the proposed technique measures the stability of the network based on these two factors

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