Energy Efficient Ad-Hoc on-Demand Distance Vector Routing Protocol

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Abstract – This paper suggests an Energy Efficient AODV to the MANET. It illustrates the energy conservation techniques to improve the routing protocol efficiency. The energy conservation is attained in the MAC layer. It deals with the proposed energy conservation scheme. It explains the relation of routing overhead and energy conservation and it deals with the routing overhead reduction. It calculates the available and required energy of communication node and it evaluates the conserved energy level. It simulates the consuming energy in EE-AODV and, it compares the simulation result with AODV protocol.

Index Terms – Energy Efficiency, EE-AODV, Overhead, Power Aware Routing.

1. INTRODUCTION

1.1. Introduction to Energy Management

The nodes in ad-hoc networks are battery operated and have limited energy resources. This makes energy efficiency a key concern in ensuring system longevity.[1][2] Further, studies have shown that the communication subsystems consume a large fraction of total energy and therefore, solutions for energy efficient communication are of great interest. Moreover, under some circumstances, MANET has to be deployed in remote or hostile areas. This makes it impossible to replace or recharge the batteries.[7][8] Therefore, it is desirable to keep the energy-dissipation level as low as possible to avoid frequent battery replacement. Energy conservation has posed a big challenge due to MANETs' nature of distributed control, constantly changed network topology and the fact that mobile nodes in MANETs usually are hand-held devices.

In mobile ad hoc networks, energy efficiency is more important than other wireless networks. Due to the absence of an infrastructure, mobile nodes in ad hoc network must act as a router. Since a MANET is a 'cooperative' network, the nodes join in the process of forwarding packets. Therefore, traffic loads on nodes are heavier than in other wireless networks with fixed access points or base stations (Vahid Nazari Talooki, et al. 2010). A communication-related energy consumption function is needed to design a system to limit unnecessary power consumption. Energy efficiency design issue must consider the trade-offs between different network performance criteria. For example, routing protocols usually try to find a shortest path from a source to a destination. It is likely that some nodes which are on so called 'key positions' will over-serve the network and their energy will be drained quickly, and thus cause the network to 'break'. To avoid this, the energy-efficient design should balance traffic load among nodes such that low- power nodes can be idle while traffic is routed through other nodes.

One of the basic characteristics of MANET is the multi-hop connection, in which the Mobile Nodes cooperate to relay traffic to the distant Destination Node. Hence, the Mobile Nodes in MANET serve not only as hosts, but also as routers. The multi-hop connection can also increase the network capacity and decrease the energy nodes to fulfill the multi-hop transmission (Chansu Yu et al 2003; P. Bergamo et al. 2004). Basically, the routing protocol chooses the best route between the source and Destination Node in the network topology and strictly limited resources. However, the single path routing is not the best solution. The Multi-Path AODV protocol is then introduced, which provides redundant and alternative routes to assure successful data packet transmission. At the same time, it does not reduce the key relay nodes' power consumption and the energy exhaustion is alleviated in the network partitioning problem. However, due to the frequently changing network topology and limited resources of energy and wireless bandwidth, routing in MANET is an extremely challenging. Hence, the EE-AODV is proposed.

2. RELATED WORK

Q. Li, J. Aslam and D. Rus. 2003, proposed an approach called "Online power-aware routing in wireless ad-hoc networks". Energy use is a crucial design concern in wireless ad hoc networks. The design objectives of energy-aware routing include selecting energy-efficient paths and minimizing the protocol overhead incurred in acquiring such paths. To achieve these goals altogether, the design of two energy-aware on-demand routing protocols for different network environments.

The key idea behind our design is to adaptively select the subset of nodes required to involve in a route-searching process to acquire a high residual-energy path or the degree to which nodes are required to participate in the process of searching for a low-power path for networks where in nodes can adaptively adjust their transmission power. Analytical and simulation results are given to demonstrate the high performance of the designed protocols in energy-efficient utilization and in reducing the protocol overhead incurred in acquiring energy-aware routes.

J-H. Chang and L. Tassiulas.2005, proposed an approach called "Maximum lifetime routing in wireless sensor network". In this work we study energy efficient routing strategies for wireless ad-hoc networks. In this kind of networks, energy is a scarce resource and its conservation and efficient use is a major issue. Their strategy follows the multi-cost routing approach, according to which a cost vector of various parameters is assigned to each link. The parameters of interest are the number of hop on a path, and the residual energy and the transmission power of the nodes on the path. These parameters are combined in various optimization functions, corresponding to different routing algorithms, for selecting the optimal path. We evaluate the routing algorithms it proposed in a number of scenarios, with respect to energy consumption, throughput and other performance parameters of interest. From the experiments conducted and conclude that the routing algorithms that take into account energy related parameters, increase the lifetime of the network, while achieving better performance than other approaches, such as minimum hop routing.

C. E. Perkins et al 2002, proposed an approach called "Ad hoc On-Demand Distance Vector (AODV) Routing". Ad hoc wireless networks are power constrained since nodes operate with limited battery energy. Thus, energy consumption is crucial in the design of new ad hoc routing protocols. To design such protocols, we have to look away from the traditional minimum hop routing schemes. In this paper, authors proposed three extensions to the state-of-the-art shortest-cost routing algorithm, AODV.

3. ENERGY EFFICIENT AD-HOC ON-DEMAND ROUTING PROTOCOL

The Energy management issues are very important in the context of MANET. The node energy needs to be optimally utilized so that the nodes can perform their functionality satisfactorily. MANETs are energy constrained as most Ad-Hoc nodes to day operate with limited battery power. So, it is important to minimize energy consumption of the entire network in order to maximize the life time of the network. Hence, a new on-demand routing protocol (EE-AODV) is proposed. As per the method, the EE-AODV selects a route at any time based on the minimum energy availability of the routes and the energy consumption per packet of the route at that time.

3.1 Selection of Minimum Energy Node

The energy efficiency is attained through the energy conservation and the routing overhead reduction in network. A new power-aware routing protocol is suggested to balance the traffic load using distributed energy control (Sheetal kumar Doshi and Timothy X Brown, 2002). Since, it aids to increase the battery lifetime of the nodes. Hence, the overall useful life of the MANET is increased. These protocols are based on the conventional AODV. Congested node is able to serve the flows at a higher rate, and then sources are automatically able to send packets at a higher rate. These EE-AODV extensions increase the network survivability and lead to a longer battery life of the terminals. They achieve the balanced energy consumption with minimum routing overhead.

3.2 Calculation of node energy level

The main objective is to balance energy consumption among all participating nodes. In this approach, each mobile node relies on local information about the remaining battery level. It aids to decide whether to participate in the selection process of a routing path or not. An energy-hungry node can conserve its battery power through the activation of sleeping during the idle time (You-Lin Chen and Shiao-Li Tsao, 2006; Siuli Roy et al. 2003). The available energy level and the required transmit power level of a node are taken into account while making routing decision. The subtraction of current available energy levels and the required transmit power levels of nodes indicate how likely these nodes are depletes battery energy. In order to do that a Source Node finds a minimum energy route at a time t such that the following cost function is maximized.

$$C\,(E, t) = \max\,\{Erem\} \quad (1)$$

$$Erem = Eavailable(t) - Erequired(t) \quad (2)$$

Where, Erem is the remaining energy of node, Eavailable(t) is the available energy of node, Erequired(t) is the required transmit power of a packet at node. The energy required in sending a data packet of size D bytes over a given link can be modeled as:

$$E\,(D) = K1\,D + K2 \quad (3)$$

$$K1 = (Pt\ Packet + P\ back) \times 8/BR \quad (4)$$

$$K2 = ((Pt\ MAC\ DMAC + Pt\ packet\ D\ header) \times 8/BR) + E\ back \quad (5)$$

Where, Pback and E back are the background power and energy used up in sending the data packet, Pt MAC is the power at which the MAC packets are transmitted, DMAC is the size of the MAC packets in bytes, Dheader is the size of the trailer and the header of the data packet, Pt packet is the power at which the data packet is transmitted and BR is the transmission bit rate. Typical values of K1 and K2 in 802.11 MAC environments at 2Mbps bit rate are 4µs per bytes and 42µs respectively.

3.3 Algorithm for Overhead Reduction

Step1: Source broadcasts RREQ packets are forwarded to its neighbor nodes within the coverage area

Step2: The neighboring nodes re-broadcast the RREQ packet

Step3: Destination forwards the RREP packet only to the first received RREQ packet

Step4: Source address, destination address and previous node addresses are stored during RREP packet

Step5: The data packet contains only source & destination addresses in its header.

Step6: When the data packet travels from source to destination, through intermediate nodes, for re-broadcasting of data packet, the node verifies source and destination addresses in its cache. If it is present, the data packets are forwarded, otherwise it is rejected.

Step7:After re-broadcasting the data packet, acknowledgement are sent to the previous node

In AODV, each mobile node has no choice and must forward packets for other nodes. In EE-AODV, the Source Node forwards the packet to the Destination Node. During this process, the Source Node forwards a RREQ packet to the intermediate nodes. The intermediate nodes initially in the sleeping state, awakens when the RREQ packet arrives and it forwards to the next node and again it is going to the sleep node. In EE-AODV algorithm, the intermediate nodes are sleeping during idle time and the only antenna of the nodes consumes power. All other parts of the nodes are in the doze mode. So, whenever a packet is arrived at the intermediate node, the node awakens and it transfers the packet to the next node according to the AODV algorithm and then again goes to the sleep mode. So using this way, the intermediate nodes consumes its energy.

4. PERFORMANCE EVALUATION

The performances of the proposed algorithms are evaluated using ns2 simulator. The traffic pattern and the metrics are described which are used for the experiments. The scenarios can also be exported for the network simulators ns-3, GloMoSim/QualNet, COOJA, MiXiM, and ONE.

Table 1: List of Simulation parameters

Parameter	**Value**
Simulator	Ns2 - 2.26
Number of nodes	30 , 50, 100
Simulation Time	20 min
Packet Interval	0.01 sec
Simulation Landscape	1000 x 1000
Traffic Size	CBR
Packet Size	1000 bytes
Queue Length	50
Initial Energy	10 Joules
Node Transmission range	250 m
Initial Energy	100 Joules
rxPower	0.3 W
txPower	0.6 W
Antenna Type	Omni directional
Mobility Models	Random-waypoint (0-30 m/s)
Routing Protocol	AODV
MAC Protocol	IEEE 802.11
Background Data Traffic	CBR

4.1 Simulation Environment

The size of environment is 500 x 500 m2, and every node moves at random as well as its position. Radio transmission range of node is 250 m and its way of wireless communication is free space. In addition, MAC protocol is set to 802.11. The number of nodes is variable for different measurement, which is illustrated specially.

4.2 Simulation Results

The Simulation results are illustrated in the aspects of packet delivery fraction and End-to-End delay. The effect on PDF and AED is described.

4.2.1 Effect on packet delivery ratio

The graph Figure 4.1 and 4.2 describes the packet delivery ratio for EE-AODV and AODV is analyzed. From the graph, the EE-AODV packet delivery ratio is higher than the AODV. This is because the AODV is not maintaining the alternative route to the communication path. It rediscovers a route to the destination, when the communication path is failed to transmit the data packets.

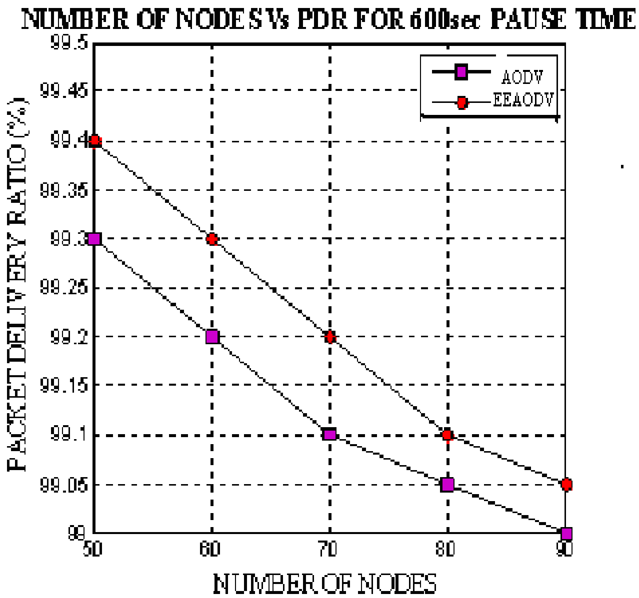

Figure 4.1 Packet Delivery Ratio Vs Number of Nodes (Pause Time=600s)

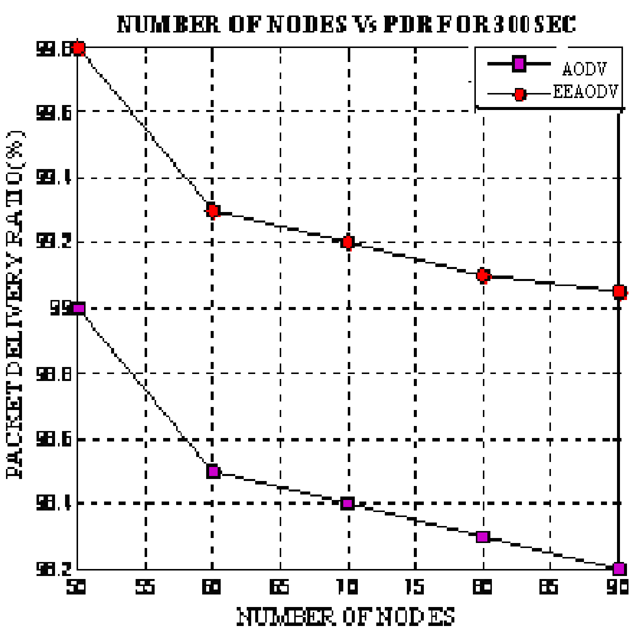

Figure 4.2 Packet Delivery Ratio Vs Number of Nodes (Pause Time=300s)

The Packet Delivery Ratio is the ratio of the number of packets received at the destination to the number of packets transmitted from the source. Packet Delivery Ratio reduces as the pause time decreases from 600 seconds to 300 seconds. It is due to the mobility of the network and the probability of link failures increases as the pause time decreases. It is observed that the EE-AODV maintains a better Packet delivery Ratio than the existing AODV. Since, the EE-AODV preemptively selects the alternative path to the communication route. Hence, the communication does not interrupt. It improves the packet delivery ratio under a network with highly dynamic network. From the simulation results, the packet delivery ratio for AODV is 99.3% over the 600 sec pause time, and the 300 sec pause time, it is 98%. The packet delivery ratio for EE-AODV is 99.4% over the 600 sec pause time, and the 300 sec pause time, it is 99.8%.

4.2.2 Effect on End-to-End delay

The Figure 4.3 and 4.4 describes the packet delivery delay for AODV and EE-AODV. The delay time is high for AODV. Since, it consumes more time to rediscover the routes when the communication path is failed to transmit the data packets. The increased number of nodes also increase the data delivery delay. The End-to-End delay is the time of the transmitted data packet takes to reach destination from the source. As the number of nodes increases, the complexity of the network increases and hence the End-to-End delay increases. As the pause time decreases, the mobility increases, which increases the probability of link failures and hence the End-to-End delay increases.

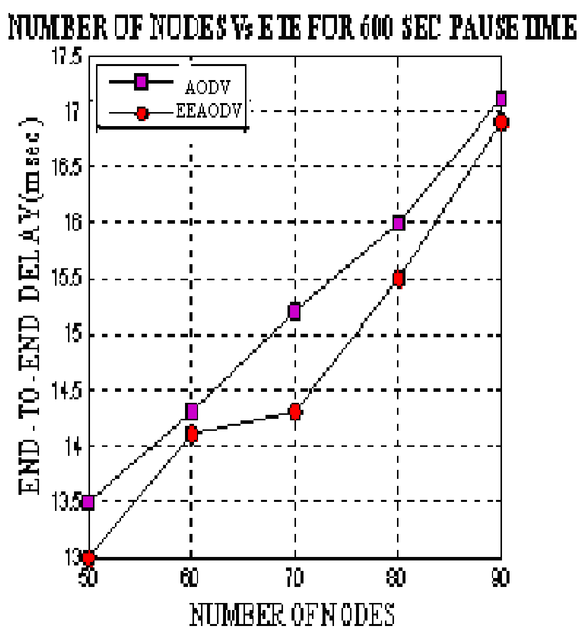

Figure 4.3 Delay Vs Number of Nodes (Pause Time=600s)

In EE-AODV, the data packets are delivered using alternative route when the primary path is fail. However, the link failure of alternative routes incurs the data delay but, it is less than the packet delay of AODV. From the simulation results, it has been observed that the End-to-End delay for AODV is 13.5 ms over the 600 sec pause time, and the 300 sec pause time, it is 14.5 ms. The End-to-End delay for EE-AODV is 13.0 ms over the 600 sec pause time, and the 300 sec pause time, it is 13.1 ms.

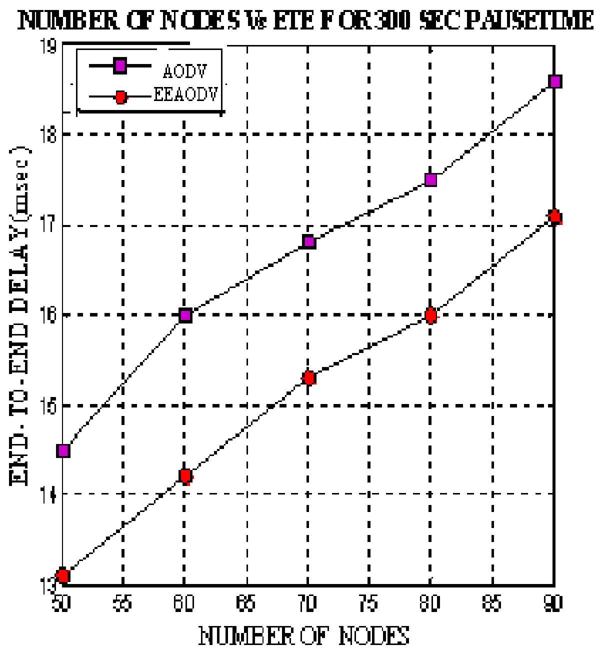

Figure 4.4 Delay Vs Number of Nodes (Pause Time=300s)

5. CONCLUSION

The paper clearly explained the performance of EE-AODV Protocol. Initially, the energy management and the performance of EE-AODV protocol are described. It clearly explained the minimum energy node selection procedure for EE-AODV. It successfully calculated the node energy level in the selected communication path. It explained the relation between the energy conservation and the routing overhead and also it explained the routing overhead reduction algorithm. It aided to conserve the node energy. The paper simulated the comparative performance of EE-AODV and AODV. It clearly explained the energy efficient performance of EE-AODV is better than the existing AODV.

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