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An Approach to Energy Efficient Routing Protocol for Mobile Ad-Hoc Networks

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***Abstract*: The increase in availability and popularity of mobile wireless devices has lead researchers to develop a wide variety of Mobile Ad-hoc Networking (MANET) protocols to exploit the unique communication opportunities presented by these devices. Devices are able to communicate directly using the wireless spectrum in a peer-to-peer fashion, and route messages through intermediate nodes, however the nature of wireless shared communication and mobile devices result in many routing and security challenges which must be addressed before deploying a MANET. In this paper we investigate the range of MANET routing protocols available and discuss the functionalities of several such as Ad-hoc On-demand Distance Vector (AODV), Ad-hoc On-demand Multipath Distance Vector(AOMDV) and improved AOMDV named as Ad-hoc On-demand Distance Vector with Fitness Function (FF-AOMDV) are proposed. Mobile Ad-hoc Network (MANET) consists of wireless mobile nodes that dynamically form a temporary network without depending on any fixed infrastructure. MANET's are distributed and the routing functionalities are carried out by mobile nodes. Energy consumption is considered as one of the major challenge as the mobile nodes do not possess permanent power supply and they rely on batteries. The proposed work emphasizes on the protocols used in MANET which acts as solution to the energy consumption problems. In this paper the reactive MANET protocols; Ad-hoc On-demand Distance Vector (AODV), Ad-hoc On-demand Multipath Distance Vector (AOMDV) and improved AOMDV named as Ad-hoc On-demand Distance Vector with Fitness Function (FF-AOMDV) are proposed. Fitness function is an optimization technique used for optimal route selection for data transmission. The protocols are implemented using Network Simulator (NS2). Secured data transmission is established with RSA algorithm. The performance of AODV and AOMDV routing protocols are compared with different performance metrics.**

***Keywords*: Energy efficient protocol, Mobile ad-hoc network, Multipath routing, Fitness function, RSA algorithm.**

1. Introduction

Nowadays Wireless Sensor Networks (WSN's) are at higher popularity in the research area. WSN belongs to ad-hoc wireless system consisting of small units known as sensors, which are distributed in space. The random spreading of nodes, sometimes gives serious impact in network coverage and connectivity. For a complete monitoring of the whole area, it must be guaranteed that an appropriate coverage with connectivity between the nodes is available. WSN plays a key role in several application scenarios such as agriculture, environment monitoring, military applications, health care, marine and so on.

Conventional methods are not suitable for networks like WSN for direct data transfer; hence a protocol based approach including the conventional methods must be appropriate. Networks have been categorized into infrastructure based and infrastructure less networks. WLAN cellular network is infrastructure based, which is base station centralized. The infrastructure less includes ad-hoc networks that have no centralized access points. MANET is a wireless decentralized network that does not have any built in (or) fixed infrastructure format.

Ad-hoc networks provide optimization of bandwidth, enhancement of transmission quality and control of power which is inherited directly. It supports robust and effective operations for mobile wireless networks. In MANET's, the network topologies are dynamic, random, multi-hop and rapidly changing [1]. The topology consists of bandwidth-constrained wireless links. The network existence is affected by the battery capacity. The links gets disconnected when battery is exhausted. In most of the MANET protocol it has been noticed, the issues regarding the energy consumption and optimal route selection. The design of the protocols is necessary that dynamically adopt itself for the change in the system.

The routing through multipath protocol increases the lifetime of the network and the route, by choosing a best route during single route discovery process from many available routes. Even though the routing with multiple paths is efficient, there are many issues. Optimal path finding from source to destination is one among them, for the larger networks most of the energy is consumed for route discovery process and data transfer. The protocols in MANET transfer the data using intermediate nodes. In MANET there are various routing protocols that are proposed considering the residual energy and energy consumption (or) both. They permit the establishment of multiple paths between two entities for data transfer [2]. Protocols in multipath routing sends a route request from sender to entire network to know all the routes that are available to the destination. But source node will not find the optimum (or) shortest path to the destination always. So, an energy efficient protocol for MANET's with multiple path routing need to be proposed.

2. Background & Related work

A. AODV Routing Protocol

AODV stands for Ad-hoc On-demand Distance Vector which self-adapts quickly and dynamically for different link conditions of the network. Figure 1 shows AODV routing table format. New route between two nodes will be discovered with the use of Route Request (RREQ) control message. Route Reply (RREP) confirms the path, and is received by sender after the predetermined amount of time once the RREQ's have been spread over the network. If a particular RREQ has been already spread over the network, and if it is broadcasted again then such RREQ will be discarded. If fresh requisition is received by any node which does not contain a strong route to the receiver, then RREQ hop-count is increased and route requisition is forwarded to the neighbors. AODV protocol has two mechanisms for route recovery for a case with failed route. When a link breakage occurs the data is transmitted using some active link in the network using Route Error (RERR) control message and it is called as local repairing of the route. The node which gets the error message will decide whether to continue (or) to stop the data transmission and it needs to update its routing table.

B. Route Discovery & Maintenance

Route discovery and route maintenance involve finding multiple routes from a source to a destination node. Multipath routing protocols can try to discover the link-disjoint, node-disjoint or non-disjoint routes. AOMDV"s primary idea is in discovering multiple routes during the process of route discovery. The design of AOMDV is intended to serve highly dynamic ad-hoc networks that have frequent occurrences of link failure. A new process of route discovery is necessary in the event when all paths to the destination break.

AOMDV utilizes three control packets: RREQ; RREP; and RERR. Initially, when a source node is required to transmit data packets to a specific destination, the source node broadcasts a RREQ [4]. Because the RREQs are flooded network-wide, several copies of the same RREQ may be received by a node. In the AOMDV, all duplicate copies undergo an examination to determine the potential alternate reverse path.

However, of all the resulting set of paths to the source, only the use of those copies, which preserve loop-freedom and disjointedness, get to form the reverse paths. In the event the intermediate nodes get a reverse path through a RREQ copy, it conducts a check to determine the number of valid forward paths to the destination, if RREP is generated by the node and the request is sent back to the source using the reverse path. In route discovery, the RREP has a forward path that was not employed in any prior RREPs. The RREQ is not further propagated by the intermediate node. Otherwise, the node would broadcast the RREQ copy again in case any other copy of this RREQ has not been previously forwarded and this copy has led to the updating (or) the formation of a reverse path. the destination produces a RREP, despite forming reverse paths that use only RREQ copies arriving through loop-free and disjoint alternate paths towards the source. A RERR packet is used in AOMDV route maintenance. In the event when link breaks it generates a RERR message

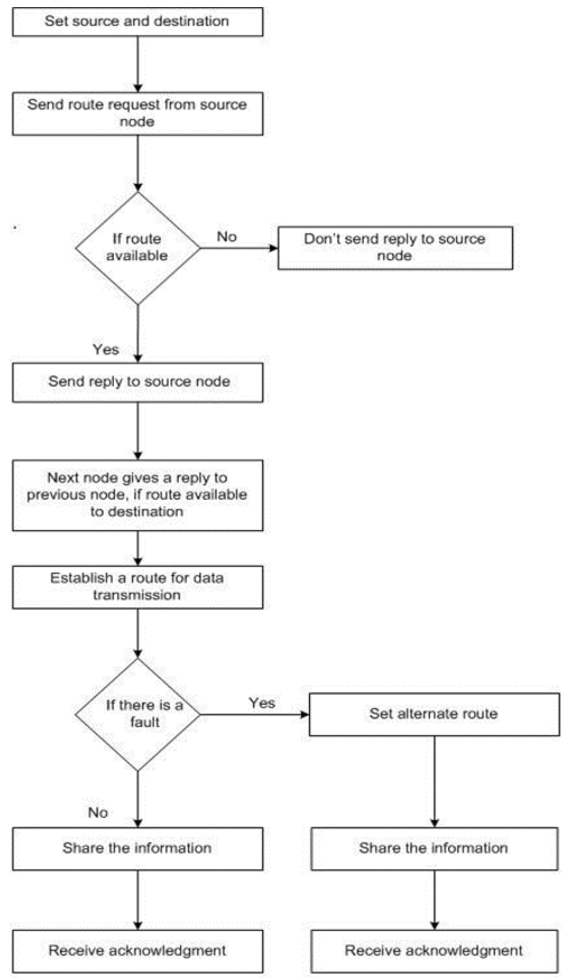

Fig. 1. Proposed system work flow

Protocols like AODV, AOMDV and improved AOMDV (FF-AOMDV) are compared. The algorithm and working principles for AODV and AOMDV routing protocol implementation are as stated below.

Algorithm for AODV routing protocol:

1. Start.
2. If routing table contains a valid route, update the table and transfer the data to intended node.
   Else
   Broadcast a signal to find another node in the network. If node is found, then transfer the data.
3. To check whether a node is ready for transmission (or not), the destination node sends a ready signal.
   Else
   Maintain routes and activate the local route repair.

The block diagram for proposed system is as shown in figure 1.

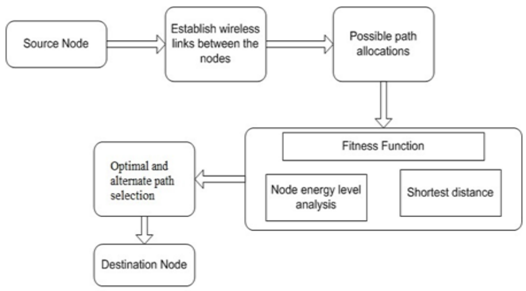

Fig. 2. Proposed system block diagram

3. Experimental Results

The performance of AODV and AOMDV protocols are compared based on the parameters such as number of packets sent, packets received, Packet Delay Rate (PDR), throughput, average E2E delay and normalized routing overheads are formulated and are as in table II. The energy consumption, PDR and delay for AOMDV protocol are analyzed graphically as shown below.

Table 1
Simulation parameters

Parameters	Value	Unit
Operating system	CentOS 6.9	
Simulator	NS 2.5	
Number of nodes	25, 50	Nodes
Channel used	Wireless	Channel
Model of propagation	Two ray ground	Model
Queue format	Drop Tail	
Type of antenna	Omni Antenna	Model
Topology	Flat grid	
Queue size	50, 100, 340	Packets
Routing protocols	AODV, AOMDV, FF-AOMDV	Protocol
Type of data traffic	CBR	
Initial energy	10, 100	Joules
Reception power	0.15, 0.036	Watts
Transmission power	0.25, 0.02	Watts
Sleep power	0.005, 0.001	Watts

Table 2
Performance evaluation

Metrics	AODV protocol	AOMDV protocol
Network size	25 nodes	25 nodes
Number of packets sent	606 bytes	2105 bytes
Number of packets received	480 bytes	2048 bytes
PDR	79.207 %	97.292%
Average throughput	323.18 kbps	572.40 kbps
Average E2E delay	397.621ms	154.461 ms
Normalized routing overheads	0.904	0.00

From the performance evaluation of AODV protocol, it is evident that for a network with 25 nodes, the amount of data sent to the received ratio is around 79.207%. PDR shown by the AODV is good, as it is a protocol used for data transfer through single path. The average network delay is quite high and average throughput is quite low. It concentrates to transfer the data over a single path at a time. The normalized routing overheads are high. The AODV performs better when used for single path routing, but designing a multipath routing protocol with same concept is a better option to improve the working efficiency. Multipath routing protocol AOMDV is implemented.

The performance evaluation of AOMDV protocol shows a PDR of 97.2922%, that makes AOMDV a highly efficient protocol. The average throughput of AOMDV for a network with 25 nodes is high, that makes the protocol the best. The energy consumption of proposed has better performance metrics, it outperforms the AODV protocol. Energy consumption is a challenge faced by the protocols in MANET as seen for AOMDV.

The average delay and overheads are reduced. The graphical analysis of AOMDV protocol performance parameters shows that AOMDV is an improved version over the AODV protocol in the following aspects.

The figure 3 gives the comparison of proposed system with the existing in terms of PDR. It is evident from the comparison that, PDR shown by the proposed protocol is higher than the existing system. Throughput provided by the proposed protocol is very much higher than the existing, that makes the proposed more efficient as evident from graph shown in Figure 4. The energy consumed by the existing protocol decreases constantly with the simulation time, whereas the energy consumption of proposed protocol is constant with the time that makes it efficient as evident from the graph shown in figure 5.

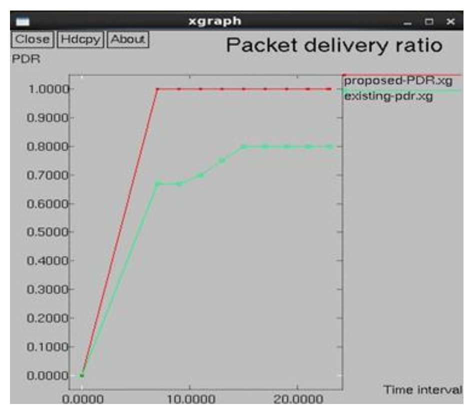

Fig. 3. Packet delivery ratio

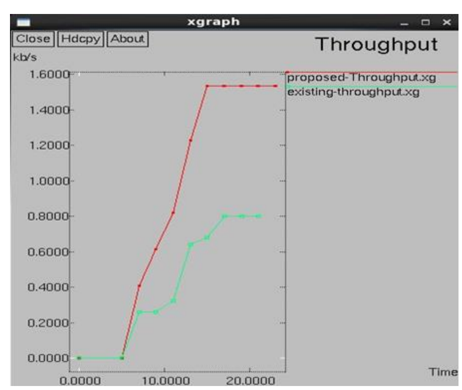

Fig. 4. Throughput

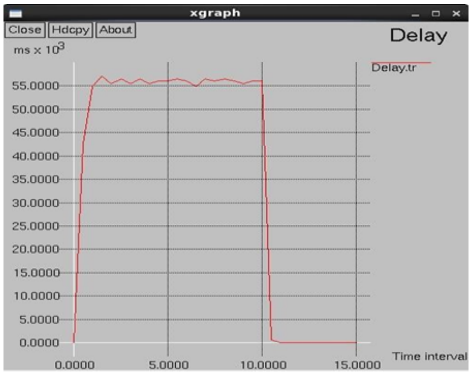

Fig. 5. End to end delay

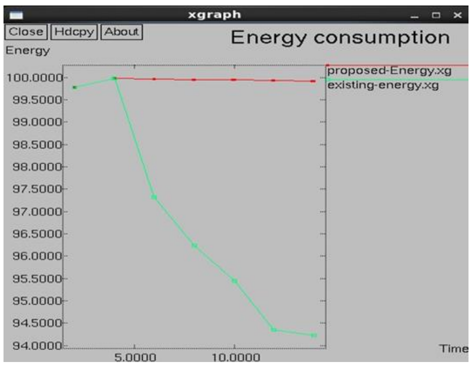

Fig. 6. Energy consumption

4. Conclusion and Future work

In this research, the proposed protocols are tested for different performance metrics using NS2 simulator. Simulation results showed that the AOMDV routing protocol outperforms AODV protocol under majority of network parameters. The issue with the energy consumption in AOMDV is solved with design of improved AOMDV protocol. The Highly secured data transmission is established as the message is encrypted using RSA algorithm before transmission and it is decrypted back to original message at the destination. The future work can be extended with high throughput and higher rate of transmission.

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