Design and Evaluation of Hybrid Vector Routing Protocol in Wireless Sensor Networks.

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Abstract: **These days' ad hoc networks have found many applications. Multiple ad hoc routing protocols have been proposed, of which on-demand routing protocols are very popular because they are easy to realize and have no power and priority concept for data communication in routing.**

1. INTRODUCTION

A sensor node might vary in size from that of a shoebox down to the size of a grain of dust, although functioning "motes" of genuine microscopic dimensions have yet to be created. The cost of sensor nodes is similarly variable, ranging from a few to hundreds of dollars, depending on the complexity of the individual sensor nodes. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and communications bandwidth.

In this paper new routing protocol HYBRID AODV (HAODV) is proposed incorporating the constraints of TEEN in AODV. The purported routing protocol HAODV is significantly better than traditional AODV. This protocol finds active nodes and maintain the route while transmission of data which is better than TEEN. The proposed approach is innovative and enhances the overall network performance.

II. RELATED WORK

A. AODV (Ad hoc On-demand Distance Vector):

AODV is a reactive routing protocol and a route from one node to another node can be found when required [5]. Each intermediate node in the network forwards the Route Request (RREQ) message until it reaches the destination node. The destination node responds to the RREQ message by transmitting the Route Reply (RREP) message. As the RREP flows through the network, it determines the route from source node to destination node. The sequence number is increased by each originating node and used to determine whether the received message is the most recent one [6]. The older routing table entries are replaced by the newer ones. Active nodes in the networks are determined by broadcasting a"Hello" message periodically in the network. If a node fails to reply a link break is detected and a Route Error (RERR) message is transmitted which is used to invalidate the route as it flows through the network. A node also generates a RERR message if it gets message destined to a node for which a route is unavailable.

Types of messages in AODV:

1. Route Request (RREQ) message: It is used to form a route from one node to another node in a network.
2. Route Reply (RREP) message: It is used to connect destination node to source node in a network.
3. Route Error (RERR) message: It is used to indicate any route broken or node failure.
4. HELLO message: It is used to determine the activeness of the network.

The transmission of data depends on route discovery and route maintenance in AODV. The route discovery depends on RREQ and RREP messages, if a node initiate's request of route it will form route after getting the RREP. The route will be maintained by sending HELLO messages to neighbor nodes, if any link failure it will indicate using RERR message.

TEEN is a reactive protocol proposed for time-critical applications [7]. BASE STATION broadcasts the attribute, Hard Threshold (HT) and Soft Threshold (ST) values to its cluster members. The sensor nodes starts sensing and transmits the sensed data when it exceeds HT. HT is the minimum attribute range above which the values are expected. The transmitted sense value is stored in an internal variable called Sensed Value (SV). The cluster nodes again starts sensing, when its value exceeds the ST. The minimum change in the sensed value it switches on its transmitter and transmits. The energy is conserved since the sensor nodes in the cluster senses continuously but transmits only when the sensed value is above HT. The ST further reduces the transmission which could have been occurred when there is a little change or no change in sensed attribute. As the cluster heads (CH) need to perform extra computations it consumes more energy compared to other nodes. The main drawback of this protocol is that the transmission from nodes to CH will not be there when the sensed value is not greater than HT, hence the CH will never come to know even when any one of the sensor node dies. Accurate and clear picture of the network can be obtained by fixing the ST as smaller value even though it consumes more energy due to frequent transmissions [10].

III. PROTOCOL DESIGN

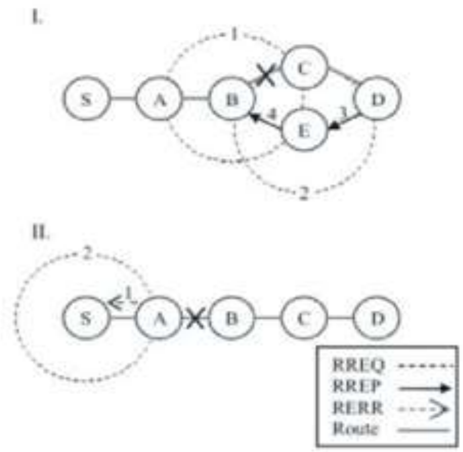
A. Assumptions:

1) In the proposed model, nodes never move after deployment, maintaining a static plain topology. It is true in many application scenarios especially in data collection applications. During the lifetime of the network, some nodes may die but the mobile characteristic is not considered.

2) The number of clusters and Cluster Head formed is static. As a cluster member wants to transmit data to base station, it transmits the data through the cluster head. The constraints of TEEN are incorporated in AODV routing protocol.

Each cluster node sense the data, if the value is greater than HT, then node sends RREQ to the destination. By receiving RREP message from destination source node transmits the data to destination node. The HT value is stored in SV a variable which stores the transmitted threshold value. The cluster nodes again starts sensing, when its value exceeds the ST i.e. The minimum change in the sensed value occurs it switches on its transmitter and transmits. . Active nodes in the networks are determined by broadcasting a “Hello” message periodically in the network. If a node fails to reply a link break is detected and a Route Error (RERR) message is transmitted which is used to invalidate the route as it flows through the network. A node also generates a RERR message if it gets message destined to a node for which a route is unavailable.

3.1] Route Discovery: When a source node needs a route to a destination node and there is not the valid route in the routing table, the source node broadcasts a route request packet (RREQ) to the destination node. When each node receives the RREQ, it creates or updates a reverse route to the source node in the routing table. If it does not have a valid route to the destination node in the routing table, it rebroadcasts the RREQ. When the RREQ flooding from the source node arrives at the destination node, the destination node creates or updates the reverse route. And it unicasts a route reply packet (RREP) which has an incremented the sequence number to the reverse route.



When each node receives the RREP, it creates or updates a forward route to the destination node and it forwards the RREP to the reverse route. When the RREP arrives at the source node along with the reverse route, it creates or updates the forward route and starts communications.

For example, **Figure 1-I shows the process of the route discovery**, which the source node S broadcasts the RREQ and the destination node D unicasts the RREP. If each node has the valid route to the destination node in the routing table when it receives the RREQ, it unicasts the RREP to the source node instead of the destination node. For example, Figure 1-II shows such a process, which the node B unicasts the RREP instead of the node D. During the route discovery, when each node receives the RREQ that it has already processed, it discards the RREQ, so the loop is avoided and the overhead becomes low.

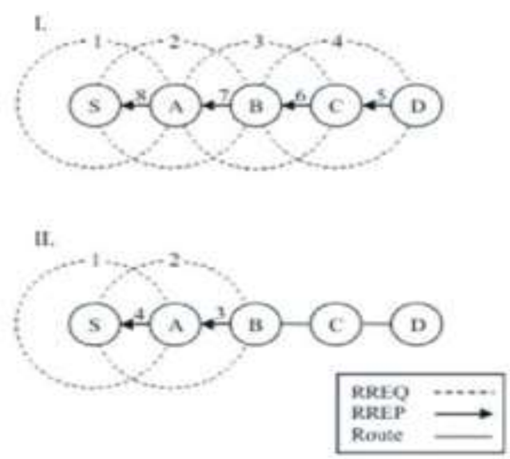


Fig. 2: The processes of route maintenance

3.2] Route Maintenance: Each node broadcasts a Hello packet periodically for local connectivity. It broadcasts the RREP with TTL=1 as the Hello packet. When the node does not receive any packets from a neighbor during a few seconds, it assumes a link break to the neighbor. In addition, when the node has the link break to the neighbor based on an acknowledgment of MAC layer, it detects a route break to the destination node that the next hop of the route is the neighbor. When the node that detects the link break is close to the destination node (that is to say the number of hops to the destination node is smaller than the number of hops to the source node), it requires a new route to the destination node, which is known as Local

3.3] Repair: The local repair is the route discovery which is similar to the description above. During the local repair, arrival data packets received are buffered. When the RREP is received and the local repair is successful, the node starts sending data packets in the buffer.

For example, Figure 2-I shows the process of the local repair after the link break between the node B and the node C. On the other hand, when the node that detects the link break is far from the destination node, or when the local repair is unsuccessful, the node propagates a route error packet (RERR), which contains the addresses of the unreachable destination, toward the source node. When each intermediate node receives the RERR, the routes which have the unreachable destination node and have the next hop which is the propagation node of the RERR are made invalid and it propagates the RERR again. When the source node receives the RERR, the route to the destination node is made invalid similarly and it rediscovers the route again. For example, Figure 2-II shows the process of the route maintenance after the link break between the node A and the node B.

IV. HAODV Routing Protocol:

In this algorithm each intermediate node on an active route detects the danger of the link break to the upstream node and route breaks are avoided by reestablishing a new route before route breaks.

4.1] Detection of a Danger of a Link Break:
Each intermediate node on an active route detects a danger of a link break to an upstream node based on four elements which are the received radio, the overlap of routes, the battery and the density. When it detects the danger of the link break, it notifies the danger to the upstream node.

4.2] Overlap of Routes: When there is a certain intermediate node on several active routes, the transmission delay increases by the traffic loads and also the battery of the node is quickly consumed. In addition, several routes are broken at the same time by the node being downed. Because of this, when the node receives date packets from several source nodes and the number of received data packets per a second is more than the average of number of received data packets from the start of communication, it detects the danger of the link break.

The node selects the route which it is possible to perform the local repair from among routes, or the route which has the smaller number of hops to the source node if it is not. And the node notifies the danger of the link break to the upstream node. After that, the received RREQ is discarded and not processed for a while. However, in the case of one hop from each intermediate node to the source node or the destination node, it does not notify the upstream node after detecting the danger of the link break.

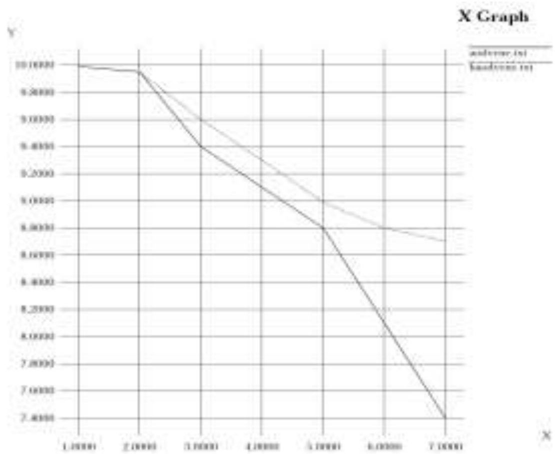
4.3] Simulation Environment: The source node S and the destination node D are not moved and are set on the field of 1000×1000m. The node S transmits data packets to the node D during 60 seconds. Other nodes are set to the random position at first and move with the random way point movement model. It is the movement model which moves at a certain fixed speed below maximum speed from a certain position to a certain destination one and stops during a pause time after arriving at the destination one and starts moving again after the pause time.

And there are several sources other than the node S, which transmit data packets to a certain destination. The buffer size of each node is 64 packets and each node drops buffered packets after 30 seconds. The battery of each node is consumed at the time of sending and receiving packets and at the time of idle state and it is impossible to communicate when the battery is empty. In this simulation, an RREP-ACK and a Gratuitous-RREP are not used. And for each parameter of AODV, the default value of ns -2 is used.

V. Result Analysis:

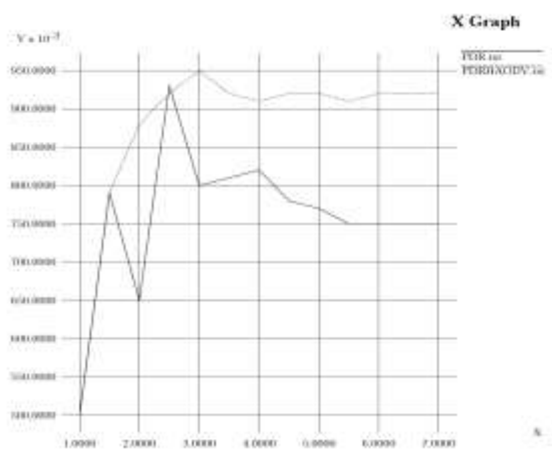
Energy Consumption:
The energy consumption is main factor in a network and the average energy in AODV and HAODV protocols is shown in figure 5.1. In HAODV the

number of transmissions is reduced due to threshold constraints.



Packet Delivery Ratio:

Packet Delivery Ratio is used by ad-hoc and wireless sensor networks (WSNs) protocols for selecting best routes, optimum transmission rate and minimal consumption of energy**.**



Conclusion:

In this paper the energy efficient hybrid AODV protocol is presented. It is based on hierarchical on demand routing. It is a three level cluster based routing algorithm. It is also a power efficient routing. Node's transmission power plays a very crucial role for increasing routing stability. From the Simulation results, the Hybrid AODV not only increments the average energy efficiency but also improves the network performance through the packet delivery ratio.

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