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A Comparative Analysis for Hybrid Routing Protocol for Wireless Sensor Networks

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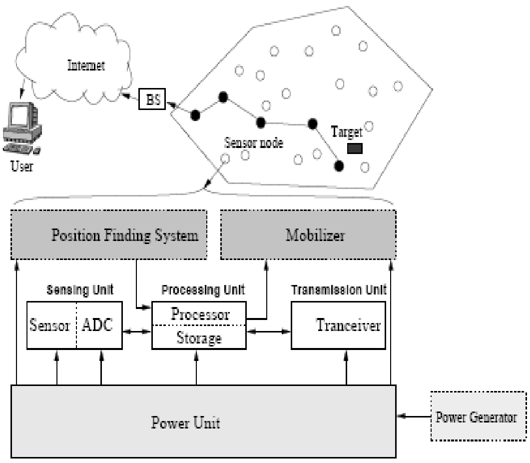
Abstract
Wireless Sensor Networks (WSNs) consist of smallnodes with sensing, computation and wireless communicationscapabilities. These sensor networks interconnect a several othernodes when established in large and this opens up severaltechnical challenges and immense application possibilities.These wireless sensor networks communicate using multi-hopwireless communications, regular ad hoc routing techniquescannot be directly applied to sensor networks domain due tothe limited processing power and the finite power available toeach sensor nodes hence recent advances in wireless sensornetworks have developed many protocols depending on theapplication and network architecture and are specificallydesigned for sensor networks where energy awareness is anessential consideration. This paper presents routingprotocols for sensor networks and compares the routingprotocols that are presently of increasing importance.
In this paper, we propose Hybrid Routing Protocol whichcombines the merits of proactive and reactive approach andovercome their demerits.
Keywords: Ad hoc network, Hybrid Routing Protocol, AODV, Broadcast Reply (BR), etc

I. INTRODUCTION

Wireless sensor networks are a bridge to thephysical world. It is a fast growing and existing researcharea which has attracted considerable research attention inthe recent past; this is backed by the recent tremendoustechnological advancement in the development of low-cost sensor devices equipped with wireless network interfaceswhich are technically and economically feasible. Thesensing electronics measure ambient conditions related tothe environment surrounding the sensor and transform theminto an electric signals which when processed reveal someproperties about objects located or events happening in thevicinity of the sensor.

A Wireless Sensor Network (WSN) contains hundreds or thousands of these sensor nodes whichcan be networked in many applications that requireunattended operations, these have the ability to communicate either among each other or directly to an external basestationand also allows for sensing over larger geographicalregions with greater accuracy. The figure 1 shows theschematic diagram of sensor node components where eachsensor node comprises sensing, processing, transmission, mobilizes, position finding system, and power units and alsoshows the communication architecture of a WSN. Eachsensor node bases its decisions on its mission, theinformation it currently has, knowledge of its computing, communication, and energy resources and have capability tocollect and route data either to other sensors or back to anexternal base station or stations which may be a fixed or amobile node capable of connecting the sensor network to anexisting communication infrastructure or to the Internetwhere users have access to the reported data.



Networking unattended sensor nodes may have profoundeffect on the efficiency of many military and civilapplications such as target field imaging, intrusion detection,weather monitoring, security and tactical surveillance,distributed computing, detecting ambient conditions such astemperature, movement, sound, light or the presence ofcertain objects, inventory control and disaster management.Routing in WSNs is very challenging due to theinherent characteristics that distinguish these networks fromother wireless networks like mobile ad hoc networks orcellular networks. Firstly, due to the relatively large numberof sensor nodes, it is not possible to build a globaladdressing scheme for the deployment of a large number ofsensor nodes as the overhead of ID maintenance is highhence traditional IP-based protocols may not be applied toWSNs. In WSNs getting the data is more important thanknowing the IDs of the node that sent the data. Second, incontrast to typical communication networks, almost allapplications of sensor networks require the flow of senseddata from multiple sources to a particular Base Station butthis does not prevent the flow of data to be in other forms.Third, sensor nodes are tightly constrained in terms ofenergy, processing, and storage capacities. Thus, theyrequire careful resource management. Fourth, in mostapplication scenarios, nodes in WSNs are generallystationary after deployment except a few mobile nodes.Sensor networks are application specific, i.e., designrequirements of a sensor network change with application.Fifth, position awareness of sensor nodes is important sincedata collection is normally based on the location.

Currently,it is not feasible to use Global Positioning System (GPS)hardware, for this purpose many new algorithms have beenproposed for the routing problem in WSNs. These routingmechanisms consider the inherent features of WSNs and theapplication and architecture requirements. The task offinding and maintaining routes in WSNs is nontrivial sinceenergy restrictions and sudden changes in node status causefrequent and unpredictable topological changes. Tominimize energy consumption, routing techniques proposedin the literature for WSNs employ some well-known routingtactics as well as tactics special to WSNs.Classification of Almost all of the routing protocolscan be according to the network structure as flat,hierarchical, or location-based. In flat networks, all nodesplay the same role while hierarchical protocols aim atclustering the nodes so that cluster heads can do someaggregation and reduction of data in order to save energy.Location-based protocols utilize the position information torelay the data to the desired regions rather than the wholenetwork. In this paper, the routing techniques in WSNs thathave been developed in recent years are explored andclassified, providing deeper understanding of the currentrouting protocols and also some open research issues thatcan be further pursued are identified here.

II. ROUTING CHALLENGES AND DESIGN ISSUES INWSNs

Despite the countless applications of WSNs,these networks have several restrictions. The design ofrouting protocols in WSNs is influenced by manychallenging factors which must be overcome before efficientcommunication is achieved in WSNs. Some of the routingchallenges and design issues that affect routing process inWSNs.

A. Node deployment

Node deployment in WSNs is applicationdependent and affects the performance of the routingprotocol which can be either deterministic or randomized. Indeterministic deployment, the sensors are manually placedand data is routed through pre-determined paths. In randomnode deployment, the sensor nodes are scattered randomlycreating an infrastructure in an ad hoc manner. If theresultant distribution of nodes is not uniform, optimalclustering becomes necessary to allow connectivity andenable energy efficient network operation.

B. Energy consumption without losing accuracy

Sensor nodes can use up their limited supply ofenergy performing computations and transmittinginformation in a wireless environment but their lifetime isstrongly battery dependent and hence energy-conservingforms of communication and computation are essential.

C. Data Reporting Model

Data sensing and reporting in WSNs is dependenton the application and the time criticality of the datareporting. Data reporting can be categorized as either time driven (continuous), event-driven, query-driven, and hybrid.The routing protocol is highly influenced by the datareporting model with regard to energy consumption androute stability.

D. Fault Tolerance

Some sensor nodes may fail or be blocked due tolack of power, physical damage, or environmentalinterference. If many nodes fail, MAC and routing protocolsmust accommodate formation of new links and routes to thedata collection base station which requires actively adjustingtransmit powers and signaling rates on the existing links toreduce energy consumption or rerouting packets throughregions of the network where more energy is available. Therefore, multiple levels of redundancy may be needed in afault-tolerant sensor network.

E. Connectivity

High node density in sensor networks precludesthem from being completely isolated from each other.Therefore, sensor nodes are expected to be highly connected.This, however, may not prevent the network topology frombeing variable and the network size from being shrinkingdue to sensor node failures. In addition, connectivitydepends on the, possibly random, distribution of nodes.

F. Quality of Service

In some applications, data should be deliveredwithin a certain period of time from the moment it is sensed; otherwise the data will be useless. Therefore boundedlatency for data delivery is another condition for timeconstrainedapplications. As the energy gets depleted, thenetwork may be required to reduce the quality of the resultsin order to reduce the energy dissipation in the nodes and hence lengthen the total network lifetime. Hence, energy awarerouting protocols are required to capture this requirement.

G. Operating Environment

We can set up sensor network in the interior oflarge machinery, at the bottom of an ocean, in a biologicallyor chemically contaminated field, in a battle field beyond theenemy lines, in a home or a large building, in a largewarehouse, attached to animals, attached to fast movingvehicles, in forest area for habitat monitoring etc.

H. Production Costs

Since the sensor networks consist of a largenumber of sensor nodes, the cost of a single node is veryimportant to justify the overall cost of the networks andhence the cost of each sensor node has to be kept low.

III. ROUTING PROTOCOLS IN WSNs

In this section, we survey the state-of-the-artrouting protocols for WSNs. Recent advances in wirelesssensor networks have led to many new protocols specificallydesigned for sensor networks where energy awareness is anessential consideration.

A. Ad hoc On-Demand Distance Vector(AODV)

The Ad hoc On-demand Distance Vector (AODV) [6, 8, 9]protocol, one of the on-demand routing algorithms that hasreceive the most attention, however, does not utilize multiplepaths. It joins the mechanisms of DSDV and DSR. The periodicbeacons, hop-by-hop routing and the sequence numbers of DSDVand the pure on-demand mechanism of Route Discovery andRoute Maintenance of DSR are combined. In AODV [6], at Every instance, route discovery is done for fresh communication whichconsumes more bandwidth and causes more routing over-head.The source prepares RREQ packet which is broadcast to it's neighboring nodes. If neighboring node will keep backward pathtowards source. As soon as destination receives the RREQpacket, it sends RREP packet on received path.This RREP packet is unicast to the next node on RREP path. Theintermediate node on receiving the RREP packet make reversalof path set by the RREQ packet. As soon as RREP packet isreceived by the source, it starts data transmission on the forwardpath set by RREP packet. Sometimes while data transmission isgoing on, if path break occurs due to mobility of node out ofcoverage area of nodes on the active path, data packets will belost. When the network traffic requires real time delivery (voice,for instance), dropping data packets at the intermediate nodescan be costly. Likewise, if the session is a best effort, TCPconnection, packet drops may lead to slow start, timeout, andthroughput degradation.

B. Threshold - sensitive Energy Efficient sensor Network protocol (TEEN):

TEEN is a reactive protocol proposed for time-criticalapplications [7]. BASE STATION broadcasts the attribute, HardThreshold (HT) and Soft Threshold (ST) values to its clustermembers. The sensor nodes starts sensing and transmits thesensed data when it exceeds HT. HT is the minimum attributerange above which the values are expected. The transmitted sensevalue is stored in an internal variable called Sensed Value (SV).The cluster nodes again starts sensing, when its value exceeds theST. The minimum change in the sensed value it switches on itstransmitter and transmits.The energy is conserved since the sensor nodes in thecluster senses continuously but transmits only when the sensedvalue is above HT. The ST further reduces the transmissionwhich could have been occurred when there is a little change orno change in sensed attribute. As the cluster heads (CH) need toperform extra computations it consumes more energy comparedto other nodes. The main drawback of this protocol is that thetransmission from nodes to CH will not be there when the sensedvalue is not greater than HT, hence the CH will never come toknow even when any one of the sensor node dies. Accurate andclear picture of the network can be obtained by fixing the ST assmaller value even though it consumes more energy due tofrequent transmissions [10].

C. Hybrid Routing Protocol:

Hybrid Routing Protocols combines the merits of proactive andreactive routing protocols by overcoming their demerits.The constraints of TEEN are incorporated in AODVrouting protocol. The modified algorithm is shown in figure 3.Each cluster node sense the data, if the value is greater than HT,then node sends RREQ to the destination. By receiving RREPmessage from destination source node transmits the data todestination node. The HT value is stored in SV a variable whichstores the transmitted threshold value. The cluster nodes againstarts sensing, when its value exceeds the ST i.e. The minimumchange in the sensed value occurs it switches on its transmitterand transmits. Active nodes in the networks are determined bybroadcasting a “Hello” message periodically in the network. If anode fails to reply a link break is detected and a

Route Error(RERR) message is transmitted which is used to invalidate theroute as it flows through the network. A node also generates aRERR message if it gets message destined to a node for which aroute is unavailable. The RREP packet is broadcast by the node along the path. Thenodes that are neighbor to the node and not along the pathreceives the RREP packet, updates their routing table and dropthe packet. As a results of broadcasting RREP from destinationtowards source, node on the active path as well as nodesneighbor to active path node able to gather more routinginformation.

Route Discovery in Hybrid Protocol:

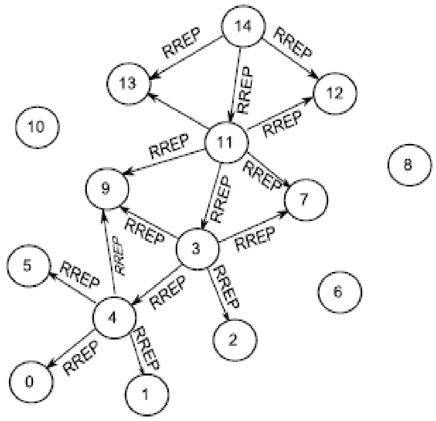


Figure : RREP Transmission in the Network

In Hybrid protocol, RREP packet is broadcast to all neighbors whichare in the coverage area of the replying node. The RREP packetis broadcast to all neighbor nodes along with intendednode. Onreceiving RREP packet, neighboring node makes an entry in therouting table about complete path which has received in RREP. Ifneighboring node is not the intendednode, it drops RREP packet.If it is intendednode, it adds own id in the received path andrebroadcast RREP. This process of extracting useful informationfrom RREP packet and updates of RREP packet is carried outuntil RREP packet is not received by the destination which issource of RREQ packet. Figure 5.2 shows the process of RREPpacket transmission.In the Figure, node *14* is sending a RREP packet is responseto RREQ from node *0*. Routing table at node *14* after processingRREQ packet from node *0*

Dest	Next hop	Hop count
0	11	4

At node *14* the next hop towards node *0* is node *11* shown inabove Table with node *11* as intended node. It prepares RREPpacket and broadcast with node *11* as the intended node.Neighboring node *11,12,13*will receives the RREP packet.

Route Maintenance in Hybrid Protocol:

Usually link failure occurs due to node mobility. A node ondetecting link failure send a route error message (RERR). ThisRERR message is forwarded to the source. Source will start freshroute discovery procedure after receiving RERR message Thisprocess is shown in Figure bellow:

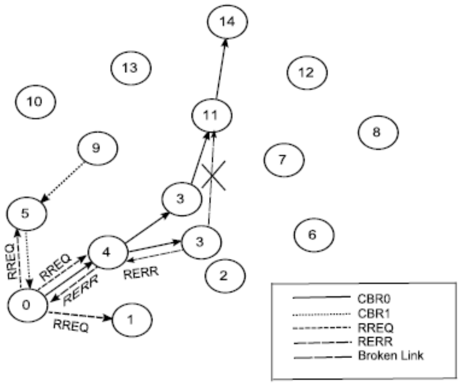


Figure : Link Failure and Recovery

IV. 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.

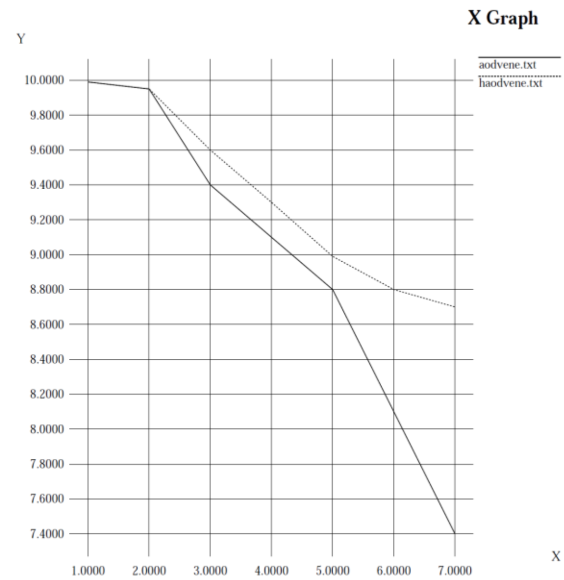


Figure 5.1: Graph 1: Energy in joules vs time in sec.

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**.**

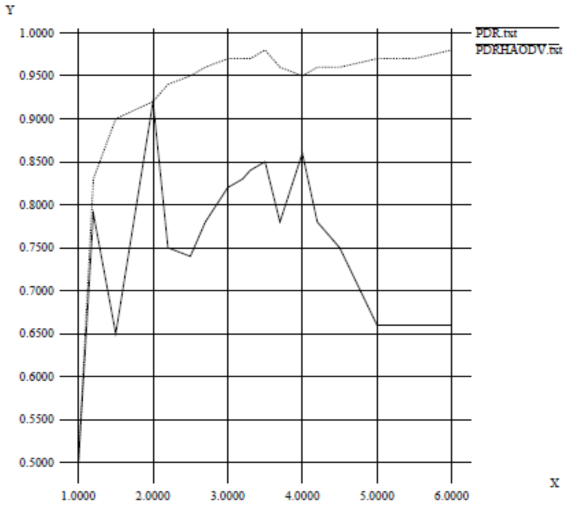


Figure 5.2: Graph 2: PDR vs time in seconds.

Throughput:

Throughput is the sum of data rates delivered to a network per time slot. Throughputs are measured in Kbps, Mbps &Gbps. Figure 5.3 shows throughputs for HAODV and AODV protocols. From the graph it is observed that throughputs for HAODV is better than AODV

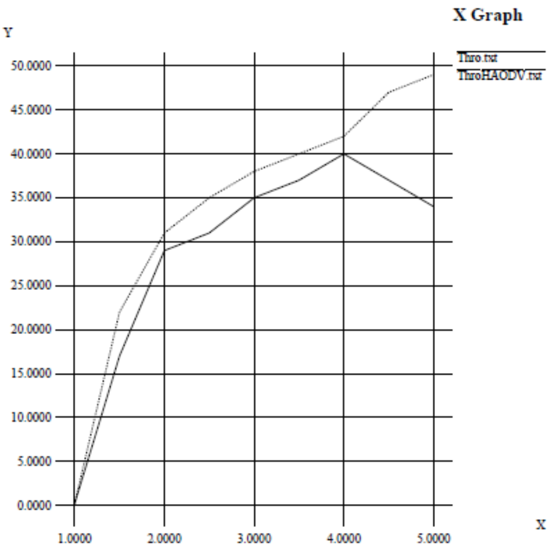


Figure 5.3: Graph 3: Throughput in kbps vs time in seconds

V. 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 & throughput.

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