An Investigation and study for Routing Protocols Applications for Wireless Sensor Networks

HADEEL AHMAD AL-FAHAD

Training Specialist Engineer,

Higher Institute of Telecommunications and Navigation, Kuwait.

EIMAN ALI AL-JAZZAF

Training Specialist Engineer,

Higher Institute of Telecommunications and Navigation, Kuwait.

ABDELSALAM. H. A. HAMZ

Prof. Dr. of Electrical Engineering,

Shoubra Faculty of Engineering, Benha University, Cairo Egypt.

***Abstract*—Wireless Sensor Networks (WSN) has gained vast attention in the last decade. Routing protocols are the heart of WSN; their role is connecting the network together. This paper identifies routing protocols, routing types, techniques used to classified routing protocols, some of problems WSN is suffering from, and some experiments with results.**

Keywords-component; Wireless Sensor Networks (WSN); Routing protocols; Routing types and techniques.

I. INTRODUCTION

Wireless Sensor Networks (WSN) has gained vast attention in the last decade; it plays a key role in the wireless communication field. WSN is described as a group of sensor nodes capable of sensing, computing and communicating with each other wirelessly using radio frequency. The two major powerful aspects of WSN lie in combining sensing computation and communication into tiny device (node), and the ability to install large number of these nodes in a network. The capabilities of WSN have a huge area of researches and range of applications. The applications vary from medical, security, to military and from personal use, business, to industry.

In general WSN consists of a base station (Gateway) that communicates with all the wireless sensors (nodes) in the network through a radio frequency, where the data is collected by the nodes and transmitted to the gateway either directly or through other nodes, and then the data delivered to the system by the gateway connection. Routing protocols are the heart of WSN; it controls and manages the flow of messages in the Wireless network. Before discussing routing protocol lets understand Routing first; routing defines as a method that constructs maps presenting the positions of all the nodes in the network and provides directions to destination and gives it to the router.

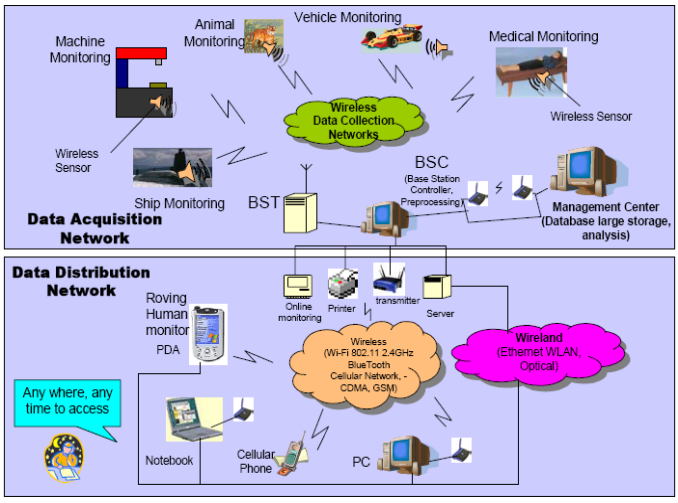


Figure1: Wireless Sensor Network [11]

The basic function of the router is to select the best route to send the information to destination, router stores tables contain information about other routers in the network and it uses these tables to choose the best and shortest path to destination. Generally there are two types of routing:

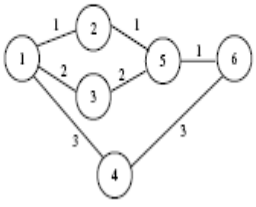
- Static Routing: In this type routing tables are entered manually by the administrator. This means the paths between nodes are fixed and any changes in the position of any node or any failure occurs between nodes cannot be detected or repaired by the network. It has to be updated by the administrator. Its advantages are : High security because the source of the information is the administrator itself, and since there is no exchanging in routing tables

means no consuming in the bandwidth and low processing power which leads to cheaper router. The disadvantages are it updates manually, Reconfiguration of the nodes will be a problem if there is any change in the connecting links.

- Dynamic routing: this type the routing is affected by the network itself, the router learns and maintains routes to the remote destinations by exchanging routing updates with other routers and the routing tables are depending on the activeness of the destination. The advantage here is it's updated automatically, which means any changes, such as the loss of a node, or loss of a connection between nodes can be detected.

Routing protocol definition is a set of rules and regulations that controls the way the routers communicate with each other in the network. Routing protocol has two types of behavior:

Classless Routing: This means both variable size of subnet depending on the requirement of that subnet, and transmitting the subnet mask along with each route in the routing updates sent by that protocol. Subnet is a division of the network, which is created to improve performance and provide security. It improves the performance by limiting the number of nodes that compete for available bandwidth; the network is divided into groups that communicate with each other. For security, the subnet divisions can be based on servers that have restricted applications. Where Subnet mask means a binary model stored in the router to determine the packet destination. Classful Routing: means a fixed size of subnet, and no transmitting of mask information.



routing table					
dest	2	3	4	5	6
next hop	2	3	4	2	2

forwarding tables					
2→1	-	3	4	3	4
3→1	2	-	4	2	2
4→1	2	3	-	2	2

Figure2: Sample topology, routing and forwarding tables.

Since WSN routing protocols are still under active research, there are problems with implementing and operating these wireless networks, here are some of these problems:

a. Slow Convergence: convergence means that all routers will ends up with the same information about the location of each other, and which are the best routes to use to reach them. Unfortunately, there are some nodes slower to update there routing table than other nodes (It takes a long time for all routers to get the same information).

For example, a network consists of nodes 1-2-3-4. Each hop from the one node to the ascending node in increments of 1 will be counted as 1 hop. The link between nodes 1 and 2 has gone down. This will result in node 2 updating its routing table to indicate that the path between nodes 1 and 2 is infinity (or 16, if the maximum count is implemented). But if node 3 broadcasts that the link between nodes 1 and 2 is still alive to node 4 before node 2 broadcasts that the link is already broken, the shortest path as seen by node 4 will still be implemented, going to node 3 then node 2 then node 1 as the shortest path. When the data from node 4 reaches to node 2, it will not send data to node 1, returning back the data to node 3. Since node 3 still sees node 2 as the shortest path to node 1, it will still send the data to node 2, forming a loop.

Slow Convergence problem can be solved using Split Horizon method. This method means that if node A has learned a route to node C through node B, then node A does not send the distance vector of C to node B during a routing update [10].

b. Routing Loop: it occurs when an operation in the algorithm of the routing protocol has an error, and that error results in a miscalculated routing that occurs as a loop from one node to another, then the information continue to be routed in an endless circle. For example, a network consists of nodes 1-2-3. Node 1 transmits data to node 3 via node 2 as the shortest path calculated dictates. If the link between nodes 2 and 3 breaks and node 2 has not informed node 1 that the link from node 2 to node 3 has gone down, node 1 will still transmit data to node 2. Node 1 thinks that the path is still operating properly and the shortest path is still the same. Since node 2 is informed of the breakage of link to node 3, it cannot transfer data to node 3 and thus will return back the sent data to node 1. Since node 1 is still not informed of the breakage it will still transmit data to node 2, knowing that the data will be sent from node 2 to node 3. Node 2 will still send the data back to node 1, and the routing loop occurs.

The Routing loop problem can be solved using Split Horizon method.

c. Counting To Infinity: it occurs when a path on the network has gone down, and the algorithm used by the routing protocol will compute for a new shortest routing path. This problem most common in distance vector routing protocol. A distance vector routing uses an algorithm that computes for the shortest path from one node to another. When a link fails, the algorithm will compute for new shortest paths to infinity.

For example, a network consists of nodes 1-2-3-4. Each hop from the one node to the ascending node in increments of 1 will be counted as 1 hop. A link between nodes 3 and 4 goes down and breaks the connection between the two. Node 3 will compute for a new shortest path and will see that its shortest path to node 4 is through node 2 and data will be sent from node 3 to node 2. Node 2 will compute the shortest path and will see that node 1 is the shortest path to node 4. Node 2 will send the information to nodes 1 and 3 and will compute for the shortest path. Since all nodes believe that their neighboring nodes are the shortest path to node 4, they will continue counting until infinity since they cannot reach node 4 due to a broken down link.

There are some solutions to the counting to infinity problem:

i) Defining Maximum Count: here the count is limited to a maximum count of 16 hops.

ii) Split Horizon method.

d. Security: In routing protocols network routers exchange information in order to establish routs between nodes [3], this information can be used to attack the network.

There are two attacks sources:

- External attacks: the attacker use the following techniques to attack the wsn: injecting false routing information, replaying old routing information, or distorting routing information.
- Internal attacks: which is done by one of the network nodes, where the node send incorrect routing information to the rest of the network nodes. In this attack it's difficult to detect the incorrect information or the sender node.

There are two classifications of the attacks:

- Passive attack: instead of disturbing the network, the attackers search for valuable information by listening to routing traffic. The advantage here for the attackers; it's impossible to detect them.
- Active attack: in this type the attackers desired to disable the whole network. It is done by injecting false information into the network. Here the attackers can be detected.

Types of active attack:

1) Black hole: The false node uses the network routing to announce that it has the shortest path to destination and redirect the route to itself, and then it can do anything with the information passing through it. This attack most common in AODV.[3]
2) Routing table overflow: the attacker here creates many false routers to non existing nodes to prevent the network from creating new routes. This type of attacks is impossible to perform on reactive routing since the protocol creates the routes only when needed, where proactive routing is more vulnerable to this attack since the route computed in advance.
3) Sleep deprivation: It happens to battery powered devices where they try to save power by transmitting only when needed, the attacker here request routes or send information to node just to consume batteries.
4) Impersonation: here the false node (or the attacker) can change its IP address and perform many attacks. This type can be performed on AODV and DSR.

This paper presents an overview of routing protocols in WSN discussing the classifications of routing protocols, some of routing algorithm, some experiments with results that evaluate some of routing protocols, and future work.

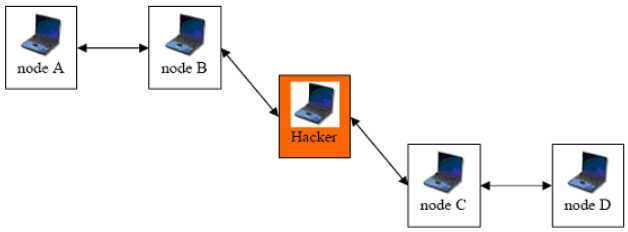


Figure 3: Routing protocols Network

II. SELECTED ROUTING SCHEMS (I)

Routing protocols can be classified on the basis of:

- State information
- Scheduling
- Communication Model
- Structure
- Casting

A. Classification on the basis of state information

a. 2.1.1 The Link State Routing (LSR) : in this protocol every node is allowed to construct a

comprehensive view of the network , that describes the connection between all the other nodes and their cost. Based on the constructed view each node will compute the best routes to all other nodes. Example of LSR: is the Open Shortest Path First (OSPF).

- The Open Shortest Path First (OSPF) protocol: is a classless link state routing protocol. It has two characteristics: Open Protocol (means public domain) and it based on shortest path first algorithm. Shortest path first algorithm which also known as Dijkstra's algorithm is an efficient way to determine the best node to take to destination, given number of nodes and paths. It performs in three stages:

Stage 1: Start Up: the first thing router does when turned on is sending "Hello" message to its neighbors, receiving their "Hello" then establishing routing connections.

Stage 2: Update: Every router sends update message describing its routing table.

Stage 3: Shortest Path Tree: Each router calculates the shortest path to destination then indicates the closest router to send a message.

b. Distance Vector Routing (DVR): It requires a frequent exchange of information between nodes. Nodes exchange two types of information: Distance from destination and which router to use to send the message to destination.

After the router received the information it develops a table of destination addresses and distances then it select the shortest route to destination. Two examples of DVR: Routing Information Protocol (RIP) and Interior Gateway Routing Protocol (IGRP).

- Routing Information Protocol (RIP): is a Distance-Vector routing protocol; routers share information of the entire network with neighbors. It has two types of messages: Request Message and Response message. It sends the complete routing table out to all active nodes every 30 seconds. RIP uses hop count to determine the best way to a wireless network; hop count is the number of nodes the packet has to pass through to reach destination. RIP has a maximum allowable hop count of 15, which means that 16 is unreachable. RIP is suitable for a small wireless networks. RIP has two versions: RIP version 1 uses only routing, because RIPv1 does not include the subnet mask when it sends updates, all devices in the network must use the same subnet mask. RIP version 2 uses multicasts to update its routing tables. Multicast means the source can send a single packet using single address for several destinations.

- Interior Gateway Routing Protocol (IGRP): It was created to solve the limitation problem of RIP; it sends information at regular intervals and uses the following measurements: Bandwidth – Delay – Reliability – and maximum Transmission Unit (MTU).

  IGRP has a maximum hop count of 225 and that is helpful in large networks. IGPR has set of timers to measure the performance:

  a) Update Timer: it measures the frequent routing updates message send (default 90sec.)

  b) Invalid Timer: measures the router waiting time before declaring an invalid route.

  c) Hold down Timer: hold down period.

  d) Route Flush Timer: How long the route waits before flushing invalid route from table.

TABLE I: Link-State Routing vs. Distance-Vector Routing

LSR	DVR
Calculates the distance to the neighbors	Calculates the distance to all nodes
Exchanges information with all nodes	Exchanges information only with the neighbors
Big memory requirements	Not necessarily

B. Classification on the basis of scheduling

a. Table-driven routing: It's also known as proactive routing. In this protocol the routes of all nodes are computed in advance and updated (whenever a change is recognized). Example of Proactive routing: Destination-Sequenced Distance-Vector (DSDV) and Wireless Routing Protocol (WRP).

- Destination-Sequenced Distance-Vector Routing protocol (DSDV): is a table-driven protocol. When sources choose a certain destination to send data, the destination labels each route table with a sequence number. Distance-Vector routing uses the sequence number labeled on the tables and the number of hops stored in the tables to determine which nodes are accessible. The advantage of DSDV is it's suitable for creating ad hoc networks with small number of nodes, but the disadvantages are since DSDV requires a regular update of its routing tables, it will use up battery power and a small amount of bandwidth, whenever the topology of the network changes, a new sequence number is necessary before the network re-converges; thus, DSDV is not suitable for highly dynamic networks.

- Wireless Routing Protocol (WRP): is a table-driven based protocol with the goal of maintaining routing information among all nodes in the network. Each node in the network is responsible for maintaining four tables: Distance table, Routing table (contain distance to a destination node), Link-cost table (the cost of the link to its nearest neighbors), Message retransmission list table (list of which neighbors are yet to acknowledged an update message).The WRP has the same advantage as that of DSDV and also it has faster convergence and involves fewer table updates. The disadvantages are the complexity of maintenance of multiple tables demands a larger memory and greater processing power, and it requires large memory storage. It's not suitable for large mobile ad hoc networks.

b. On demand routing: It's also known as reactive routing. In this protocol the route to a destination is computed only when it is needed. When a source needs to send information to a destination it finds a route to the destination, this process called route discovery, the route remains valid as long as it's needed. Two examples of reactive routing: Ad hoc On-demand Distance Vector Routing protocol (AODV) and Dynamic Source Routing (DSR).

- Ad hoc On-demand Distance Vector Routing protocol (AODV): It is a combination of both DSDV and DSR. Where it establishes routes only upon demand like the DSR, it is based on routing tables like DSDV. Routing tables in AODV are updated after some timing period provided by the timer based states in each node. AODV uses sequence numbers on destinations to avoid routing loops. The advantages of AODV are the connection setup delay is low, it is simple and doesn't require large memory. The disadvantages are it requires more time to establish a connection.

- Dynamic Source Routing (DSR): is a simple and efficient routing protocol designed specifically for use in multi-hop wireless ad hoc networks of mobile nodes. DSR allows the network to be completely self-organizing and self-configuring, without the need for any existing network infrastructure or administration. where each node stores a route cache that contains hop-to-hop routes from source to destination. When a node wants to transmit to a certain destination, it first checks if the destination exists in its route cache. If not, it performs route discovery to this destination, where then a route request packet (RREQ) containing addresses of both the source node and the destination node, and also the request ID, is sent to neighbor nodes. Advantage is it performs well in static, low mobility environment. Where the disadvantages are the connection setup delay is high, and rout maintenance does not repair a broken link.

TABLE 2: Proactive Routing vs. Reactive Routing

Proactive Routing	Reactive Routing
Routes are calculated before one is needed	A route is only calculated, when it is needed
Tries to keep routing-information to all nodes updated	Does not try to keep routing-information to all nodes

C. Classification on the basis of Communication Model

2.3.1 Multichannel Protocol: is a routing protocol that uses multiples channels for instantaneous communication without interference. It is always on

demand. It used when there are more than one communication channel available. It combines channel assignment – route discovery – and route maintenance. Example: On Demand routing protocol.
2.3.2 Single Channel Protocol: is a routing protocol that uses a single channel for communication. Most protocols are designed to work in single channel. Example: Ad hoc On-demand Distance Vector Routing protocol (AODV)

D. Classification on the basis of Structure

a. 2.4.1 Uniform Protocol: all nodes act (send and respond) at the same way, and all nodes in the network having the same importance, role and functionality. Example: Dynamic Source Routing protocol (DSR).

b. Non – Uniform Protocol: It separates routers in acting with the information. It has advantages in reducing complexity and improving scalability. Scalability is the ability to support large number of nodes.

E. Classification on the basis of Casting

- Full broadcast: the message is transmitted to all nodes in the network.
- Local broadcast: the message is only for the nodes that the sender can reach.
- Limited broadcast: the message is transmitted to certain nodes of the network.

III. SELECTED ROUTING SSCHEMES (II)

A. Global State Routing (GSR)

It's an especially designed algorithm to achieve the medium access control efficient in ad-hoc wireless network. It's a combination of two algorithms LSR for its routing accuracy, and Distributed Bellman Ford (DBF) for its dissemination method. DBF is based on having tables showing the number of hops needed to destination choosing shortest path.

GSR has the following tables:

a) Neighbor List: Contains all the nodes that can be heard from the current node.
b) Topology Table: For each destination node, the Topology table contains the link state information as reported by the destination and the timestamp of the information.
c) Next Hop table: For each destination, the next hop table contains the next node from the source to which the packets from this source must be forwarded.
d) Distance table: it contains the shortest distance for each destination from source.

On every link change an update message is transmitted and the nodes update their tables depending upon the timestamp of their message [2].

B. Fisheye State Routing

This algorithm is an improvement of the Global State Routing algorithm; it uses "Fisheye" technique. The term "Fisheye technique "came from the characteristic of the eye of the fish, where it captures with high detail the graphic near the focal point, and the detail decreases as distance from focal point increase. In routing "Fisheye" approach means continue having the accurate distance and path information about the nearest nodes, and less detail and accuracy as the distance increases. In other word the routing information packets contain the information of certain neighboring packets only. It exchanges information about closer nodes more frequently than the farther nodes. Even though a node does not have accurate information about distant nodes, the packets are routed correctly because the route information becomes more and more accurate as the packet moves closer to the destination.

V. SIMULATION OF EXPERIMENTAL RESULTS

A. Experiment for GSR & LSR (Simulation Environment) [4]

What distinguishes this experiment that the simulation environment consists of truly mobile nodes. The simulation environment has area of 500 x 500 unit2 and programmed in C++. Arbitrary numbers of nodes, representing the mobile hosts, move independently on their own orbits within this virtual space. The maximum moving speed and number of nodes was kept to 60. Further assumptions made in the simulation were: no node failure during simulation, node number is always constant in the run time of simulation; a time slotted system; radio transmission range is fixed at R, which is specified at the beginning of the simulation; and two nodes can hear each other if they are within the transmission range.
Two metrics are used to evaluate the routing performance of GSR and LSR: (Routing inaccuracy and control overhead).

1. Routing Inaccuracy: is examine by comparing the next hop table of each node with the tables generated by an off-line algorithm. This off-line

algorithm has knowledge of the exact network topology to compute the optimal solution for each node at each time slot.

2. Control Overhead: is evaluated by examining the average number of routing control packets exchanged on each link.

Results:

a) LSR performs better at all speed ranges, because it reacts faster to topology changes than GSR.

b) GSR has flat distribution of packet overhead and it performs better than LSR, when mobility increases GSR overhead remains constant, but LSR overhead increases.

VI. EXPERIMENT FOR AODV AND DSDV (SIMULATION ENVIRONMENT) [6]

A simulation environment of fixed area 1000m x 1000m, with simulation time of 1000 sec is considered and assumed. It consists of four simulation experiments to study AODV and DSDV with varying Input parameters:

- maximum moving speed
- number of connections
- number of mobile nodes

Experiment 1 – varying maximum speed:

The purpose of this experiment is to study the effect of the speed on the protocol performance; the speed was varied from 4 – 24 m/s.

Results:

- Delivery ratio of DSDV drops faster as speed increases.
- The normalized overhead of AODV is 2—4 times more than DSDV when the network is loaded.
- The overhead of DSDV keeps stable as node mobility increases.
- The power consumption of both protocols is stable and close to each other.

Experiment 2 – Varying number of connections*:*

The purpose of this experiment is to examine the performance of both protocols under different loads (10-80).

Results:

a) Delivery ratios of both protocols drops as network fully loaded.

b) The normalized overhead of AODV increases faster when network fully loaded.

c) The power consumption of both protocols is stable and close to each other.

Experiment 3 – Reasons for packet drop*:*

The purpose of this experiment is to investigate the reasons that cause packet loss.

Results:

- In both protocols, congestion is the primary reason for packet drop.
- DSDV is easier to lead to congestion
- In DSDV, when links break, the intermediate nodes will buffer packets until new routes are available. This reduces packet drop.

Experiment 4 – varying number of mobile nodes:

The purpose of this experiment is to study the impact of number of nodes on protocol performance, were number of nodes varied from 20 – 70 node.

Results:

1) When the number of nodes > 50, the delivery ratio of DSDV is better than AODV.

2) The protocol overhead of AODV is larger than DSDV when the network is fully loaded.

Overall Observations and results:

1) In less stressful environments, AODV outperforms DSDV for all metrics except protocol overhead. DSDV performs better in denser networks with a heavier load.

2) On-demand protocols propagate the link changes faster, and reduce the packet drop caused by them.

3) Network congestion is the dominant reason for packet drop. The performance of the protocols can be improved by congestion avoidance.

VII. EXPERIMENT FOR AODV (SIMULATION ENVIRONMENT).

A simulation environment of fixed area L x L, but varied the number of nodes as 50,100, 500 and 1000. The movement algorithm is the same for all the nodes can move anywhere in the simulation area. The speed of each can be between 0.4 to 0.8 m/sec. Detecting the hidden node problems and the back off times for each node when a neighbor is transmitting. A session send transmission data until it times out or sends the desired number of segments.

Results:

- Performance of AODV does not decrease significantly when number of nodes are increased, which means that AODV is scalable.
- The number of collisions is more when the information size is large, means it's poor in case of large information.

VIII. EXPERIMENT FOR DSR (SIMULATION ENVIRONMENT)

This experiment is intended to evaluate the performance of DSR in different node arrangement model (grid – random – uniform), with simulation area of 1000mX1000m, varying number of nodes (10 – 20 – 40 – 80 – 100), one source, one destination, constant speed at 10m/s, and constant pause time of 30s.

Results:

- DSR perform better in uniform environment.

IX. CONCLUSION

This paper has discussed a variety of criteria for classifying routing protocols schemes, provided comparisons of some of these schemes, and a brief surveys on some of routing protocols techniques including advantages and disadvantages of these techniques.

Many challenges and problems are facing routing protocols and causing failure in the wireless connection. Some of these problems has mentioned, specially security problem; which is an important problem that cannot easily solved, because it is impossible to find a general technique that can prevent all kinds of attacks.

Also good efforts has carried out to find the superior routing protocol by evaluating and comparing routing protocols through survey of experimental works; and it has concluded that there is no one protocol has a greater performance than the others. In fact to choose a superior routing protocol will depend on the application type and the intention use of the WSN.

X. FUTURE WORK

Routing protocols are still under study and development and there is some problems facing the designing WSN. In my opinion there is an issue that requires further research and concern, which is the security problem. The focus must be in providing more security against the injection of false information, and the illegitimate nodes joining WSN.

REFERENCES

[1] Elizabeth M. Royer and Charles E. Perkins, "Ad hoc On Demand Distance Vector Routing", IEEE, 1997.

[2] Chen, T. & Gerla, M., "Global State Routing: A New Routing Scheme for Ad-hoc Wireless Networks", Proc. IEEE ICCs, 1998.

[3] Elizabeth M. R. & Chai-Keong, T, "Review of Current Routing Protocols for Ad Hoc Mobile Wireless Network", IEEE Personal Communications, Vol. 6, No. 2, pp. 46-55, April 1999.

[4] Petteri Kuosmanen, "Classification of Ad Hoc Routing Protocols", IEEE, 2002.

[5] Xukai Zou, Byrav Ramamurthy and Spyros Magliveras, "Routing Techniques in Wireless Ad Hoc Networks Classification and Comparison", Proceedings of the Sixth World Multi-conference on Systemics, Cybernetics, and Informatics (SCI 2002), 2002.

[6] Jong Youl Choi, "Security problems for ad hoc routing protocols", Technical report, 2003.

[7] Yi Lu, Weichao Wang, Bharat Bhargava , "Study of Distance Vector Routing Protocols for Mobile Ad Hoc Networks", CERIAS and Department of Computer Sciences Purdue University, March 24th, 2003.

[8] Sanghwan Lee, Yinzhe Yu, Srihari Nelakuditi, Zhi-Li Zhang, Chen-Nee Chuah, "Proactive vs Reactive Approaches to Failure Resilient Routing ", IEEE, 2004.

[9] D.J. Cook and S.K. Das, "Wireless Sensor Networks", John Wiley, New York, 2004.

[10] Lindqvist, Janne, "Counting to Infinity", Telecommunications Software and Multimedia Laboratory", Helsinki University of Technology. 2004.

[11] Mr. Ankur Khetrapal, "Routing techniques for Mobile Ad Hoc Networks Classification and Qualitative/Quantitative Analysis", New Delhi: Delhi College of Engineering, Delhi University.

[12] Chun-Chuan Yang and Li-Pin Tseng, "Fisheye Zone Routing Protocol for Mobile Ad Hoc Networks", CCNC2005, 2005.

[13] Krishna Gorantala, Master's Thesis in Computing Science, "Routing Protocols in Mobile Ad-hoc Networks", June 15, 2006.

[14] Lu. Zhang and Leonard J. Cimini, Jr., " Hop-by-Hop Routing Strategy for Multihop Decode-and-Forward Cooperative Networks", Department of Electrical and Computer Engineering, University of Delaware, 2008.

[15] Prof.S.P.Setti and Narasimha Raju K, "Performance Evaluation of DSR in Various Placement Environments", IJCA Special Issue on "Mobile Ad-hoc Networks, 2010.

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