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A Survey on Routing Around Connectivity Holes

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This paper focuses on ALBA-R, a protocol for converge casting in wireless sensor networks. Due to random deployment, environmental factor and outside attacks, appearance of holes in wireless sensor networks is unavoidable. The basic objective is to provide a routing mechanism, so as to route the packets to the sink, this is carried out using a cross layer protocol known as Adaptive load balancing algorithm, which integrates various features as routing of packets across the geographic area with avoidance of contention, and also supports routing of packets across the connectivity holes. Thus routing around dead ends cannot be carried out using graph planarization and face routing hence ALBA uses Rainbow mechanism. In this work the survey is carried out to analyze the various methods used to route the packets across dead ends

Key words: ALBA-R, connectivity holes, dead ends, rainbow mechanism, crosslayer protocol

I. INTRODUCTION

A region in which a group of sensor nodes stops functioning and does not involve in data sensing and communication is termed as a hole in the network [1]. These are the obstruction for communication. They have a huge influence on the performance of the network. The detection makes out the damage, attack or unreachable nodes. If s a hole is present in the network the data will route along the hole boundary nodes again and again leading to premature collapse of power present at these nodes [2]. This will ultimately increase the size of hole in the network. Detection of holes avoids the extra power used around holes because of congestion. It guarantees good network life and sufficient quality of service.

Wireless Sensor Networks are distributed autonomously to observe the physical or environment conditions. Various routing schemes are utilized for this, one is the geographic routing scheme here it depends on geographic position information, but this fails to route around connectivity holes i.e refers to place where incoming and outgoing packets gets dropped. thus to overcome the problem of routing around connectivity holes an dead ends ,cross layer protocol known as Adaptive load balancing algorithm(ALBA)along with rainbow mechanism(ALBA-R)is used. The paper is organized as follows : section 2 provides an overview of protocols, section 3 provides description about methodologies to route packets around connectivity holes, and finally paper is concluded in section 4.

II. OVERVIEW OF PROTOCOLS

Protocols are classified as Reactive and Proactive protocols. In Proactive method the nodes will maintain the route information about all the routes from source to destination, hence they require periodic exchange of messages, which results in more usage of bandwidth.

In Reactive method the routing information is carried out on demand which overcomes the need of unused routes, and thus also results in high latency.

In Case of reactive protocols average end to end delay is variable but it remains constant in proactive protocols for a given WAN. Packet delivery ratio in Reactive approach is much more efficient as compared to proactive approach. The performance of reactive approach is much faster as compared to proactive approach. Reactive protocols are adaptive and thus work efficiently in different topologies as compared to proactive protocols.

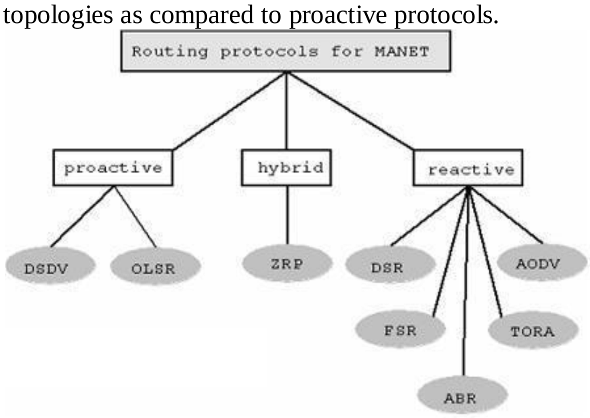


Fig 1: Routing Protocols

PROACTIVE:

DSDV (Destination-Sequence Distance Vector)

DSDV has one routing table, each entry in the table contains: destination address, number of hops towards destination, next hop address. herehere routing table has all the destinations for every node. When a source A communicates with a destination B, it looks up routing table for the entry which contains *destination* address as B. Next hop address C was taken from that entry. A then sends its packets to C and asks C to forward to B. C and other intermediate nodes will work in a similar way until the packets reach B. DSDV marks each entry by sequence number to distinguish between old and new route for preventing loop.

DSDV use two types of packet to transfer routing information: full dump and incremental packet. The first time two DSDV nodes meet, they exchange all of their available routing information in full dump packet. From that time, they only use incremental packets to notice about change in the routing table to reduce the packet size. Every node in DSDV has to send update routing information periodically. When two routes are discovered, route with larger sequence number will be chosen. If two routes have the same sequence number, route with smaller hop count to destination will be chosen.

DSDV has advantages of simple routing table format, simple routing operation and guarantee loop-freedom. The disadvantages are (i) a large overhead caused by periodical update (ii) waste resource for finding all possible routes between each pair, but only one route is used.

REACTIVE:

On-demand Routing Protocols

In on-demand trend, routing information is only created to requested destination. Link is also monitored by periodical Hello messages. If a link in the path is broken, the source needs to rediscovery the path. On-demand strategy causes less overhead and easier to scalability. However, there is more delay because the path is not always ready. The following part will present AODV, DSR, TORA and ABR as characteristic protocols of on-demand trend.

AODV Routing

Ad hoc on demand distance vector routing (AODV) is the combination of DSDV and DSR. In AODV, each node maintains one routing table. Each routing table entry contains:

Active neighbor list: A list of neighbor nodes that are actively using this route entry. Once the link in the entry is broken, neighbor nodes in this list will be informed.

Destination address

Next-hop address toward that destination

Number of hops to destination

Sequence number: for choosing route and prevent loop

Lifetime: time when that entry expires

Routing in AODV consists of two phases: Route Discovery and Route Maintenance. When a node wants to communicate with a destination, it looks up in the routing table. If the destination is found, node transmits data in the same way as in DSDV. If not, it start Route Discovery mechanism: Source node broadcast the Route Request packet to its neighbor nodes, which in turns rebroadcast this request to their neighbor nodes until finding possible way to the destination. When intermediate node receives a RREQ, it updates the route to previous node and checks whether it satisfies the two conditions: (i) there is an available entry which has the same destination with RREQ (ii) its sequence number is greater or equal to sequence number of RREQ. If no, it rebroadcast RREQ. If yes, it generates a RREP message to the source node. When RREP is routed back, node in the reverse path updates their routing table with the added next hop information. If a node receives a RREQ that it has seen before (checked by the sequence number), it discards the RREQ for preventing loop. If source node receives more than one RREP, the one with greater sequence number will be chosen. For two RREPs with the same sequence number, the one will less number of hops to destination will be chosen. When a route is found, it is maintained by Route Maintenance mechanism: Each node periodically send Hello packet to its neighbors for proving its availability. When Hello packet is not received from a node in a time, link to that node is considered to be broken. The node which does not receive Hello message will invalidate all of its related routes to the failed node and inform other neighbor using this node by Route Error packet. The source if still want to transmit data to the destination should restart Route Discovery to get a new path. AODV has advantages of decreasing the overhead control messages, low processing, quick adapt to net work topology change, more scalable up to 10000 mobile nodes . However, the disadvantages are that AODV only accepts bi-directional link and has much delay when it initiates a route and repairs the broken link.

DYNAMIC SOURCE ROUTING PROTOCOL

DSR is a reactive routing protocol which is able to manage a MANET without using periodic table-update messages like table-driven routing protocols do. DSR was specifically designed for use in multi-hop wireless ad hoc networks. Ad-hoc protocol allows the network to be completely self-organizing and self-configuring which means that there is no need for an existing network infrastructure or administration.

For restricting the bandwidth, the process to find a path is only executed when a path is required by a node (On-Demand-Routing). In DSR the sender (source, initiator) determines the whole path from the source to the destination node (Source-Routing) and deposits the addresses of the intermediate nodes of the route in the packets.

Compared to other reactive routing protocols like ABR or SSA, DSR is beacon-less which means that there are no hello-messages used between the nodes to notify their neighbors about her presence.

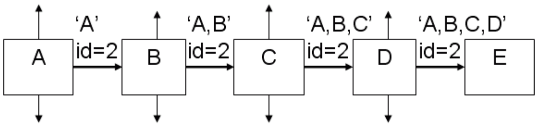
DSR was developed for MANETs with a small diameter between 5 and 10 hops and the nodes should only move around at a moderate speed.

DSR is based on the Link-State-Algorithms which mean that each node is capable to save the best way to a destination. Also if a change appears in the network topology, then the whole network will get this information by flooding.

DSR contains 2 phases

- Route Discovery (find a path)
- Route Maintenance (maintain a path)

Route Discovery



If node A has in his Route Cache a route to the destination E, this route is immediately used. If not, the Route Discovery protocol is started:

1. Node A (initiator) sends a RouteRequest packet by flooding the network
2. If node B has recently seen another RouteRequest from the same target or if the address of node B is already listed in the Route Record, Then node B discards the request!
3. If node B is the target of the Route Discovery, it returns a RouteReply to the initiator. The RouteReply contains a list of the "best" path from the initiator to the target. When the initiator receives this RouteReply, it caches this route in its Route Cache for use in sending subsequent packets to this destination.
4. Otherwise node B isn't the target and it forwards the Route Request to his neighbors (except to the initiator).

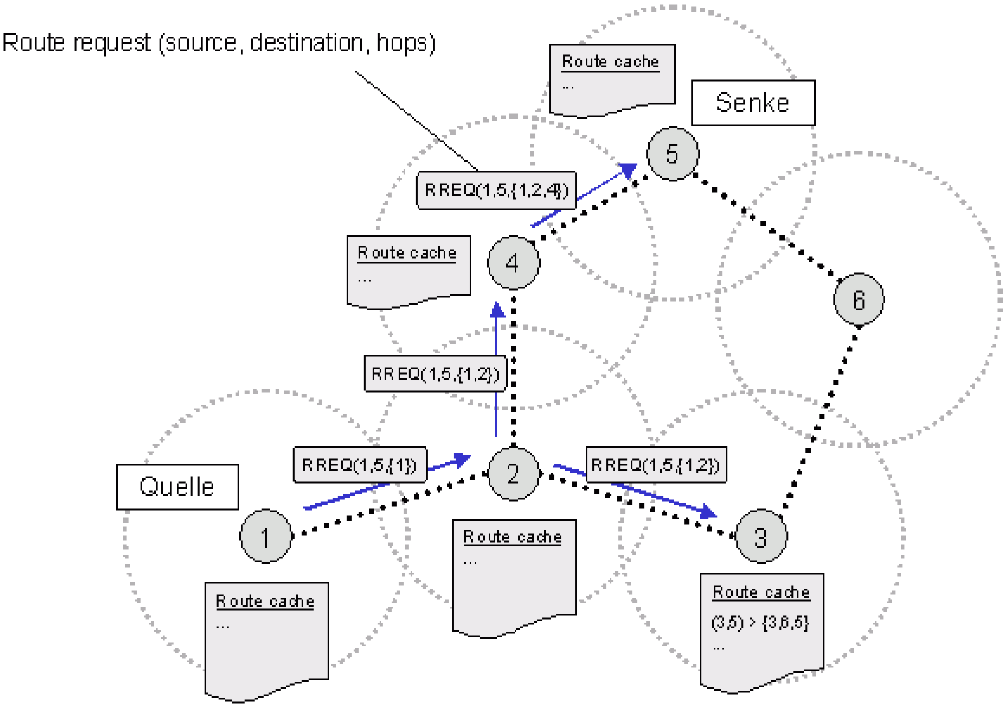
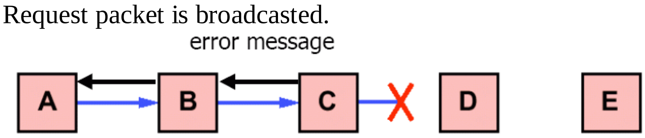


Fig 2: Path-finding-process: Route Request & Route Reply

Route Maintenance

In DSR every node is responsible for confirming that the next hop in the Source Route receives the packet. Also each packet is only forwarded once by a node (hop-by-hop routing). If a packet can't be received by a node, it is retransmitted up to some maximum number of times until a confirmation is received from the next hop.

Only if retransmission results then in a failure, a RouteError message is sent to the initiator that can remove that Source Route from its Route Cache. So the initiator can check his Route Cache for another route to the target. If there is no route in the cache, a Route Request packet is broadcasted.



1. If node C does not receive an acknowledgement from node D after some number of requests, it returns a RouteError to the initiator A.
2. As soon as node receives the RouteError message, it deletes the broken-link-route from its cache. If A has another route to E, it sends the packet immediately using this new route.
3. Otherwise the initiator A is starting the Route Discovery process again.

TORA (Temporary Ordered Routing Algorithm)

TORA is based on link reversal algorithm. Each node in TORA maintains a table with the distance and status of all the available links. Detail information can be seen at [38]. TORA has three mechanisms for routing:

Route Creation: TORA uses the "height" concept for discovering multiple routes to a destination. Communication in TORA network is downstream, from higher to lower node. When source node does not have a route to destination, it starts Route Creation by broadcasting the Query messages (QRY). QRY is continuing broadcasted until reaching the destination or intermediate node that have the route to the destination. The reached node then broadcast Update (UPD) message which includes its height. Nodes receiv e this UPD set a larger height for itself than the height in UPD, appendthis height in its own UPD and broadcast. This mechanism is called reversal algorithm and is claimed to create number of direct links from the originator to the destination.

Route Maintenance: Once a broken link is discovered, nodes make a new reference height and broadcast to their neighbors. All nodes in the link will change their reference height and Route Creation is done to reflect the change.

Route Erasure: Erases the invalid routes by flooding the "clear packet" through the network The advantages of TORA are: having multiple paths to destination decreases the route creation in link broken case therefore decrease overhead and delay to the network. TORA is also claimed to be effective on large and mildly congested network [9]. The drawbacks are requiring node synchroniza tion due to "height" metric and potential for oscillation. Besides that, TORA may not guarantee to find all the routes for reserving in some cases.

ALBA-R protocol:

In Adaptive load balancing algorithm the sender first broadcasts the RTS packets, then neighbouring nodes will responds to this with CTS packet, which carries information regarding the choice of best relay. In Rainbow mechanism it functions along with ALBA i.e ALBA-R to deal with the dead ends, it selects a node for packet forwading and it avoids the use of local minima in routing through a coloring scheme, here to identify the relay the nodes will be colored.

III. METHODOLOGIES TO ROUTE PACKETS AROUND CONNECTIVITY HOLES

I.Stojmenovic[1] ,utilized a methodology to route the packets around connectivity holes included Greedy mode and Recovery mode. Greedy method resulted low delivery ratio and high communication overhead for sparse graph. thus robust based routing cannot forwad a message when the communicating model gets deviated due to obstacle

L.Blazevic,J.-Y.Le Boude ,and S.Giordano[2],utilized the location information to route packets, but resulted in disadvantage that it is difficult to route packets if there are holes in network topology or if the nodes are mobile. it used Terminode routing approach that forwads packet to fixed geographic points-anchored paths.

Q.Fang,J.Gao,and L.J.Guibas[3],in this the criteria used is that a packet will be forwaded to one hop neighbor, is closer to destination than current node. here it makes use of local minima concept, which avoids network hot spots, supports path migration, information storage mechanism. it also uses Tent rule:it requires each node to know its1-hop neighbor location, and Boundhole rule: find boundary of hole.

Z.Li,R.Li,Y.Wei and T.Pei[4] carried out survey on various localization methods which includes :Centralised localization method requires base station to gather information,but it resulted in more computational power.In Distributed localization method here each node is independent and it performs limited communication and poor localization.Range free localization method uses the distance between the node to obtain unknown node location,but it results in additional energy consumption.Absolute localization method is based on Global positioning system(GPS),it makes use of sensors induced with GPS receiver,its user friendly.whereas in Relative localization method angle between nodes is found,but this approach results in computational overhead.

Q.Cao and T.Abdelzaher[5],utilized the planarization technique,it has several drawbacks ,here spanner graph for the respective topology had to be built,hence it will result in overhead,and thus latency also increases.

A. Rao, S. Ratnasamy, C. Papadimitriou, S. Shenker, and I. Stoica[6], a scalable coordinate-based routing algorithm was utilized that does not depends on any location information, and hence it can be used in ad hoc and sensor environments.

Ana Maria Popescu, Gabriel Ion Tudorache, Bo Peng, Andrew H. Kemp[7],considered position based routing to be effective,here one of the position based protocol is geographic approach,where packet is forwaded from source to destination in a network without wasting network resourcesor creating havoc in network.this approach find its application in home,industries,environment,commercial,military.

A. Caruso, S. Chessa, S. De, and A. Urpi[8],here they analyzed the problem of constructing a coordinate system meanwhile where no location information is present in a wireless sensor network. hence to meet this they introduced the virtual coordinate assignment protocol (VCap) which defines a virtual coordinate system based on hop distances.Vcap is very simple in use and its requirements are also very less,hence it won’t result in communication overhead

IV. COMPARISON AMONG DIFFERENT METHODOLOGIES

(1). ALBA vs. GeRaF and IRIS

We compare ALBA with two protocols that are exemplary of cross layer routing in dense WSNs, i.e., in networks where dead ends are not likely to occur. The first protocol is GeRaF, one of the first cross layer protocols based on geographic greedy forwarding. The other protocol is IRIS, which performs convergecasting based on a hop count metric and on a local cost function.

ALBA achieves the best performance in terms of all investigated metrics (packet delivery ratio, per packet energy consumption, and end-to-end latency). It scales to increasing traffic much better than the other two protocols because of the effectiveness of the QPI-based selection scheme in balancing the traffic among relays, of its low overhead, and its being able to aggregate packets into burst. It depicts nodes surrounded by "halos" colored depending on the amount of packets they handle. Nodes closer to the sink, as expected, are more congested (darker "halos"). However, traffic is fairly shared by the nodes.Among the three compared protocols, GeRaF shows the worst performance. In GeRaF a node currently handling a packet stops volunteering as a relay. Therefore, as traffic grows, it becomes harder and harder to find relays, resulting in high number of retransmissions and packet loss. Since GeRaF is based only on geographic advancement, the nodes tend to pick less reliable relays.IRIS finds routes that are shorter than those traveled by packets in ALBA. However, it shows worse latency performance since, although longer, ALBA routes are faster because of its QPI-based relay selection method.ALBA is also the most lightweight protocol among the three.A detailed analysis of the relative performance of the protocols, together with a thorough discussion of the impact of the different design choices on performance,is included in the supplemental material document.

(2). ALBA-R on sparse topologies.

Results refer to scenarios with 100 and 200 nodes.Each node has a limited number of neighbors (sparse networks), dead ends occur, and greedy forwarding has been shown to fail often. For example, with 200 nodes, only about half of the nodes are colored C0 and can therefore greedily deliver packets to the sink.This percentage falls to 10% in topologies with 100 nodes.Despite the increased traffic,the amount of energy consumption and overhead is smaller in ALBA-R1 and in ALBA-R∞ than in ALBA-R0.Nodes no longer waste time and energy searching for relays where packets will ultimately get stuck and discarded. It is also interesting to note that the overhead in sparse networks decreases with increasing traffic for any number of colors used.The reason is that the growing traffic causes the average node queue length to increase, which in turns triggers back-to-back packet transmissions more often. Sharing the relay selection overhead among multiple packets ultimately

(3). Comparison with Rotational Sweep.

We have compared Rainbow with a recently proposed mechanism for handling dead ends in WSNs, namely,Rotational Sweep (Ruhrup and Stojmenovic). Both path traversal schemes of Rotational Sweep, i.e., Sweep Curve (SC) and Twisting Triangle (TT), have been implemented in ns2 and run on top of ALBA. We consider sparse topologies (networks with 100 and 200 nodes).Results are displayed for $\lambda = 0.25$. All other parameters are set as listed above.We compare the three schemes with respect to the following metrics: Packet delivery ratio (PDR), end-to-end (E2E) latency, per packet energy consumption and stretch factor. Results, , show that Rainbow is able to successfully deliver all generated packets while Rotational Sweep traversal schemes suffer a packet loss ranging from 2% to 19%. This is essentially due to Rotational Sweep higher congestion, which results from its longer routes and from a less effective data packet aggregation into bursts. When recovering from a dead end, SC and TT select the next hop relay based on the position of the predecessor of the sender from which the packet is received. Packets received by the sender from different predecessors are therefore likely to be forwarded to different relays, making the back-to-back transmissions of ALBA less effective. Rainbow is also able to deliver packets successfully to the sink with much shorter routes than those of Rotational Sweep.The reason is that the stretch factor of Rotational Sweep degrades when the best relays cannot be picked because they are asleep. Rainbow instead selects among relays that are awake based on their color, which ensures a limited route length increase independently of the nodes that are currently awake. The effectiveness of Rainbow in delivering all packets to the sink pays off also in terms of energy consumption per delivered packet. Rainbow energy consumption per packet is 38% lower than that of Rotational Sweep in the most critical case ($n = 100$).The improvement is 5% in networks with 200 nodes.Compared to Rotational Sweep, the packet transmission in burst and the shorter routes produced by Rainbow result in an overall reduction of the per packet energy consumption, well justifying the overhead required by the coloring phase.

V. CONCLUSION

This paper lists out various work carried out to route the packets across connectivity holes. ALBA-R is utilized for efficient routing. There are many advantages and disadvantages associated with different methodologies being used for routing the information, thus a comparison is carried out in order to know the routing mechanisms in more appropriate manner and route the packets effectively.

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