Hybrid Routing Protocol

For wireless sensor networks

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Abstract

Increasing network (WSN) lifetime is a challenge in routing protocol design for ad hoc network, especially in such a network each node (sensor) is powered by batteries, characterized ability calculation and limited storage. Hierarchical routing protocols are best known in regard to energy efficiency. By using a clustering technique hierarchical routing protocols greatly minimize energy consumed in collecting and disseminating data. In this paper we discuss the problem of routing in networks with unidirectional links. We proposed Hybrid routing protocol (HRP) to decrease probability of failure nodes and to prolong the time interval before the death of the first node (stability period) and increasing the lifetime in heterogeneous WSNs, which is crucial for many applications.

HRP (Hybrid routing protocol) is a hierarchical protocol based on GPS (Global positioning system). It is similar to Zone-based Hierarchical Link State.

Keywords: *Network Clustering, routing protocol, HRP, Ad hoc Network, ZHLS, sensor network*

1. Introduction

Routing techniques are the most important issue for networks where resources are limited. WSNs technology's growth in the computation capacity requires these sensor nodes to be increasingly equipped to handle more complex functions.

Computer networks, including networks of wireless sensors, have known a large growth. The latter consists of a set of stand-alone devices, capable to self-organize and communicate with each other the collected information about their environments.

The Mobile environments offer a flexibility of employment. In particular, they allow the networking sites that wiring would be too expensive to implement in full, if not impossible. Several systems are already using the cellular model of wireless networks and experiencing very strong growth at present. It requires a large logistics infrastructure and material sets. The consideration of the cellular networks is mobile ad hoc networks. An ad hoc network is a collection of mobile entities connected by a wireless technology forming a temporary network without the aid of any administration or any fixed support. The ad hoc network applications are numerous. Our work is a part of the study of the problem of routing in mobile ad hoc networks and proposes a protocol that improves network performance and increases its lifespan.

Our simulation result shows an improvement in effective network life time and increased robustness of performance in the presence of energy heterogeneity.

1.1 Routing in Wireless Sensor Network

The routing protocols suggested for wireless sensor network can be classified into two main categories: proactive and reactive.

In proactive routing, every node attempt keep up-to-date topological map of the entire network. When a node needs to forward a packet, the route is readily available; thus, there is no delay in searching for a route. The proactive protocols such as the link state routing (LSR) protocol (open shortest path first) [5] and the distance vector routing protocol (Bellman–Ford) [5] were never designed to work in mobile networks [6]. They do not converge fast enough for the rapidly changing topology. Other distance vector routing protocols such as the destination-sequenced distance vector routing protocol [7] and the wireless routing protocol [8] were proposed to eliminate the counting-to-infinity and looping problems of the distributed Bellman–Ford algorithm. On the other hand, in reactive schemes (e.g., the ad hoc on-demand distance vector routing protocol [9], the temporally ordered routing algorithm [10], and the dynamic source routing protocol [11]), nodes only maintain the routes to active destinations. A route search is needed for every new destination. Therefore, the overhead communication is reduced at the expense of the delay due to route search.

Haas and Pearlman proposed a hybrid reactive/proactive scheme; each node proactively maintains the topological information within its routing zone only.

1.2 Comparison of proactive and reactive

Both proactive and reactive routing has specific advantages and disadvantages that make them suitable for certain types of scenarios. Since proactive routing maintains information that is immediately available, the delay before sending a packet is minimal. On the contrary, reactive protocols must first determine the route, which may result in considerable delay if the information is not available in caches. [1] Moreover, the reactive route search procedure may involve significant control traffic due to global flooding. This, together with the long setup delay, may make pure reactive routing less suitable for real-time traffic.
However, the traffic amount can be reduced by employing route maintenance schemes. [10]

2. RELATED WORKS

2.1 Problematic

A routing protocol is responsible for building and maintaining paths between sources and destinations while optimizing performance network. The ability to compute and store, as well as the instability of the wireless communication medium result in topology changes fast and unpredictable. As a result, traditional routing protocols designed with the assumptions of a fixed topology and a stable medium of communication are no longer adapted to the context of WSNs. Another feature of WSNs to be supported in designing routing protocols is that mobile devices constituting the use of energy sources including self-life is limited. The energy conservation is important in WSNs to prolong the life of the nodes and consequently that of the entire network.

Hierarchical routing is to efficiently maintain the energy consumption of sensor nodes; by involving them in multi-hop communication within a particular cluster; and by performing data aggregation and fusion in order to decrease the number of transmitted messages to the sink. ZHLS can be classed in to a hierarchical routing and as a hybrid reactive/proactive routing protocol. ZHLS reduces the proactive scope to a zone centered on each node.

2.2 ZHLS

The zone-based hierarchical protocol, as its name implies, is based on the concept of zones. A routing zone is defined for each node separately, and the zones of neighboring nodes overlap. The routing zone has a radius ρ expressed in hops. The zone thus includes the nodes, whose distance from the node in question is at most ρ hops. An example routing zone is shown in Figure 1, where the routing zone of S includes the nodes A–I, but not K. In the illustrations, the radius is marked as a circle around the node in question. It should however be noted that the zone is defined in hops, not as a physical distance. [10].

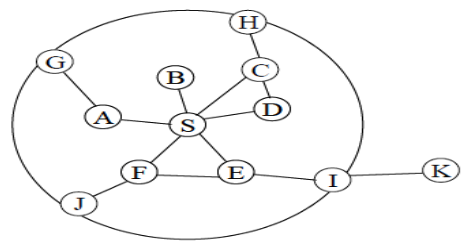
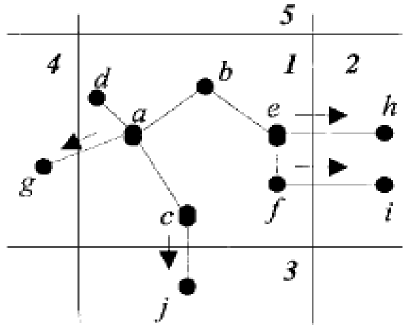


Figure 1: Example routing zone with □=2

In the broadcasting process, the broadcasting node sends a route request packet to each of its peripheral nodes. This type of one-to-many transmission can be implemented as multicast to reduce resource usage. One approach is to let the source compute the multicast tree and attach routing instructions to the packet. Another approach is to reconstruct the tree at each node, whereas the routing instructions can be omitted. This requires that every interior node knows the topology seen by the broadcasting node. Thus, the nodes must maintain an extended routing zone with radius 2r-1 hops. Note that in this case the peripheral nodes, where the request is sent, are still at the distance r. This approach is named Distributed Broadcasting (DB). [2] [3]

The zone radius is an important property for the performance of ZHLS. If a zone radius of one hop is used, routing is purely reactive and broadcasting degenerates into flood searching. If the radius approaches infinity, routing is reactive. The selection of radius is a tradeoff between the routing efficiency of proactive routing and the increasing traffic for maintaining the view of the zone. [4]

Each zone consists of multiple nodes (sensors) that relies on GPS to end localized. ZHLS level in two topologies that are defined as node level and level areas. As mentioned before each node uses GPS to locate and a specific mapping between ID and the ID list box to set Zone ID.



2.3 Energy analysis

In order to predict the energy and quality of different algorithms and protocols, it is important to have accurate models for all aspects of the sensor node. The characteristics are summarized in Table 1. Thus, to transmit a k-bit message, a distance d, the radio expends:

$$ETx(k,d) = ETx\text{-}elec(k) + ETx\text{-}amp(k,d)$$
$$= Eelec*k + eamp*k*d2$$

and to receive this message, the radio expends:

$$ERx(k) = ERx\text{-}elec(k)$$
$$= Eelec*k$$

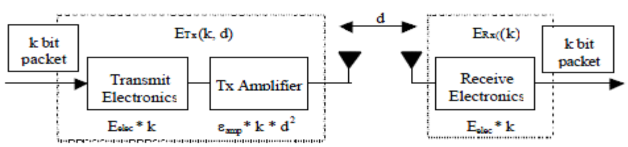


Figure 2. The Radio Energy Dissipation Model

operation	Energy dissipated
transmit or receive circuitry	E_{elec} = 50 nJ/bit
Transmit Amplifier if dmaxtoBS ≥d0	*єmp=0.0013pJ/bit/m4*

Table I. Radio characteristics

3. Hybrid Routing Protocol (HRP)

HRP is a hybrid protocol that separates the network into several zones, which makes a hierarchical protocol [2] as the protocol ZHLS (zone-based hierarchical link state). HRP is based on GPS (Global positioning system), which allows each node to identify its physical position before mapping an area with table to identify it to which it belongs.

The number of messages exchanged in high ZHLS is what influences the occupation of the bandwidth. Our protocol attempts to reduce the number of messages exchanged, thus increasing network performance and service life.

3.1 Operation of the Protocol HRP

HRP is a protocol that is based on the concept of zones; each zone can contain multiple nodes as illustrated in Figure 3. So we can define tree levels:

- Level node.
- Level Getaway.
- Level Cluster Head

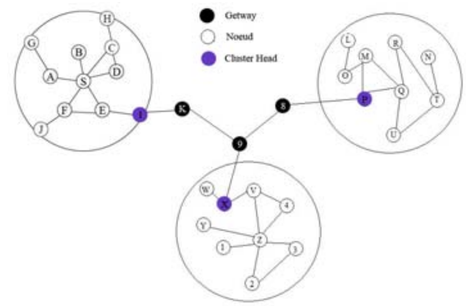


Figure 3. Architecture Hybrid Routing Protocol

Each node deploys a relocation method to find its physical location and determines its zone ID by mapping its physical location to the zone map. Equipped with this zone ID, the node can start the intrazone (level of node) clustering and then the interzone (level of getaway) clustering procedures to build its routing tables.

Each asynchronously broadcasts a link request. Nodes within its communication range in turn reply with link responses node ID, zone ID .After all link responses are received, the node generates its node LSP that contains the node ID of its neighbors of the same zone and the zone ID of its neighbors of different zones.

Nodes may receive link responses from the nodes of their neighboring zones. After LSP receipt, cluster head communicates with the getaway that is sending a scope on the table containing the nodes belonging to the area. Their getaways change the tables received by the cluster head and update their routing table.

For cluster-head and getaways are devices performance at the scope and power.

3.2 Determining the routing zone radius

With the correct zone size, it is possible to reduce the control traffic to a minimum. Each network configuration has an optimal zone radius value. To determine the optimal value, it is necessary to understand how different factors influence on the traffic amount. According to simulations performed in [10], the main factors are the zone radius ρ, network size N, node density δ (average number of neighbors per node) and average node velocity v (affecting route stability). Of these, only the zone radius is a configurable parameter.

Our protocol is proactive and in the same area is reactive between zones, which will influence the number of messages exchanged. The number is important when it is proactive, and it depends on number of nodes and the number of area.

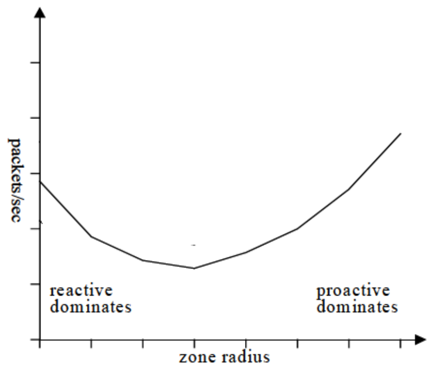


Figure 4: HRP traffic per node (schematic)

3.3 Analysis of results and HRP protocol

In this phase we compare the protocols ZHLS and HRP. The architecture used by HRP is a hierarchical architecture combining both proactive and reactive strategies. ZHLS in the protocol, as already mentioned, if a network contains N nodes, each node generates a message indicating its neighbors, and these entire nodes will retransmit the message. Each box contains (N / M) nodes where the number of messages to internal zones is N^2 / M. In this architecture, each node generates a message with its neighbors, where the number of messages exchanged is:

$$\mathbf{ZHLSmsg = N^2 / M + NM} \quad \mathbf{(1)}$$

In the case of HRP protocol, the network is divided into M zones. Each zone contains M/N nodes which imply that the number of messages exchanged within an area is (N^2 / M). Each manager area (cluster Head) sends a message to the exchange that GATWAY tables between neighboring nodes GATWAYS where the number of messages exchanged is:

$$\mathbf{HRPmsg = N^2 / M + M + G^2} \quad \mathbf{(2)}$$

The table 2 shows the results found and the difference between ZHLS and HRP (Hybrid Routing Protocol).

Nombre de noeud	HRPmsg		ZHLSmsg $N^2/M + NM$
	N^2/M	$N^2/M + M + G^2$	
100	3333	3345	3633
200	13333	13345	13933
500	83333	83345	84833
600	120000	120012	121800

Figure 5: Comparison between our protocol and ZHLS in a network consisting of 3 zones and 3 Getaways

4. SIMULATION

4.1 Simulation settings

We evaluate the performance of our protocol using MATLAB. We simulated HRP and ZHLS using a wireless sensor network.

Performance metrics used in the simulation study is:

- Variation of residual energy for an advanced and normal node per round.
- Active nodes per round

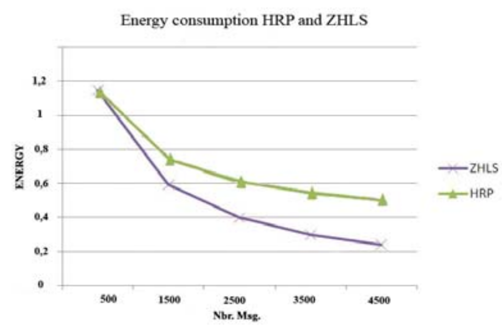


Figure 6: Consumption Energy HRP and ZHLS

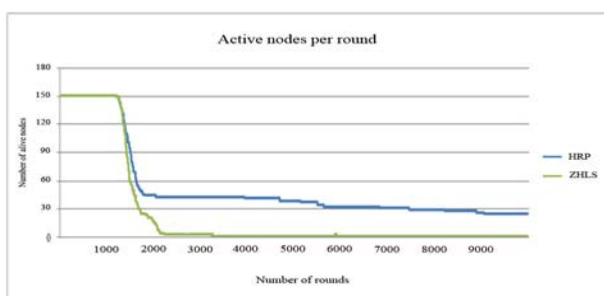


Figure 7: Number of active nodes per round

From our simulations, HRP protocol has the following advantages:

- Reduces energy consumption of the HRP relative ZHLS in heterogeneous settings.
- The Gateways reduces energy consumption and extends the lifetime of the cluster head in network.

5. Conclusion

HRP which is an extension of the ZHLS, This is a hierarchical protocol based on GPS, and it divides the network into zones to reduce the rate of the messages exchanged.
HRP works in rounds, each round is divided into two phases, the Setup phase and the Steady State.
A node that has a packet to send first checks whether the destination is within its local zone. In that case, the packet can be routed proactively. Reactive routing is used if the destination is outside the zone.

The reactive routing process is divided into two phases: the route request phase and the route reply phase. In the route request, the source sends a route request packet to its peripheral nodes, If the receiver of a route request packet knows the destination, it responds by sending a route reply back to the source. Otherwise, it continues the process by border casting the packet, until the arrival of the request to the cluster head, that will send a message to the gateway neighbor, the latter sending response indicating the area where the destination

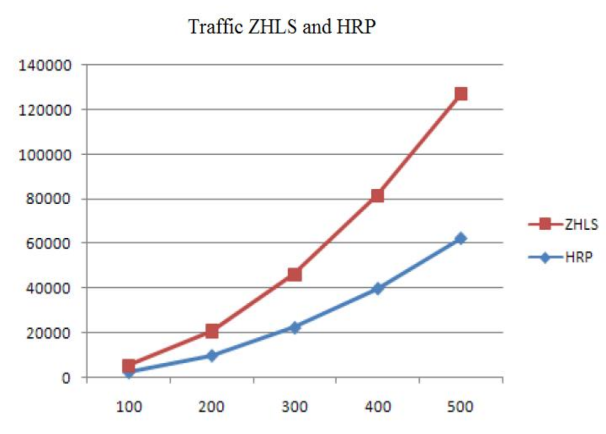


Figure 6: Comparison traffic ZHLS and HRP

HRP reduces network traffic, which will decrease the consumption of bandwidth and increase network performance.

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