EEHRP: Energy Efficient Hybrid Routing Protocol for Wireless Sensor Networks

Deepali S. Anarase
JSPM College, Pune University
India

Prof. N. P. Kulkarni
SKNCOE, Pune University
India

***Abstract*—** Due to wide variety of real time applications Wireless Sensor Network (WSN) is the hottest research field in the world of computer network. Wireless Sensor Network consists of tiny, autonomous sensor nodes deployed in a remote area to detect, collect and process data and transmit it to the user. In such network nodes are able to move and synchronize with the neighbors. Due to mobility of nodes, network changes dynamically and nodes get added and removed. In this paper, we are going to survey different hybrid routing protocols in WSN. Different hybrid routing protocols perform well in different scenario and their performance is compared based on different metrics. Also, we have proposed Energy Efficient Hybrid Routing Protocol (EEHRP) in WSN.

***Keywords*—**WSN, MANET, Routing Algorithms, Cluster formation, Energy-Aware Routing.

I. Introduction

Wireless Sensor Network (WSN) is basically combination of different technologies like wireless communication, information technology and electronics field [1]. The concept of WSN is based on equation Sensing+CPU+Radio = Thousands of real time applications .Sensor nodes in WSNs are small sized and have ability to sense, gather and process data while communicating with other nodes in the network, via radio frequency(RF) channel. The process of determining path between source and destination for data transmission is called as routing. In WSN network layer is mostly used for implementing routing of incoming data and designing routing protocol is one of the challenging task in WSN. Due to node deployment recharging sensor node is normally impracticable. Therefore, energy saving is one of the important design issue in wireless sensor network. Also, data transmission and reception dominates the energy consumption of sensors. Therefore, ultimate objective behind designing the routing protocol should be energy efficient as possible to prolong the network lifetime. Various hybrid routing protocols have been proposed to meet the application requirements of WSNs.

ANHR is one of the hybrid routing protocol which is combination of plane routing protocol with hierarchical routing protocol in WSN [2].This protocol judge the current state of the node and routing selection through the performance of residual energy of the node. There are some drawbacks associated with existing ANHR protocol. It uses RRSI value for selecting cluster head. So, there may be chances that cluster node may run out of energy. So, instead of RRSI value used remaining energy of node so node with highest energy is selected as cluster head. It results into increase in network lifetime. In this paper we have proposed energy efficient hybrid routing protocol (EEHRP) in WSN. The protocol has highest generation efficiency of cluster head which can effectively reduce the network load and energy consumption. Also, it maximizes the network lifetime.

II. Related Work

Routing protocols in WSN have to deal with number of challenges and design issues. WSNs have some restrictions on sensor nodes like limited battery power, bandwidth constraint, limited computation power and limited memory. Single routing protocol in WSN cannot meet all the application requirements. Thus, many routing protocols are proposed in WSN based on application and network architecture. Based on different classification standards, routing protocols are classified into different categories [3]. Routing protocols in WSN can be categorized depending on network structure, protocol operation and path establishment. Figure 1 shows the categorization of routing protocols.

Routing path can be established in one of the three ways namely proactive, reactive or hybrid [4]. In proactive protocol all the routes are computed before they are actually needed and then store these routing in a routing table in each node. As WSN consists of thousands of small sensor nodes, the routing table that each node would have to keep could be huge and therefore proactive protocols are not suitable for WSNs. Reactive protocols computes routes only when they are needed i.e. dynamically. Hybrid routing protocol is combination of both the ideas [5].

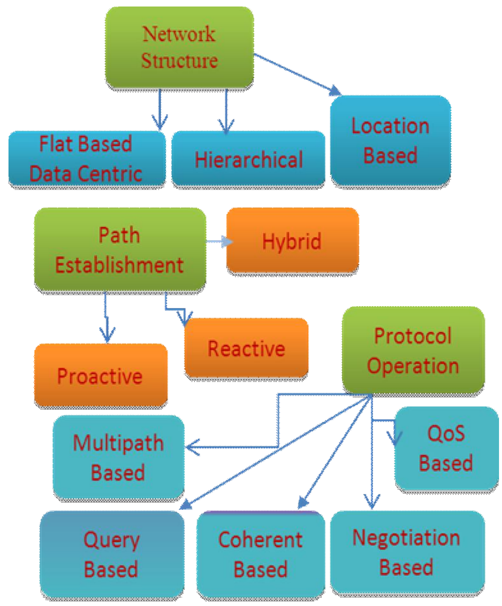

Fig. 1 Categorization for routing protocols in WSN

Routing path can be established in one of the three ways namely proactive, reactive or hybrid [4]. In proactive protocol all the routes are computed before they are actually needed and then store these routing in a routing table in each node. As WSN consists of thousands of small sensor nodes, the routing table that each node would have to keep could be huge and therefore proactive protocols are not suitable for WSNs. Reactive protocols computes routes only when they are needed i.e. dynamically. Hybrid routing protocol is combination of both the ideas [5].

Table I: Routing Protocols for WSNs

Category	Representative protocol
Location Based protocol	MECN, SMECN, GAF, GEAR, TBF, etc.
Data Centric Protocol	SPIN, Direct Diffusion, Rumor Routing, EAD, COUGAR, etc.
Hierarchical Protocol	LEACH, PEGASIS, TEEN, APTEEN, etc.
Mobility Based Protocol	SEED,MULES,TTDD, etc.
Multipath based Protocol	Sensor-Disjoint multipath, Braided Multipath, etc.
Heterogeneity Based	IDSQ, CADR, CHR, etc.
QoS Based Protocol	SAR, SPEED, Energy aware routing
Hybrid Routing Protocol	HRP,HEED, APTEEN, HEER, ANHR, etc.

III. SURVEY OF VARIOUS HYBRID ROUTING PROTOCOL

In this paper we are going to compare various hybrid routing protocols in WSNs. Different hybrid routing protocols perform well in different scenario and good for specific parameter.

A. Adaptive Periodic Threshold Sensitive Energy Efficient Sensor Network Protocol (APTEEN):

APTEEN has been proposed just as an improvement to TEEN in order to overcome its limitations and shortcomings. It mainly focuses on the capturing periodic data collections (LEACH) as well as reacting to time-critical events (TEEN). Thus, APTEEN is a hybrid clustering-based routing protocol that allows the sensor to send their sensed data periodically and react to any sudden change in the value of the sensed attribute by reporting the corresponding values to their CHs [6]. The architecture of APTEEN is same as in TEEN, which uses the concept hierarchical clustering for energy efficient communication between source sensors and the sink. APTEEN guarantees lower energy dissipation and a helps in ensuring a larger number of sensors alive. When the base station forms the clusters, the CHs broadcast the attributes, the hard and soft threshold values, and TDMA transmission schedule to all nodes, and a maximum time interval between two successive reports sent to a sensor, called count time (TC). CHs also perform data aggregation in order to save energy. APTEEN supports three different query types namely:

1) Historical query, to analyze past data values,

2) One-time query, to take a snapshot view of the network; and

3) Persistent queries, to monitor an event for a period of time.

Experiments have demonstrated that APTEENs performance is between LEACH and TEEN in terms of energy dissipation and network lifetime. While in LEACH sensors transmit their sensed data continuously to the sink, in APTEEN sensors transmit their sensed data based on the threshold values.

B. Hybrid Energy-Efficient Distributed Clustering (HEED):

HEED extends the basic scheme of LEACH by using residual energy and node degree or density as a metrics for cluster selection to achieve power balancing [4]. It operates in multi-hop networks, using an adaptive transmission power in the inter-clustering communication. HEED was proposed with four primary goals namely.

1) Prolonging network lifetime by distributing energy consumption,

2) Terminating the clustering process within a constant number of iterations,

3) Minimizing control overhead, and

4) Producing well-distributed CHs and compact clusters.

In HEED, the algorithm periodically selects CHs according to a combination of two clustering parameters. The primary parameter is their residual energy of each sensor node (used in calculating probability of becoming a CH) and the secondary parameter is the intra-cluster communication cost as a function of cluster density or node degree (i.e. number of neighbours). The primary parameter is used to select an initial set of CHs while the secondary parameter is used for breaking ties requires several rounds. Every round is long enough to receive messages from any neighbour within the cluster range. As in LEACH, an initial percentage of CHs in the network (Cprob) is predefined but in HEED the parameter Cprob is only used to limit the initial CH announcements and has no direct impact on the final cluster structure. Hence each sensor node sets the probability CH prob of becoming a CH as CH prob= Cprob * Eresidual / Emax .Where Eresidual is the estimated current residual energy in this sensor node and Emax is the maximum energy corresponding to a fully charged battery, which is typically identical for homogeneous sensor nodes. A CH is either a tentative CH, if its CH prob is<1, or a final CH, if its CH prob has reached. During each round of HEED, every sensor node that never heard from a CH elects itself to become a CH with probability CH prob. The newly selected CHs are added to the current set of CHs. If a sensor node is selected to become a CH, it broadcasts an announcement message as a tentative CH or a final CH. A sensor node hearing the CH list selects the CH with the lowest cost from this set of CHs. Every node then doubles its CH prob and goes to the next step. If a node completes the HEED execution without electing itself to become a CH or joining a cluster, it announces itself as a final CH. A tentative CH node can become a regular node at a later iteration if it hears from lower cost CH. Here, a node can be selected as a CH at consecutive clustering intervals if it has higher residual energy with lower cost. In HEED, the distribution of energy consumption extends the lifetime of all the nodes in the network, thus sustaining stability of the neighbour set. Nodes also automatically update their neighbour sets in multi-hop networks by periodically sending and receiving messages. The HEED clustering improves network lifetime over LEACH clustering because LEACH randomly selects CHs (and hence cluster size)., which may result in faster death of some nodes. The final CHs selected in HEED are well distributed across the network and the communication costs minimized. However, the cluster selection deals with only subset of parameters, which can possibly impose constraints on the system. These methods are suitable for prolonging the network lifetime rather than for the entire needs of WSN.

C. Hybrid Routing Protocol (HRP)

HRP is a hybrid protocol that separates the network into several zones, which makes a hierarchical protocol [7] 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. HRP attempts to reduce the number of messages exchanged, thus increasing network performance and service life.

D. A New Hybrid Routing Protocol (ANHR)

A new hybrid routing in WSNs combines the plane routing protocols with hierarchical routing protocols and determines the current state of last hop node and the current residual energy according to the received signal strength of the node [2]. This protocol judge the suitability of the node and route selecting through the value of remaining energy of node. Every node in the network communicates with other by best effort to transmit data as well as forced to establish adaptive dynamic cluster head. ANHR is compared with CHR- RSTP protocol, HMRP protocol and PHR protocol.

Table II: Survey of Hybrid routing protocols in WSNs

Protocol	Advantages	Disadvantages
APTEEN	1) Guarantees lower energy dissipation, 2) It ensures that a larger number of sensors are alive, 3) Simulation of APTEEN has shown it to outperform LEACH	1) The overhead and complexity of forming clusters in multiple levels, 2)Implementing threshold-based functions and 3) Dealing with attribute -based naming of queries.
HEED	1) Prolonging network lifetime by distributing energy consumption, 2) Terminating the clustering process within a constant number of iterations, 3) Minimizing control overhead, and 4) Producing well-distributed CHs and compact clusters.	1)The cluster selection deals with only subset of parameters
HRP	1) Reduces energy consumption of the HRP relative ZHLS in heterogeneous settings. 2) The Gateways reduces energy consumption and extends the lifetime of the cluster head in network.	1) Only the zone radius is aconfigurable parameter 2) Number of messages exchanged depends on number of nodes and the number of area.
ANHR	1) successful packet delivery rate 2) Network load of ANHR is relatively small. 3) energy consumption of	1) There may be chances that cluster node may run out of energy 2) Efficiency of cluster head declaration may be

	ANHR is minimum	improved by using ant colony optimization (ACO

IV. EEHRP: Energy Efficient Hybrid Routing Protocol in WSN

A. Introduction

Existing ANHR protocol uses RRSI value for selecting cluster head. There may be chances that cluster node may run out of energy. So, instead of RRSI value used remaining energy of node so node with highest energy is selected as cluster head. It results into increased lifetime of network.
Also efficiency of cluster head declaration may be improved by using ant colony optimization (ACO). Following are some assumptions made during designing of proposed system.

i) Every node sends data to sink node so destination for all node is same. This is most common scenario in WSN, nodes collecting some data and sending to control station.
ii) Every node is having initial energy different.
iii) Cluster head selection phase in executed periodically so node with highest remaining energy is selected as cluster head. As a cluster head all communication goes through it, its energy is decreasing rapidly, so periodically we have to change cluster heads.

B. Analytical Model

For multi-hop communication, the calculation of energy consumption model is

$$\varepsilon(n) = c(n) \times h(n) \times e(n) \qquad \text{------------ (1)}$$

Where
c (n) is the number of transmitted bit,
h (n) is the average number of hops for the transmission,
e (n) is the energy consumption to transmit single bit.

Every node sends data only to cluster node (i.e. h (n) =1) so energy consumption by individual node ni is in time t,

$$\varepsilon(ni) = c(ni) \times 1 \times e(ni) \times sri \times t$$

Where
sri is sampling rate of node ni in samples per second
t is time in seconds

Cluster head is responsible for forwarding all data in cluster, energy consumption of cluster head is

$$\varepsilon(ch) = h(ch) \times \sum_{i=0}^{n}(\varepsilon(ni)) \qquad \text{----------- (2)}$$

where
h (ch) is number of hops for transmission from cluster head to sink,
n is number of nodes in cluster

In **existing approach** node is selected as cluster head based on RSSI values, same node (which is closer to many nodes) is selected as cluster head throughout network life time. Energy consumption of cluster node in time t is

$$\varepsilon_t(ch) = t \times h(ch) \times \sum_{i=0}^{n}(\varepsilon(ni)) \qquad \text{--------- (3)}$$

In **our approach** cluster head is selected periodically based on remaining energy of node, every node get chance to be cluster head for some period, i.e. in period t every node is cluster head for time t/n, and (t-t/n) time as normal node .energy consumption by each node in time t is

$$\varepsilon(n_i) = c(n_i) \times 1 \times e(n_i) \times sr_i \times \left(t-\frac{t}{n}\right) + \frac{t}{n} \times h(ch) \times \sum_{i=0}^{n}(\varepsilon(ni)) \qquad \text{----------- (4)}$$

By comparing equation 3 and 4, it is clear that proposed system consumes less energy and energy efficient.

C. Algorithm

Phase 1. Route Formation and cluster head declaration in this phase routes and cluster head is decided.

Table III. Route Formation and cluster head declaration

i) Every node participates in route deciding process. Each node stores cluster head = self, cluster Energy = self-remaining energy initially. Every node sends route request packet with following structure.
RREQ (Seqno, source Address, remaingEnergy, InitailEnergy)
ii) For every RREQ packet received from neighbour sensor nodes repeat step 3
iii)(a) If cluster head = self then
 (1)If RREQ packet received has remaining energy more than current node then it sets cluster head = source address in received packet
 (2)Set cluster energy = remaining energy in received packet
 (b) Compare cluster energy with remaining Energy in received packet
 (1)If remaingEnergy in received packet is more than cluster Energy then
 (2)Sets cluster head = source address in Received packet
 (3)Set cluster energy = remaining energy in received packet
iv) If cluster Head = self then broadcast announcement message Announce (SourceAdress, remaining Energy)

Phase 2. Data Transmission

Table IV. Data Transmission

Actual Data Transmission will take place in this phase. Nodes transmits data packet only to cluster head with Dpacket (SourceAdress, Destination Address, seqno, Cluster Head Address, Data)

Conclusion

One of the major challenges in the design of routing protocols for WSNs is energy efficiency. Therefore, routing protocols designed for WSNs should be as energy efficient as possible to prolong the lifetime of individual sensors, and hence the network lifetime. We have proposed energy efficient new hybrid routing protocol (EEHRP) in WSN. It will enhance the network life time. Our feature work includes validation of proposed protocol using simulation on OMNet++.

REFERENCES

[1] Jennifer Yick, Biswanath Mukherjee, Dipak Ghosal, "Wireless sensor network survey", Computer Networks,Elsevier, vol. 52, pp. 2292-2330, **2008**.

[2] Guangcong Liu, Hua zhang, Fangjie Lei, and Dongli Wei, “A new hybrid routing protocol in WSNs”, Proceeding of 2011 IEEE international conference on cyber technology in Automation, control, and intelligent system, pp.175-180, March**2011**.

[3] YU Yong-Chang, WEI Gang, “Survey on routing protocols for wireless sensor networks”, Application Research of Computers, pp.1616-1621, 1651, **2008**.

[4] P. Kumar, M.P.Singh and U.S.Trair, “A review of routing protocols in wireless sensor network”, IJERT, ISSN: 2278-0181, Vol.1 Issue, June-**2012**.

[5] Bilal Mustafa and Umar Waqas Raja, “Issue of routing in VANET”, School of computing at Blekinge Institute of Technology, **2010**.

[6] A. Manjeshwar and D. P. Agrawal, “*APTEEN: A Hybrid Protocol for Efficient Routing and Comprehensive Information Retrieval in Wireless Sensor Networks*,” Proc. Int‟l. Parallel and Distrib. Proc. Symp., pp. 195–202.

[7] Badr CHAHIDI, Abdallah EZZATI FST, Hassan 1st University, Settat, Morocco,” Hybrid Routing Protocol For wireless sensor networks”, IJCSI International Journal of Computer Science Issues, Vol. 9, Issue 2, No 1, ISSN (Online): 1694-0814, **March 2012**