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Performance Analysis of EEHRP: Energy Efficient Hybrid Routing Protocol in Wireless Sensor Network

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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. Specially, I have concentrated on developing energy efficient routing algorithm in wireless sensor networks which will increase lifetime of network by selecting cluster head using multi attributes like average number of hops in communication, remaining energy of nodes, time to for a cluster, etc. It will supported by simulation of sensor network. We have implemented this proposed work analysis in C++ and Performance of EEHRP protocol is evaluated by simulation using OmNet++.*

Keywords: *WSN, Base Station, Routing Algorithms, Cluster formation, Energy-Aware Routing.*

1. INTRODUCTION

Recent technological advancements in micro electronics and wireless communication technologies have enabled manufacturing of small, low cost, battery operated and multifunctional sensor nodes. These sensor nodes measure ambient condition in the surrounding environment that can be processed to reveal the characteristics of the phenomena occurring at the location where the sensor nodes are deployed. A large number of these sensor nodes are either placed carefully or randomly deployed over a geographical area and networked through wireless links to form a WSN. Each sensor node in WSN is capable of communicating with each other and the base station (BS) for the purpose of data integration and dissemination. WSN are used mainly in military, civilian and for industrial applications. WSNs applications in the military field include battlefield surveillance, intrusion detection, target field and imaging. However, WSN are now being used in many civilian application areas too, including environment and habitat monitoring, health applications, home automation and traffic control [1].

WSN have unique characteristics such as denser level of node deployment, higher unreliability of sensor nodes and severe energy, computation and storage constraints which present many challenges in the development and application of WSN. Research has been made to explore and find solutions for various design architecture and application issues and significant advancement has been made in the development and deployment of WSNs. WSN typically contains hundreds or thousands of sensor nodes which allows for sensing over larger geographical regions with greater accuracy. Usually the sensor nodes are deployed randomly over geographical location and these nodes communicate with each other to form a network. Each node has three basic components as shown in figure 1[2]:

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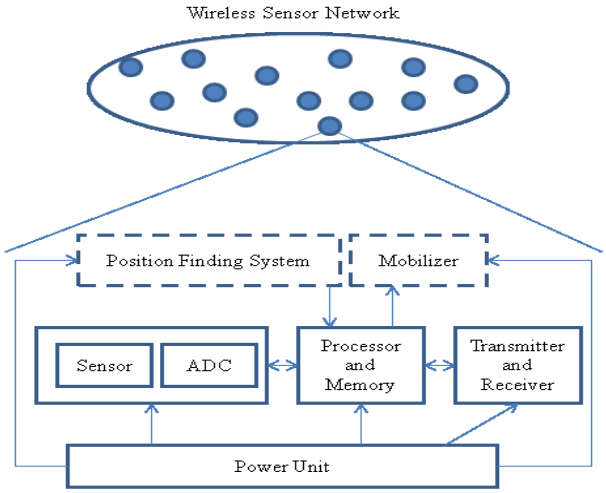

Figure 1. WSN and components of sensor node

1. Sensing unit
2. Processing unit
3. Transmission unit

The node senses the data from the environment processes it and sends it to the base station. These nodes can either route the data to the base station (BS) or to other sensor nodes such that the data eventually reaches the base station. In most applications, sensor nodes suffer from limited energy supply and communication bandwidth. These nodes are powered by irreplaceable batteries and hence network lifetime depends on the battery consumption. Innovative techniques are developed to efficiently use the limited energy and bandwidth resource to maximize the lifetime of the network. These techniques work by careful design and management at all layers of the networking protocol. For example, at the network layer, it is highly desirable to find methods for energy efficient route discovery and relaying of data from the sensor nodes to the base station.

Routing methods in WSNs have to deal with a number of challenges and design issues. Despite advancement in technology, sensor nodes in WSNs still have restrictions such as limited battery power, bandwidth constraint, limited computing power and limited memory. It creates the need for routing protocols to be highly adaptive and resource aware. Some of the challenges of routing protocols are:

1. Node deployment in either random or pre-determined manner.
2. Data reporting method which can be a time-driven, event-driven, query-driven or a hybrid of all of these methods.
3. Trade-off between energy consumption and accuracy of data gathered.
4. Node failure tolerance of the network.
5. Scalability, where routing method should be able to work with large networks.
6. Routing method should be adaptive for mobile sensor nodes.
7. Should support data aggregation to reduce redundant data.

2. 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. 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.

3. HYBRID ROUTING PROTOCOLS IN WSN

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.

3.1. 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,

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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.

3.2. 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 [9].
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.

3.3. 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.

Table 1: Survey of Hybrid routing protocols in WSNs

Protocol, Journal and Pub. Year	Advantages	Disadvantages
APTEEN (6) (IJERT, ISSN: 2278-0181, Vol.1 , **June-2012)**	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 (9) *(IOSRJCE, ISSN: 2278-0661, ISBN: 2278-8727 Volume 7, Issue 3 ,* ***Nov. - Dec. 2012)***	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 (7) (IJCSI , Vol.9, Issue 2, No 1, ISSN (Online): 1694-0814, **March 2012)**	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 a configurable parameter 2) Number of messages exchanged depends on number of nodes and the number of area.

4. EXISTING ANHR PROTOCOL

A New Hybrid Routing Protocol (ANHR) 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 [5]. 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 [10]. ANHR is compared with CHR- RSTP protocol, HMRP protocol and PHR protocol [11].

This protocol has a high production rate of the cluster head and reliable packet delivery rate, and it can effectively reduce the network loads and network energy consumption. In this protocol, two-way query mechanism based on destination

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node query and source node detection and the way of distributed data processing is adopted [12].

Table 2: Advantages and disadvantages of ANHR Protocol in WSNs

Protocol, Journal and Pub. Year	Advantages	Disadvantages
ANHR (12) (IEEE conference **March 20-23, 2011)**	1) successful packet delivery rate 2) Network load of ANHR is relatively small.	1) There may be chances that cluster node may run out of energy 2)Energy consumption of ANHR is maximum

5. PROPOSED EEHRP: (ENERGY EFFICIENT HYBRID ROUTING PROTOCOL IN WSN)

5.1. 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.

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. Every node is having initial energy different. Cluster head selection phase in executed periodically so node with highest remaining energy is selected as cluster head [8]. As a cluster head all communication goes through it, its energy is decreasing rapidly, so periodically we have to change cluster heads [13].

Table 3: Advantages and disadvantages of Proposed EEHRP Protocol in WSN

Protocol, Journal and Pub. Year	Advantages	Disadvantages
EEHRP(13) IJETT, Volume4, Issue3-2013, ISSN:2231-5381)	1)Energy Consumption of EEHRP is maximum as compare to ANHR protocol	1)Energy consumption of sink node is high

5.2. Analytical Model

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

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

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. (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

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

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

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

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

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

By comparing equation 3 and 4, it is clear that proposed system consumes less energy and energy efficient.
Because **existing system** 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 in **the proposed system** used remaining energy of node so node with highest energy is selected as cluster head. It results into increase in network lifetime.

5.3. Algorithm

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

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Table 4. 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 remaing Energy 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 5. 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)

6. SIMULATION SETUP AND RESULT ANALYSIS

In the setup of OmNet++ simulation, 20 sensor nodes are deployed randomly in the area of 200mX200m. Figure 2. Shows that energy consumption of EEHRP is minimum as compared to ANHR protocol. Instead of RRSI value in **our proposed system** we are using remaining energy of node so node with highest energy is selected as cluster head. It results into increase in network lifetime. Figure 3.shows the average packet loss by number of nodes in the simulation environment. Figure 4.shows the packet delivery fraction in the simulation environment. Figure 5. Gives the comparative result for throughput in the simulation environment.

Table 6. Simulation Parameters

Parameter	Value
Simulation time	1000 Sec
Simulation area	200 * 200 meter
Number of Nodes	20
Communication Range	Default 50 meter
Communication Model	Radio

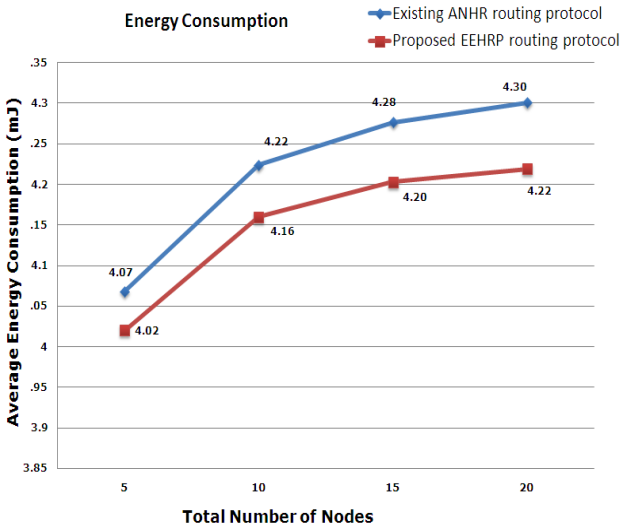

Figure 2. Energy Consumption

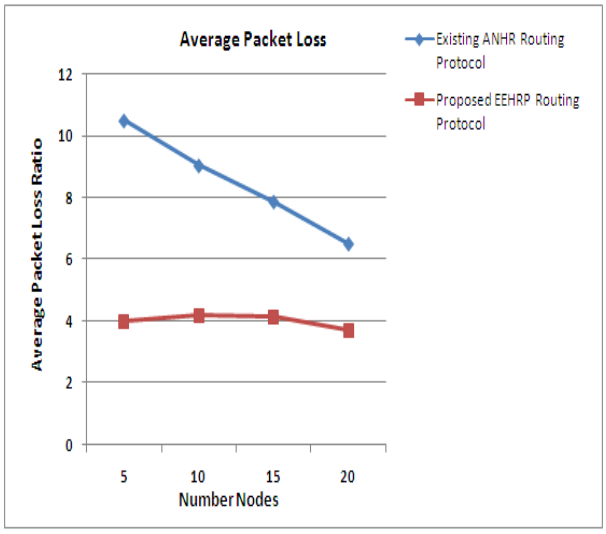

Figure 3. Average Packet Loss

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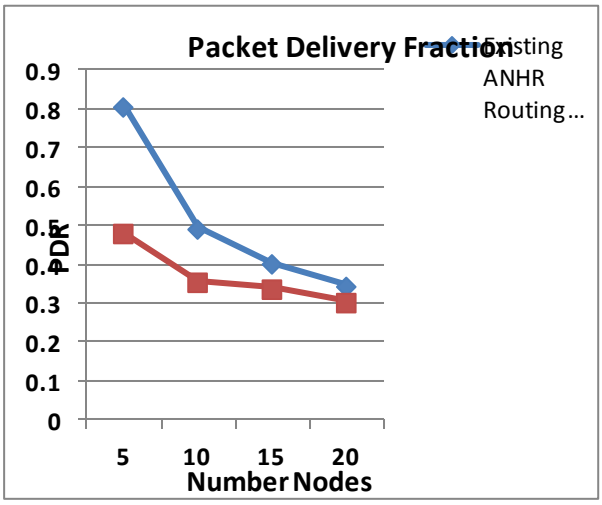

Figure 4. Packet delivery fraction

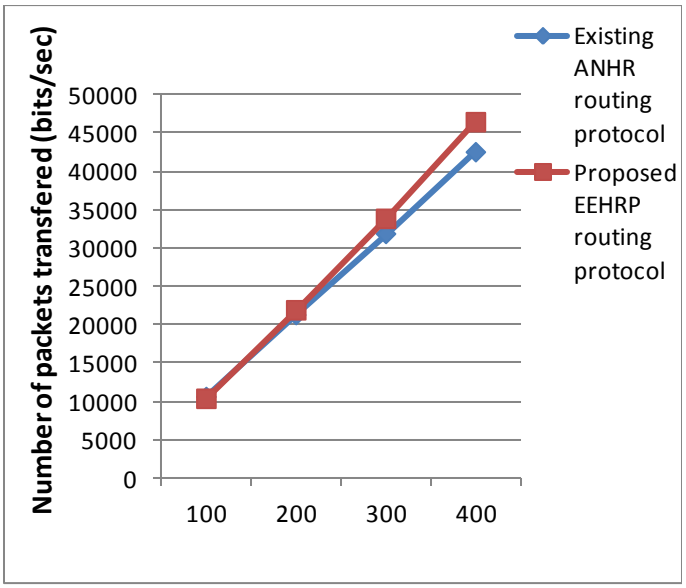

Figure 5.Throughput

7. 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 hybrid routing protocol (EEHRP) in WSN. It will enhance the network life time. Validation of proposed protocol is performed by simulation using OmNet++.

In future work, we are planning to extend the analysis of our algorithm by using dynamic nodes in a real WSN environment. We also wish to focus on tree formation of the nodes. Also, Efficiency of cluster head declaration may be improved by using ant colony optimization (ACO).

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