A Survey on Energy Efficient Routing Protocols for Wireless Sensor Networks & Comparative Analysis with USEP

Surendra Verma [#1], Dr. K C Mahajan [*2]

[#1]*Research Scholar, Electronics and Communication Department, Mewar University Chittorgargh , Rajasthan, India*

[#2] *Professor, Electronics and Communication Department, Technocrat Institute of Technology Bhopal, Madhya Pradesh, India*

Abstract:

In case of routing protocols the wireless sensor network requirements are very specific, and it is the outcome of distributed nature and dynamic topology. For efficient WSN energy consumption and life time are on highest priority .There are many energy efficient algorithm which have been proposed in recent past. We may classify these algorithm on the basis of Reliable Routing, Network topology, Communication model and Network structure. Here we are presenting a compact analysis of energy efficiency issues of WSN algorithms with USEP as a special case.

Keywords— *Routing protocols; Energy Efficiency; Wireless Sensor Networks; Threshold, Topology*

I. INTRODUCTION

The first WSN was designed and developed in early 80s by defence industries .It was extensively used in Vietnam War and at several places. It was highly energy consuming and less efficient in transmission. Since then lot of work has been done in the field, and in recent time technical efficiency and performance has improved a lot.. In [] authors have presented ultra-stable energy efficient algorithm USEP which is based on five level of energy threshold calculation. Which is so far one of the most capable method as far as performance is concerned.

This paper is organized as follows: In section 2, the related work in routing protocols history is presented. In section 3, energy consumption and route selection policies are presented. In section four USEP criteria and comparison with other algorithm is given. In last with future scope we conclude the paper.

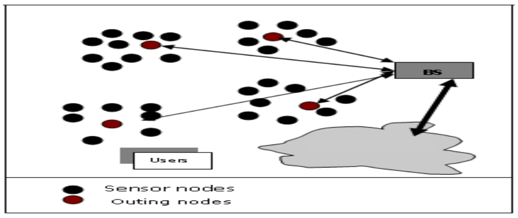

Fig. 1 WSN Deployment

II. WSN DESIGN FACTORS AND ROUTING

A. Error Tolerance

The failed sensor nodes due to power lacking or or physical damage or environmental impact is a big issue. The failure of single node should not affect the overall performance of sensor network.

B. Accurate Node Deployment

Node deployment depends upon application, and this can a good criteria for classification for different algorithm. The manual deployment process is simple but most of the time lack in performance. The data routing is done via predetermined paths. There are various ways to accomplish same path via software controlling.

C. Scalability & Life Time

The number of sensor nodes deployed in the sensing area may be on the order of hundreds or thousands, or more. Any routing scheme must be able to work with huge number of sensor nodes

D. Energy Consumption & Sustainability

Sensor nodes can use up their limited supply of energy performing computations and transmitting information in a wireless environment. Sensor node lifetime shows a strong dependence on battery.

III. WSN ROUTING PROTOCOLS

All On the basis of above mentioned criteria's WSN have been classified in various formats for their respective routing technology or methods .e.g. flat-based routing, hierarchical-based routing, and location-based routing depending on the network architecture. In flat-based routing, all nodes are assigned same work or functionality. In hierarchical-based routing, however, nodes will perform different duties, where as In location-based routing, sensor nodes' positions are exploited.

If node parameters can be upgraded as per the routing conditions and energy level then it is called adaptive routing protocol. Furthermore, these protocols can be classified into multipart-based, query-based, negotiation-based, Qos-based, or routing techniques depending on the protocol operation. In addition routing protocols can be classified into three categories, namely, proactive, reactive, and hybrid protocols depending on how the source sends a route to the destination. All routes are computed before they are really needed in case of proactive routing, while in reactive protocols, routes are computed on demand. Hybrid protocols use a combination of these two ideas. When sensor nodes are static, it is preferable to have table driven routing protocols [4].

IV. LITERATURE REVIEW

All In [3] survey on WSN is presented, It classifies the routing techniques based on network structure: flat, hierarchical and location based routing protocols. The [4] discusses few routing protocol for sensor networks and classifies them into data-centric, hierarchical and location based. In [5] authors provide a symmetrical investigation of current state of the art algorithms. Paper [6] presents a top down approach of several application and reviews on various aspects of SN.

[9] Discusses the design challenges in energy efficient medium access control protocols. It describes the 10 plus MAC but did not provide details of algorithms. This paper does not explain the energy efficient routing protocols developed on WSN Our survey is focused on the energy efficient routing protocols in WSNs where we discuss the strength and weakness of various algorithm and it is comparison with Ultra Stable Election Protocol. [1] The USEP has outperformed many other algorithm in specific conditions like under high throughput and longer life span of communication cycle.

A. LEACH (Low Energy Adaptive Clustering Hierarchy)

A proposed protocol [4] is an adaptive clustering protocol for distributing energy load among the sensor nodes in network. LEACH uses single-hop routing in which each sensor node transmits information directly to the cluster head or the sink.

B. PEGASIS (Power Efficient Gathering in Sensor Information Systems),

A greedy chain protocol [5] which resolves the data-gathering problem of the wireless sensor networks. The main thing is for each node to receive from and transmit to close neighbors and take turns being the leader for transmission to the base station. This approach will distribute the energy load evenly among the sensor nodes in the network. Initially the nodes are placed randomly in the field, and the sensor nodes are arranged to form a chain, which can either be accomplished by the sensor nodes themselves using a greedy algorithm starting from some node.

C. PEACH (Power-Efficient and Adaptive Clustering Hierarchy)

A protocol, [6] which is a power-efficient and adaptive clustering hierarchy protocol for wireless sensor networks. In wireless sensor networks, by overhearing a node can recognize the source and the destination of packets transmitted by the neighbor nodes. Based on the overheard information, PEACH forms the clusters without additional packet transmission overhead such as advertisement, announcement, joining, and scheduling messages.

D. TEEN (Threshold Sensitive Energy Efficient Sensor Network Protocol)

This is the first protocol developed for reactive networks. In this protocol [7] at every cluster change time, the cluster-head broadcasts to its members. Thus, the hard threshold tries to reduce the number of transmissions by allowing the nodes to transmit only when the sensed attribute is in the range of interest. The soft threshold further reduces the number of transmissions by eliminating all the transmissions which might have otherwise occurred when there is little or no change in the sensed attribute once the hard threshold.

E. EEABR (Energy Efficient Ant-Based Routing)

Proposed protocol [8] which is based on the Ant Colony Optimization heuristic. Initially the forward ants are sent to no specific destination node, which means that sensor nodes must communicate with each other and the routing tables of each node must contain the identification of all the sensor nodes in the neighborhood and the correspondent levels of pheromone trail.

F. SOP (Self-organizing protocol)

Proposed protocol [9] which includes cluster architecture of LEACH with multi-hop routing to decrease transmission energy. In many WSN multi-hop routing is adopted. This makes a node that wants to transmit data to a destination node find one or multiple intermediate nodes. The communication occurs among all the nodes until the data packets reach the destination [10]. In brief, the data packets take several hops among the nodes in the network. The main advantage of this approach is that transmission energy consumption is reduced. But at the same time latency of the network and delay of data packets will increase. In some cases, no rigid requirements on latency, the multi-hop routing can lead to high energy efficiency. In this protocol when clusters are organized, the cluster heads form a multi-hop routing backbone. Every cluster member node sends data to the cluster head directly for the communication [12]

V. COMPARATIVE ANALYSIS OF USEP WITH REST

USEP: Ultra Stable Threshold Sensitive Election Protocol for WSNs

In [1] USEP is a novel algorithm designed and tested by authors. It has been proved that this algorithm act well than many other algorithm in certain conditions. In USEP, there is multilevel heterogeneity, nodes with different energy levels are classified as Normal Nodes, Sub Normal Nodes, Intermediate Nodes, Advance Nodes, and Super Nodes

The respective probabilities are given as per

$$P_{nnrm} = \left\{\frac{p_{opt}}{[1+m\alpha+b\mu]}\right\} \quad (1)$$

$$P_{subnrm} = \left\{\frac{p_{opt}\,(1+\mu)}{[1+m\alpha+b\mu]}\right\} \quad (2)$$

$$P_{int} = \left\{\frac{p_{opt}(1+2\mu)}{[1+m\alpha+b\mu]}\right\} \quad (3)$$

$$P_{adv} = \left\{\frac{p_{opt}(1+\alpha)}{[1+m\alpha+b\mu]}\right\} \quad (4)$$

$$P_{super} = \left\{\frac{p_{opt}(1+2\alpha)}{[1+m\alpha+b\mu]}\right\} \quad (5)$$

For all these categories we have separate formulas for the calculation of threshold depending on their probabilities, which are given below:

$$T_{nrm} = \left\{\frac{p_{nrm}}{[1-Prnm[r.mod\,\frac{1}{p_{nrm}}]]}\right\} \quad (6)$$

$$T_{int} = \left\{\frac{p_{int}}{[1-Pint[r.mod\,\frac{1}{p_{int}}]]}\right\} \quad (7)$$

$$T_{adv} = \left\{\frac{p_{adv}}{[1-Padv[r.mod\,\frac{1}{p_{adv}}]]}\right\} \quad (8)$$

$$T_{sup} = \left\{\frac{p_{sup}}{[1-Psup[r.mod\,\frac{1}{p_{sup}}]]}\right\} \quad (9)$$

$$T_{subn} = \left\{\frac{p_{subn}}{[1-Psubn[r.mod\,\frac{1}{p_{subn}}]]}\right\} \quad (10)$$

Average total number of CHs per round will be:

$$n(1-m-b)p_{nrm} + n.b.p_{int} + n.m.p_{adj} + n(1+m+b) = n.p_{opt}$$

The detail parameter based comparison is given here in tabular format.

Protocols	Mobility	Power management	Network lifetime	Scalability
USEP	Conditional BS	Maximum	Very Good	Good
LEACH	Fixed BS	Maximum	Very good	Good
TEEN	Fixed BS	Maximum	Very good	Good
APTEEN	Fixed BS	Maximum	Very good	Good
PEGASIS	Fixed BS	Maximum	Very good	Good
SPIN	Supported	Limited	Good	Limited
DD	Limited	Limited	Good	Limited

Table 1 Comparative Analysis

Protocols	Resource awareness	Classification	Data aggregation	Query based
USEP	Yes	Hybrid Clustering	Yes	No
LEACH	Yes	Clustering	No	No
TEEN	Yes	Reactive/	Yes	No
APTEEN	Yes	Hybrid	Yes	No
PEGASIS	Yes	Reactive/	Yes	No
SPIN	Yes	Proactive/	Yes	Yes
DD	Yes	Proactive	Yes	Yes
RR	Yes	Hybrid	Yes	Yes
GEAR	Yes	Location	No	No

Table 2 Comparative Analysis

The life time and energy efficiency is visible in these graphs given below

S. No.	Network Parameters	Value
1.	Network Size	100×100
2.	Initial Energy of Node	0.5 J
3.	Packet Size	4000 bits
4.	E_{elec}	5 nJ/bit
5.	Amplification Energy LEACH	E_{fs1} = 10 pJ/bit/m^2
6.	Amplification Energy in MODLEACH (Cluster to BS) for d<d_0	E_{mp1} = 0.0013 pJ/bit/m^2

Table 3: Experimental Data used

The experimental criteria's are

1) Network lifetime: It is the time interval from the start of the network operation till the last node die.

2) Throughput: To evaluate the performance of throughput, the numbers of packets received by BS are compared with the number of packets sent by the nodes in each round

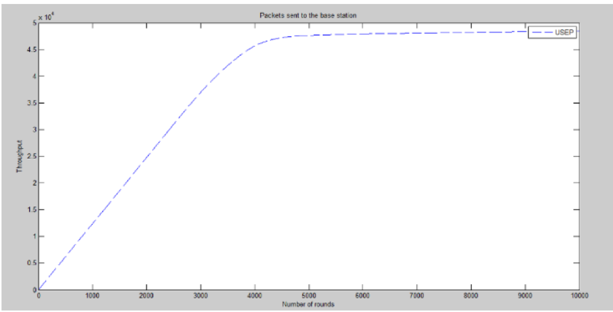

Fig. 2 : Throughput vs Iterations

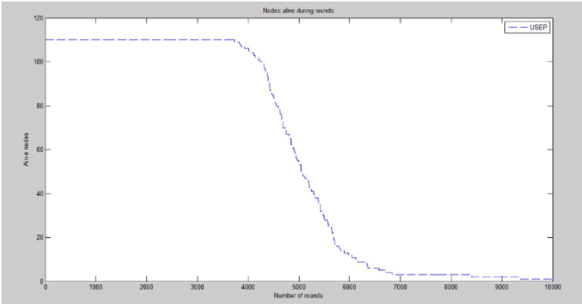

Fig.3 Throughput Vs Iterations

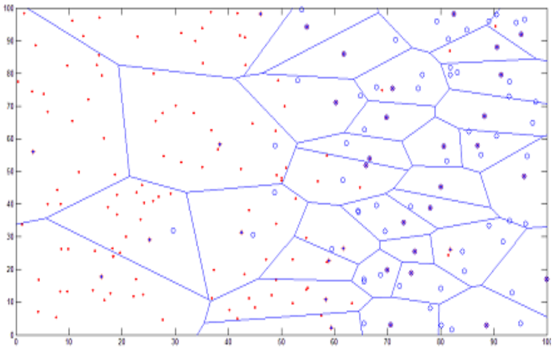

FIG.4 EAMMH Allocation of Nodes

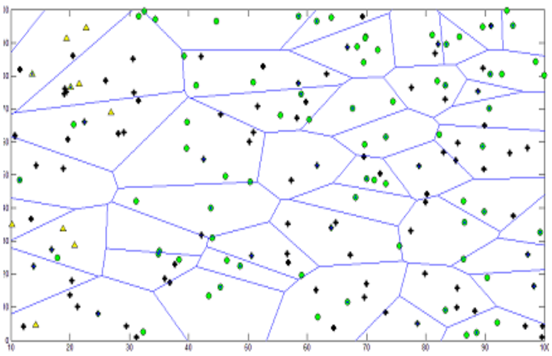

Fig. 5 LEACH Allocation of Nodes

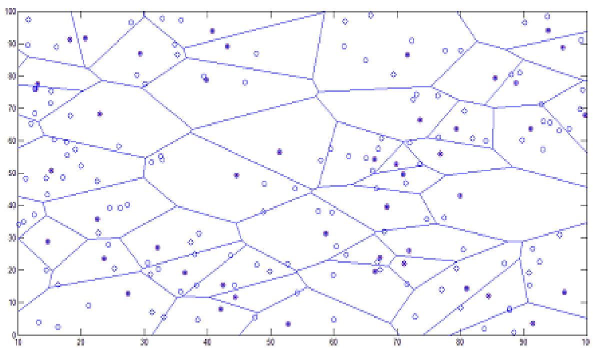

Fig. 6 TEEN Allocation of Nodes

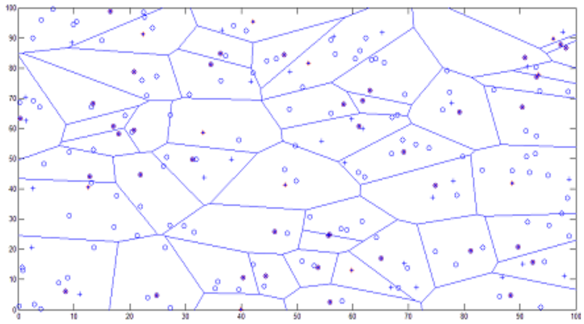

Fig.7 USEP Allocation of Nodes

VI. CONCLUSION

We have analysed and compared the performances of multiple routing protocols like TEEN, LEACH and EMMAH with USEP on the basis of network lifetime and throughput. Although, the performance of TEEN is improved as compared to LEACH but not in comparison to USEP. According to the analysis based on MATLAB simulation we clearly see that energy threshold and intelligent routing makes USEP a better approach for mobile routing selection. Hence we conclude that at the expense of the gateway node one can easily achieve higher performance of the network with USEP. So we propose real time implementation of USEP algorithm.

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