HYBRID MULTI-HOP ENERGY EFFICIENT ROUTING MECHANISM IN WSN

Ms. Surbhi Jindal*

ABSTRACT

Advances in technology recently have enabled the mass production of small sized battery powered sensor nodes. WSNs send information to a central location called base station over wireless interface where data is analyzed and presented to useful applications. The objective of our research work is to extend the WSNs lifetime using a better routing algorithm. Energy efficient routing in WSNs is a challenging task due to the inherent limitations in WSN. The key challenge in WSN is to maximize the lifetime of network using energy aware routing techniques as it is not feasible to replace the batteries of hundreds or thousands of sensor nodes after deployment. A routing protocol is said to be energy efficient if it ensures both less energy consumption over time and balanced energy consumption among sensor nodes. In general using single hop communication between the sensor nodes is not the optimum choice. It is beneficial to use multi-hop communication among the sensors. By using multihop routing each node is able to request another connected node to transfer data to the base station and energy consumption is minimized. In cluster based multihop routing protocols in WSN, problems related to energy imbalance appear. Sensor nodes which are close to base station transmit a larger amount of data than the nodes further away from base station. In particular we are interested in isolation of nodes nearby base station from other nodes so that energy consumption can be balanced. In this paper we have presented an improved hybrid routing over the network so that network communication and lifetime will be improved by dealing with hot spot problem.

Keywords: Wireless Sensor Networks (WSN), cluster, multihop, hotspot, hybrid.

* Mtech Scholar, Department of Computer Science & Engineering, Deenbandhu chhotu Ram University of Science & Technology, Murthal 131039, India

1. Introduction

A wireless sensor network (WSN) consists of hundreds or thousands of sensor nodes [1]. The Sensor nodes are tightly constrained in terms of battery power, processing capacity and storage [2]. Due to self organization capability and wireless nature, WSNs are used in Area monitoring, Environmental/Earth monitoring, Air quality monitoring, Air pollution monitoring, Industrial monitoring, Data logging, Agriculture, Greenhouse monitoring, disaster management and military applications. The base station in WSN consists of more computational power, energy and communication resources. It acts as an intermediary between sensor nodes and the end user.

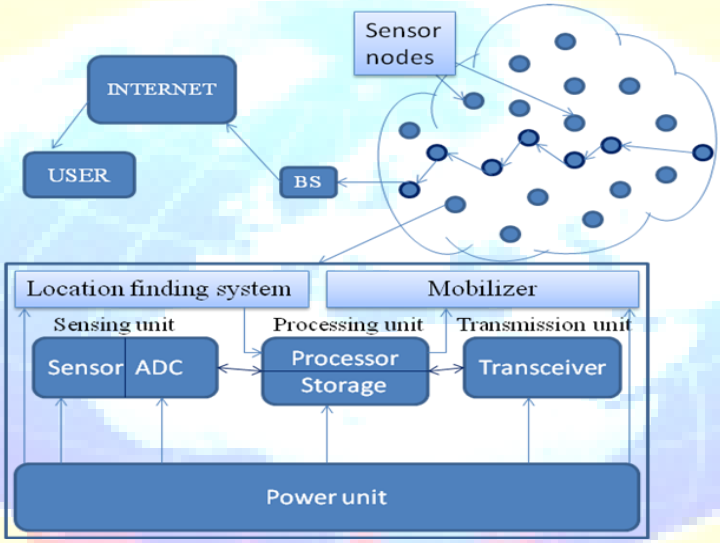

Fig 1: A typical WSN architecture

The routing protocols in WSN are classified into three categories which are based on the underlying network structure. These are: flat [3], hierarchical [4], and location-based routing [4]. In flat routing all nodes play the same role and there is absolutely no hierarchy. In hierarchical routing protocols nodes are arranged into clusters to conserve energy. In location based routing protocols, sensor networks require location information for sensor nodes to communicate. Based on protocol operation, routing techniques in WSN are classified into Multipath-based routing, Query-based routing, Negotiation-based routing, QoS-based routing and Coherent-based routing. Due to large number of sensor nodes, it is not feasible to build a global addressing scheme for the deployment of large number of sensor nodes [2]. Furthermore, sensor nodes need to be self organizing as they are deployed hostile region. Also all applications in WSN require sending of

sensed data from multiple sources to a single location, base station and sensed data has significant redundancy in it as multiple sensor nodes in nearby region may generate same data [5]. The key challenge in WSN is to maximize the lifetime of network using energy aware routing techniques as it is not feasible to replace the batteries of hundreds or thousands of sensor nodes after deployment.

2. Related Work

Routing protocols for WSN should try to minimize energy consumption in order to improve network lifetime. Traditional (or flat) routing protocols for WSN may not be optimal in terms of energy consumption [6]. Recent advances in WSN have led to many new routing protocols specifically designed for WSN. To prolong the lifetime of the WSN, designing efficient routing protocols is critical.

Among many routing protocols that have been developed for WSN, cluster based routing protocols claims more energy efficiency [5]. Cluster based routing protocols perform data aggregation to reduce data transferred to base station. In cluster based protocols nodes are grouped into clusters and one node in cluster, called cluster head, sends all gathered data to the base station. Cluster head nodes have the responsibility for collection, aggregation and transmission of data to the base station, therefore they consume more energy than other cluster member nodes. The most attractive research issue regarding cluster based is how to form clusters so that energy consumption is minimized. Even though sensor networks are primarily designed for monitoring and reporting events, since they are application dependent, a single routing protocol cannot be efficient for sensor networks across all applications. Multihop routing, clustering and data aggregation are important techniques in minimizing the energy consumption in sensor networks [7, 8, 9].

The LEACH (Low Energy Adaptive Clustering Hierarchy) is a self-healing and adaptive clustering protocol that uses randomization to distribute the energy load evenly among the sensor nodes [10]. LEACH takes a time based approach to elect cluster head. There is a possibility to elect low energy node as cluster head. Also LEACH is single hop routing protocol that means all cluster heads communicate directly with base station.

In general using single hop communication between the sensor nodes is not the optimum choice. It is beneficial to use multi-hop communication among the sensors. By using multihop routing

each node is able to request another connected node to transfer data to the base station and energy consumption is minimized. In cluster based multihop routing protocols in WSN, problems related to energy imbalance appear. Sensor nodes which are close to base station transmit a larger amount of data than the nodes further away from base station. They exhaust their energy in much more rapid manner and die quickly. In particular we are interested in isolation of the base station caused by the depletion of the energy of sensor nodes surrounding base station [11]. This problem is termed as hot spot problem.

Most of the routing protocols fail to resolve hot spot problem, which is the isolation of the base station nearby nodes with rest of nodes in network. However by using a hybrid approach that combines two routing strategies flat multihop routing and hierarchical multihop routing, hot spot problem can be minimized [11].

3. Hybrid Multihop Routing Protocol

The amount of data generated by nodes inside hot spot area is negligible as compared to volume of data flowing into hotspot area from outside the hotspot area. That means in order to decrease the power consumption in hot spot area, the amount of data flowing into the hot spot area needs to be reduced. Hybrid multihop routing protocol achieves solution by using hierarchical multihop routing algorithm which uses data compression technique to reduce the amount of data that enters the hot spot area. Also the nodes inside the hot spot area do power aware routing using flat multihop routing algorithm to minimize total power consumption by reducing transmission distance.

In hierarchical multihop routing protocols, as number of relay nodes, i.e. hops used to convey data to the base station is relatively less than that in flat multihop routing protocols, the length of the communication distance of each hop becomes greater than that in flat multihop routing protocols, and therefore requiring higher power to transmit a unit of data [11].

3.1 Proposed Work

The presented work is about to define a network model with improved hybrid routing over the network so that the network communication and lifetime will be improved. In this work we have divided the network in two main areas called hot spot area and non-hotspot area. The hotspot area nodes can perform direct communication with base station without using any cluster head.

For this a flat multihop routing is defined in this work. The nodes outside the hot spot area will communicate by creating clusters and will use hot spot area nodes as relay nodes to forward their data to the base station. The clustered communication is again defined under the multihop routing. The proposed scheme is shown in Figure 2.

3.2 Routing Outside Hot Spot Area

Since transmission power used to transmit data is proportional to volume of data, it is required to reduce the volume of data that enters into the hot spot area. This can be achieved by using data compression mechanism. If there is any relationship among collected data then it can be compressed. The compression ratio is dependent on correlation of data i.e. higher the correlation of data, more effective will be the data compression. Since sensor nodes are densely deployed therefore there is high probability that multiple sensor nodes produce same data within the vicinity of phenomenon. Our proposed work employs a hierarchical multihop routing algorithm outside the hot spot area to perform effective data compression. The nodes outside the hot spot area will communicate by creating clusters and will use hot spot area nodes as relay nodes to forward their data to the base station. The clustered communication is again defined under the multihop routing.

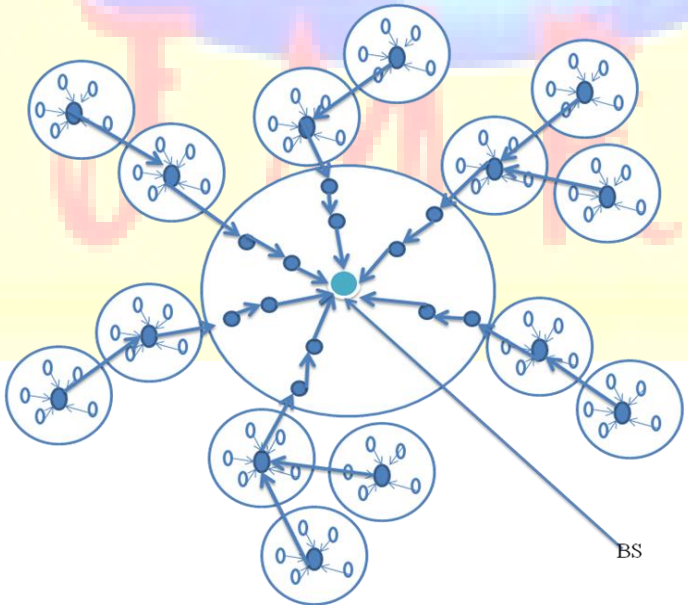

Fig 2: Hybrid multihop routing scheme

3.3 Routing Inside Hot Spot Area

In hot spot area most important aspect of a routing algorithm is to minimize the power consumption per unit of transmission while transferring data that enters into hot spot area from outside the hot spot area. This objective can be achieved by using a flat multihop routing algorithm inside the hot spot area. The flat multihop routing employs power aware routing to reduce the power consumption per unit of transmission.

3.4. Simulation Scenario

A long term data gathering is elementary task in WSN as sensor nodes in WSN are equipped with limited resources. In the given scenario the packets are multi hoped through the network to the BS that is power supplied. Once the path from all nodes to the BS is known, the number of packets per each node processed during the data gathering can be estimated. Simulation ends when there is no path to the base station, meaning that all neighbors of base station are out of energy.

3.5. Simulation Parameters

Table 1. Simulation parameters

Sr. No.	Parameters	Values
1	Area defined	100x100
2	Number of Nodes	100
3	Base station location	(0.5*area,0.5*area)
4	Hot spot range	20 m
5	Cluster Head sensing range	30 m

3.6. Assumptions

The simulation of our thesis is performed using MATLAB (R2009a). All sensor nodes are assumed to be stationary. Sensor nodes are randomly deployed. A total number of 100 nodes are taken for simulation. This number can be varied. Base station is located at (50, 50). Sensor nodes are deployed randomly. Initial power per station is 0.5 KJ. In our proposed work we have taken three parameters called energy, distance and load while performing the communication. The network architecture has limited specification in terms of maximum number of clusters in network. Number of clusters cannot exceed 10% of nodes. Also clusters are defined with specification in terms of number of nodes a CH can cover. This specification helps in load balancing. Energy threshold is defined to be 0.1. A node having energy less than energy threshold is assumed to be dead. Probability to become cluster head is assumed to be 0.2.

4. Flow Sequence Of Flat Multihop Routing Algorithm

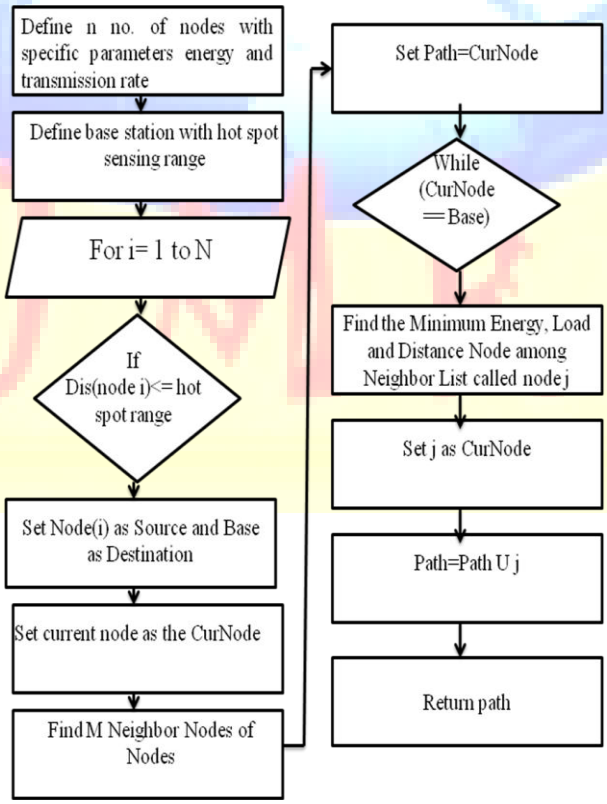

Fig 3: flow sequence of flat multihop routing

5. Flow Sequence Of Hierarchical Multihop Routing Algorithm

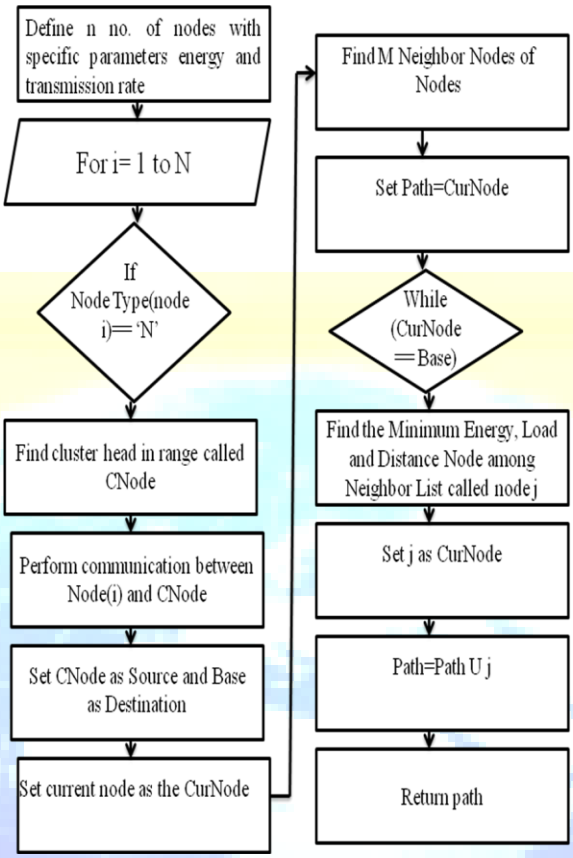

Fig 4: flow sequence of hierarchical multihop routing

6. Performance Evaluation

In this section we will evaluate the performance of our proposed algorithm. For evaluation MATLAB (R2009a) is used. The experimental results show that our proposed hybrid routing protocol decreases the amount of dead nodes and hence sensor nodes remain alive for longer durations. This experimental result also shows that the efficiency of network is improved because of increased packet transmission. Results of our proposed protocol are also compared with LEACH protocol. Fig (a) depicts dead nodes in network. Fig (b) depicts alive nodes in network. Fig (c) depicts data packets transmitted to base station.

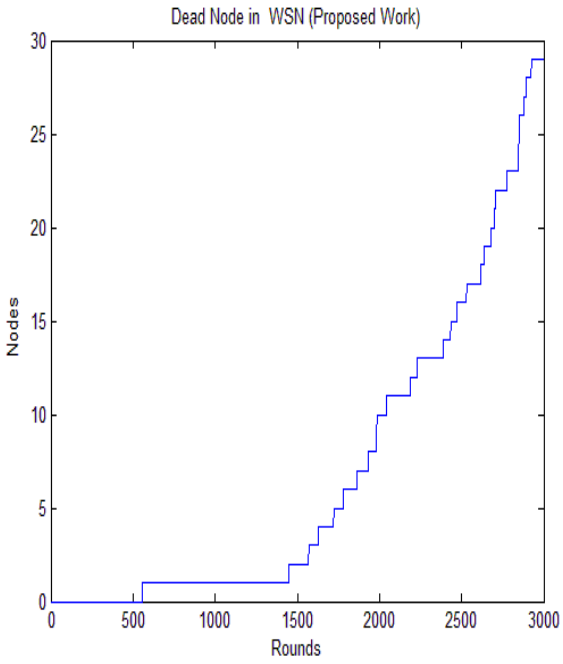

Fig 5: dead nodes in proposed work

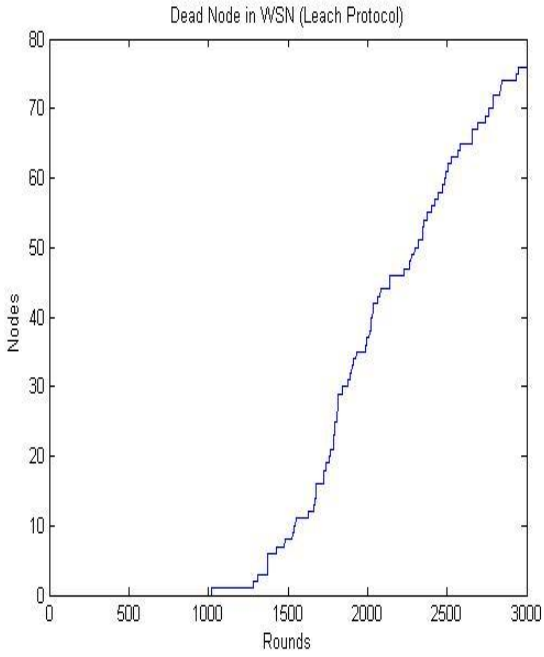

Fig 6: dead nodes in LEACH

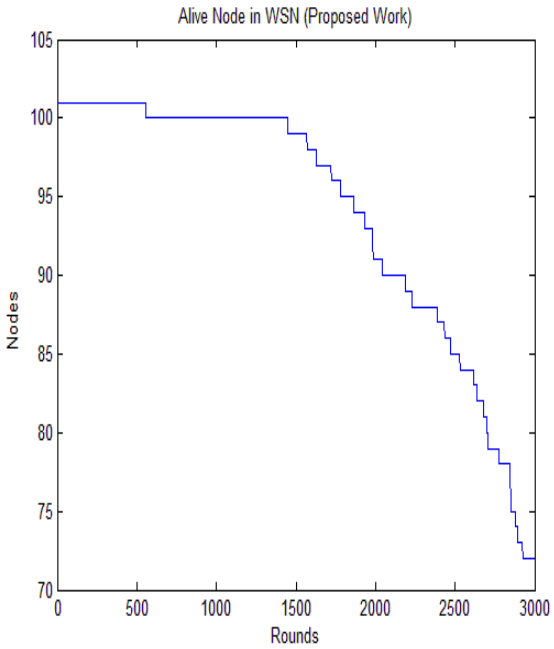

Fig 7: Alive nodes in proposed work

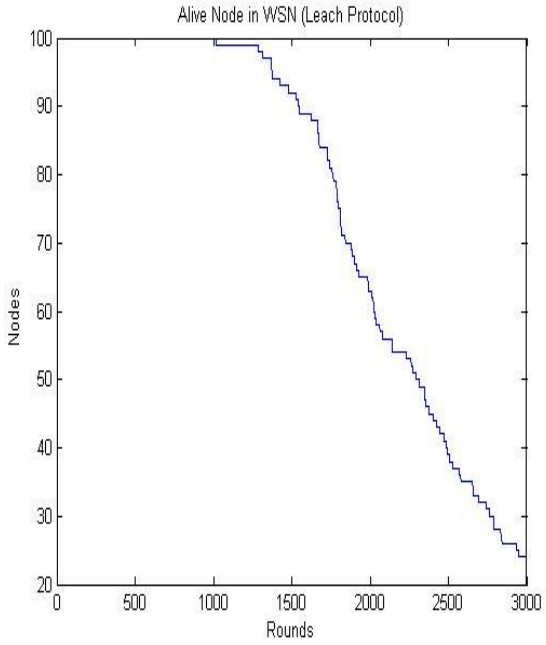

Fig 8: Alive nodes in LEACH

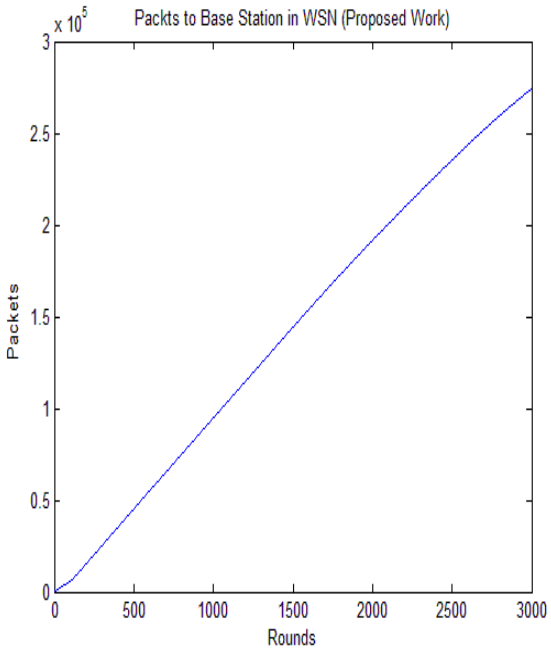

Fig 9: packets to base station in proposed work

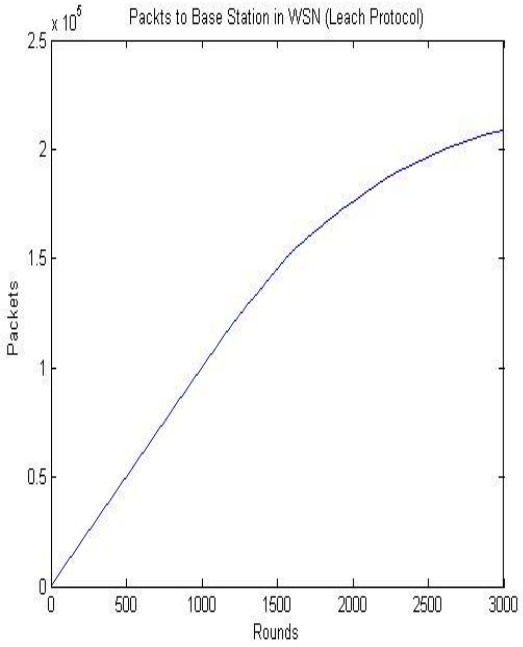

Fig 10: packets to base station in LEACH

7. Conclusion

In this paper we have presented an improved hybrid routing over the network so that network communication and lifetime will be improved by dealing with hot spot problem. As WSN is application specific network, therefore we cannot consider any protocol better than other. We can only compare routing protocols for WSN with respect to some parameters. Finally it can be concluded that hybrid routing is promising solution for hot spot problem and for improving network lifetime.

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