Energy-Aware Routing in Mobile Wireless Sensor Networks

R. Geetha, G. Umarani Srikanth, S. Prabhu

Abstract—Wireless sensor networks are resource constrained networks, where energy is the major resource in such networks. Therefore, energy conservation is major aspect in the deployment of Wireless Sensor Network. This work makes use of an extended Greedy Perimeter Stateless Routing (eGPSR) protocol that mainly focuses on energy efficient data transmission. This data transmission is based on the fact that the message that is sent to a distant node consumes more energy than the message that is sent to a short range transmission. Every cluster contains a head set that consists of many virtual cluster heads. Routing is decided by head set members. The energy level of the received signal is the major constraint to choose head set from its members. The experimental result shows that the use of eGPSR in routing has improved throughput with comparatively less delay.

Keywords—eGPSR, energy efficiency, routing, wireless sensor networks, WSN.

I. INTRODUCTION

WIRELESS Sensor Network (WSN) [1] comprises of a large quantity of low powered battery operated and resource restricted sensor nodes that are deployed in random. These nodes are deployed very close to each other and are involved in sensing the data from the environment in which they are deployed. The sensed and collected data are forwarded towards the sink node (base station) by means of either single hop or multi-hop communication scenarios. The base station in turn can communicate with the task manager node through the distribution network. WSN acts as a communication bridge between the physical network and the virtual world. A variety of components are involved in bridging the physical and virtual worlds. The different components of WSN are sensor nodes, gateway and the main network. WSN can be applied in various fields such as military application, healthcare and medical environment, home automation application etc.

WSN [8] provides a bridge between the real physical world and the virtual worlds. Several components are enrolled to bridge the worlds. The major components of WSN are sensor nodes, gateway, and the main network. *Sensor nodes* are the tiny sensing devices that are deployed in the desired environment which needs monitoring. The sensor node [12] senses the environment, gathers the data and transfers the data to the desired destination. Each sensor node contains a

transducer, micro controller, and a power source and a transceiver. The transducer produces electrical signals about the sensed data. The micro controllers store and process the data, as per the received commands. The power source is mostly a battery, of both rechargeable and non-rechargeable kinds. The transceiver is engaged in sending and receiving the message/data.

A Gateway acts as an interface between the sensor nodes and the main network. The collected data or information is forwarded to the main network. A gateway is directly connected to the main network which acts as a relay node. It relays the information between the sensor nodes and gateway. All gateways can perform protocol conversion, to make the wireless network with non-standard protocol network. The data are transmitted between the gateways via the network (e.g. Internet). It acts as a huge storage area, where the end users, gateways and other components store retrieve and transfer the necessary information.

A. Routing

To accomplish the task of transferring data, sensor nodes require routing protocols. Routing protocols for WSN are used for finding the best path to establish communication in the networks. Routing in WSN is a challenging task due to the inherent constraints with energy, communication, architecture and deployment of nodes. Hence the process of routing is referred to be one of the most complicated processes in WSN. In general all the routing protocols are categorized into data centric, hierarchical, location based protocols and opportunistic routing protocols.

1. Data Centric Protocols

Data Centric routing [10] protocols are used to manage the redundancy of data, it happens for the reason that sensor nodes do not have global identification which identifies them uniquely. Therefore, data sent to every node are having significant redundancy. In data centric routing, the destination node demands for data by sending questions. The nearby sensor node answers the query. SPIN is the first data-centric protocol, which considers between nodes in order to eliminate redundant data and maintain energy. Later, Directed diffusion has been modernized and has become a breakthrough in data-centric routing.

2. Hierarchical Routing Protocols

Standardized to a cellular phone network, sensor nodes in a hierarchical routing approach send their information to a key cluster-head and the cluster head then forwards the information to the desired receiver. The primary purpose of

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hierarchical routing [10] is to efficiently maintain the energy consumption of sensor nodes by taking them in multi-hop communication within a particular cluster and by performing data collection and fusion in order to lessen the number of communicating messages to the destination. There are numerous hierarchical routing protocols available for WSN but LEACH and PEGASIS are mostly used protocols.

3. Location Based Routing Protocol

The estimation of location-based protocols is using an arena instead of a node identifier as the object of a packet. Any node that positions within the given area will be acceptable as a destination node and can obtain and process a message. From the perspective of sensor networks, such location-based routing is important to request sensor data from any region. Since there is no addressing method for sensor networks like IP-addresses and they are spatially deployed in a neighborhood, location information can be used in routing data in an energy-efficient manner. For example, if the region to be sensed is identified, using the location of sensor nodes, the question can be disseminated only to that particular region which will eradicate the number of transmission significantly. The location-based routing protocols [10] obtain into report the mobility of sensor nodes and execute very well when the density of the network increases. Merely, the execution is very pitiful when the network deployment is sparse and there is no data aggregation and further dealing out of the header node. For example, GEAR is one of the location-based protocols.

4. Opportunistic Routing

The network is challenged which means that the connection to the nodes in the network are broken which results in the incomplete path between the source and the destination for at most time In such a scenario the communication link can be extremely unbalanced and may transform or split rapidly. If any connection between the source and the destination gets lost, the intermediary nodes may cache the data and forward it once the connection is back to form. Opportunistic Routing [10] makes use of broadcast nature of transmission in forwarding the packets through several relays. Opportunistic routing attains superior throughput than conventional routing. The key concept after the opportunistic routing is the selection of the subset of nodes among the source and the destination and the nodes that are closer to the destination node and retransmission of the packets by these nodes to the destination.

B. Clustering

Clustering [11] consists of a collection of a homogeneous nodes where the homogeneous nodes are similar in configuration. The nodes inside the cluster are coordinated by a Cluster Head (CH) node. The responsibility of the CH is to collect the information from the other sensor nodes within its cluster and forward the information towards the base station. All the CHs are connected either directly or through multihop with the base station. Base station consists of a centralized system that stores all the data collected from the various clusters. A cluster can be homogeneous cluster or heterogeneous cluster. The nodes in the homogeneous cluster are similar in configuration whereas the nodes in the heterogeneous cluster are dissimilar in configuration.

II. RELATED WORK

The concept of sensor networks with a view of convergence of micro-electro-mechanical systems (MEMS) technology, digital electronics and wireless communications has been explained by [1]. The sensor network senses the physical characteristics in the vicinity. Then the sensed data are explored in depth with many reviews of factor that influences the architectural design of the sensor networks. Secondly, the review of various factors that influence the sensor networks is analyzed. Then, the architecture of the communication scheme is sketched and the protocols for each layer are depicted.

The GPSR [9] for wireless networks has been presented by [2] in a descriptive way. In GPSR, the packet forwarding decision is taken using the exact position of the destination and the router. GPSR is meant to be a location based routing protocol for energy efficiency and hence the routing in this scheme is achieved by identifying the neighboring node which is near to the destination. This paper depicted the two methods of forwarding packets in GPSR. The first method is known as greedy forwarding and other is called perimeter forwarding. The greedy forwarding method makes decision using information about the immediate neighbors of router that is taken into account. In perimeter forwarding method, the routes are identified along the perimeter of a region. Sometimes a greedy mode fails to find a path for reaching the destination.

Colin et al. [3] have presented a Boundary State Routing (BSR) protocol which is a part of geographic routing protocol category which has two components namely Greedy Bounded Compass and Boundary Mapping Protocol (BMP). Greedy Bounded compass is an improved forwarding strategy. In this technique, packet forwarding is done around the concave boundaries without looping. In order to maintain a link state information, the BMP is needed whereas greedy forwarding produces a less rate of path completion than greedy bounded compass. The performance of BSR is improved when compared to GPSR.

An edge based routing protocol for WSN called BeamStar is discussed by [4]. The main aim of this protocol is to reduce the complexity of constraints in sensor nodes in both hardware and software. To exploit greater properties, the directional antennas and base stations are associated with power control schemes so as to achieve high reliability. The robust routing protocol design has also been described in this paper which is primarily based on location information of the sensor node and it is concluded that the high reliability is achieved using BeamStar

Saleet et al. [5] presented a routing protocol called Intersection based Geographical Routing Protocol (IGRP), exclusively for VANETs. This routing protocol is projected to be outperforming the existing VANET routing schemes. The IGRP is designed based on QoS constraints and selection of road intersection mechanism. The selection is proposed to be guarantying high probability working scenarios, greater network connectivity among the road junctions and

intersections. The authors propose an algorithm genetically to solve optimization issues so as to improve the performance of VANET.

Di Tang et al. [6] propose a Secure and Efficient Cost Aware routing (CASER) protocol. There are conflicting issues when the multihop WSN is designed with security and lifetime optimization. In order to counter these issues, the CASER protocol is proposed by the authors through two aesthetically adjustable formal parameters such as energy balance control and probability based random walking. The paper also proposed with quantitative security analysis and hence high message delivery ratio is achieved using CASER protocol by mitigating trace back attack.

Mohamed et al. [7] propose Secure and Energy-Efficient Disjoint Routing (SEDR). In multipath routing secret sharing is formulated as optimization problem. The main objective of this routing technique is to maximize the lifetime and improve network security features. SEDR is designed as a three phase disjoint routing mechanism. In the first phase discovery of network is done, in the second phase the SEDR randomly delivers shares over the network, and in the third phase it shares to the sink node thereby improving the network security significantly.

III. ENERGY AWARE ROUTING

Energy aware routing is extremely important for WSN as it deals with the lifetime of WSN deployed, augmenting the throughput, routing with energy efficiency, and handling link failures and do secure routing. Sensor Network systems are used in a variety of applications. The sensor nodes are getting connected to internet nowadays. Internet of Things (IoT) requires the sensor data to be transmitted in a secure manner where it expects higher security levels. In sensor networks security is the major threat and the main problem is to design an energy efficient routing protocol. This energy efficient routing protocol is reliable in terms of data delivery at the base station. Each cluster consists of one CH node, two deputy CH nodes and some ordinary sensor nodes. The protocol used here is hierarchical and cluster based. Based on network topology, data transmission is formulated either directly or multihop manner. Alternate paths for data transmission are introduced. Cluster panel techniques are introduced here which selects the appropriate CH from CH panel.

GPSR protocol is enhanced to support energy efficiency. The extended GPSR protocol mainly concentrates on the energy efficiency that is based on the fact that the message that is sent to a distant node consumes more energy than the message that is sent to a short range transmission. The important concept outlined here is the selection of neighboring node based on the energy level. This work implements energy efficient GPSR protocol which is energy aware and routes data with less delay. The proposed protocol routes the packets focusing on the energy conservation aspects of WSN. Proposed protocol routes the packets with reliability to a greater extent.

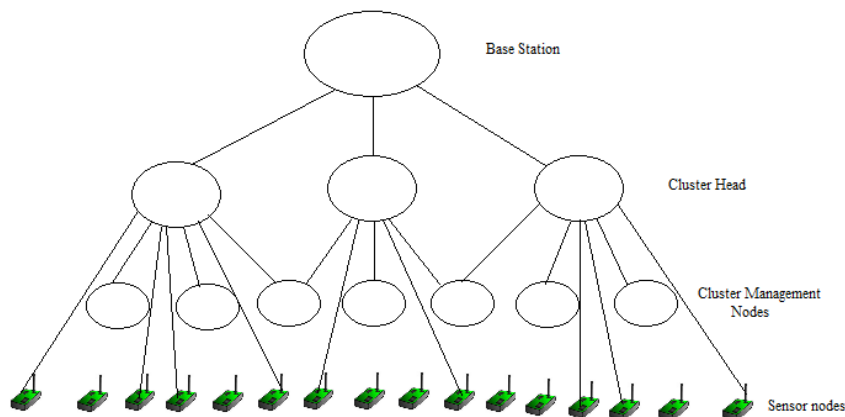To increase the lifetime, cluster management nodes are used in the network as shown in Fig. 1.

Fig. 1 System Model

A design that is modular in nature minimizes the complexity. It allows the modification that is a critical aspect of maintainability of software and leads to simpler implementation through the encouragement of the parallel development of the various parts of system. The system is split into differently named and addressable components that are named as modules. These modules are combined together so as to fulfill the problem requirements.

Sensor nodes can produce duplicate data from different regions. Data aggregation techniques combine data from various nodes, according to a definite aggregation function, e.g., duplicate repression, minima, maxima and average. Data aggregation is used to meet energy efficiency and data transfer optimization in all routing protocols.

The packet forwarding decisions in GPSR are made using the position of packets destination and router. GPSR is a location based routing protocol for energy efficiency. Routing in GPSR is performed by identifying neighbouring node which is close to the destination. Two methods of forwarding packets are carried out in GPSR: One method is called greedy

forwarding and other method is called perimeter forwarding. In network topology, the greedy forwarding mechanism takes routing decisions based on the information only about directly connected neighbours. The routes are identified along the perimeter of a region when a greedy mode fails to find a path towards destination. eGPSR is the extension of GPSR protocol where the next node is chosen based on the energy levels.

IV. RESULTS AND DISCUSSION

Throughput Ratio is defined as the ratio of the overall WSN performance to data generated by CBR sources. The efficient throughput ratio performance of existing and proposed routing protocols has been analyzed at increasing time intervals. This analysis shows that the proposed system performs better as shown in Fig. 2.

Packet Delivery Ratio (PDR) refers to the ratio of the effectively transferred packets to the destination nodes against the packets that are generated by the source nodes. The higher value of the PDR leads to the reduced rate of packet loss. This leads to the improvement of the efficiency of the routing protocol in the view of the data delivery point. In the actual real time communication scenario, the routing protocol that contains higher PDR may not be treated superior than the one with reduced PDR. This is because packets that arrive very late may be useless even though they reach the destination node effectively. Thus the percentage of the delivery of the data packet is reasonably high. The results in Fig. 3 show that the proposed system has better PDR.
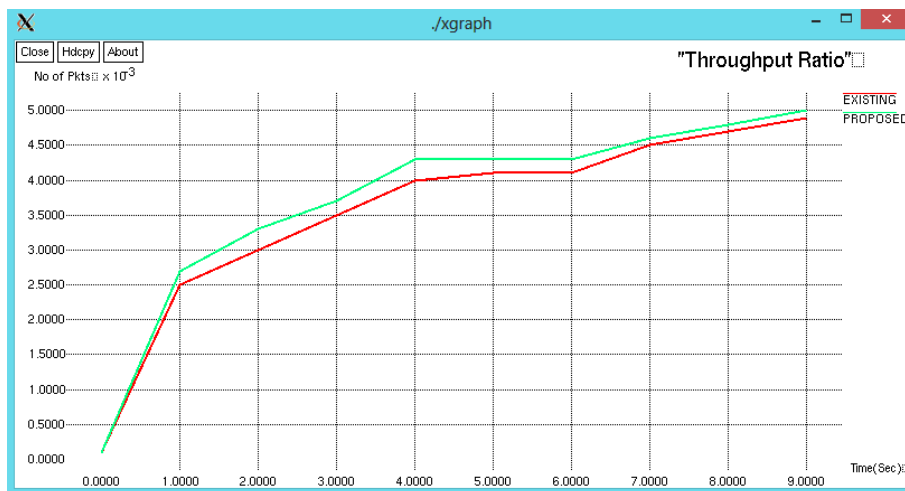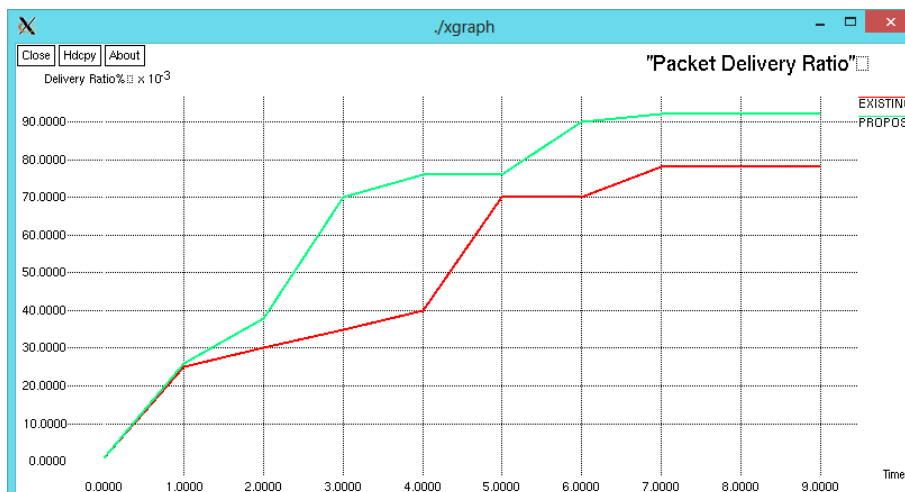

Fig. 2 Throughput ratio

Fig. 3 Packet delivery ratio

Average End-to-End delay is the average time taken to transmit a data from source to destination. It includes not only propagation and transfer time of data packets but also other delays like buffering during the route discovery phase, waiting at the interface queue, retransmission time at the MAC. The end-to-end delay is typically calculated through the summation of the times utilized by all of the received packets divided by the total number of packets received. High

performance requires the End-to-End Delay to be less. Fig. 4 shows the performance of existing and proposed routing protocols in terms of delay. The delay of the proposed system is reasonably smaller when compared to the existing one.

The increasing number of rounds and energy consumption

performance of existing and proposed routing protocols is shown in Fig. 5. The energy consumption is measured in joules. Existing system energy consumption is around 81 J and it is less in the proposed system which is around 74 J.
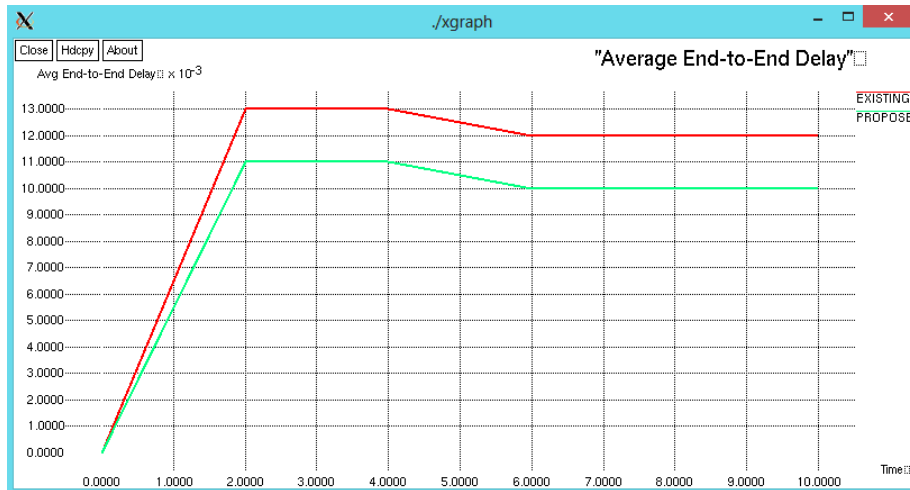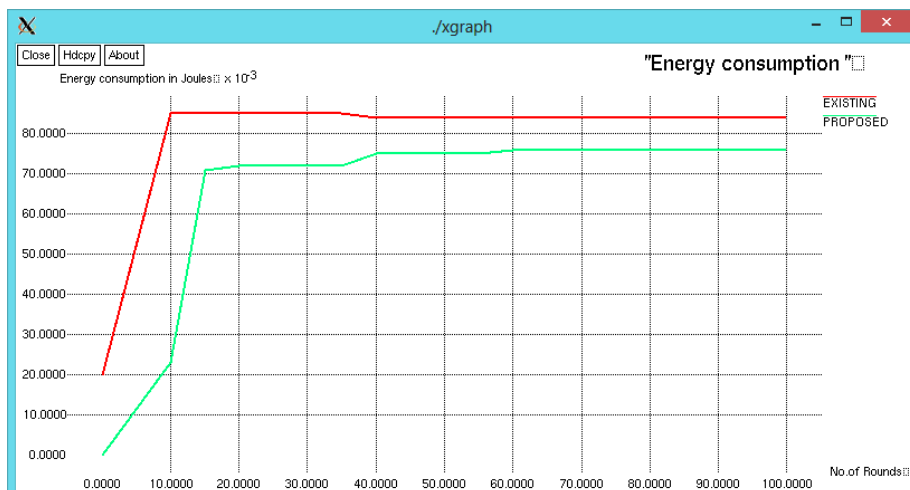

Fig. 4 Average end –to-end delay

Fig. 5 Energy consumption

V. CONCLUSION

An energy aware routing protocol is presented. The neighbouring nodes for routing are chosen on the basis of the energy level, which helps in prolonging the network lifetime. Since each neighbour node is constantly decreasing the energy due to the sensing activity, the node with high energy level is chosen as the neighbour node. GPSR is extended to support energy efficient routing phenomenon. Energy efficiency of the newly encountered nodes is the main emphasis of the proposed protocol. Thus a reliable and energy efficient communication is enabled in the network leading to improved throughput and reduced delay. In future, the protocol can be used for securing the aggregated data transmission over IoT.

The protocol can be enhanced further to provide robust secure communication.

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