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Qos Aware Energy Efficient Routing In Wireless Sensor Networks

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Abstract— Energy is a critical resource parameter in Wireless Sensor Networks. Utilizing energy in an efficient manner is a challenging task in Wireless Sensor Networks. This paper presents an overview on various energy efficient routing protocols which satisfies the criteria of QoS parameters. Various energy efficient and QoS based routing protocols have been compared. To improve the QoS in a network, data fusion and data aggregation is considered to be one of major energy saving technique. The routing protocols based on data aggregation, reduced cost routing and secure routing are also discussed in detail. Simulation tools like NS2, NS3, OMNET etc can be used to evaluate the network performance .

Keywords— energy efficiency, QoS, routing, Wireless Sensor Networks.

I. INTRODUCTION

A. Wireless Sensor Networks

Wireless Sensor Network (WSN) is used for monitoring and recording the physical conditions of the environment and communicate the information gathered from the monitored field through wireless links. A sensor network consists of a collection of few hundreds to thousands sensor nodes which can perform some specific action and are battery powered. Compared to other wireless networks, the number of nodes and density of nodes comprising WSNs is large. Due to recent technological improvements, sensor nodes have become small, inexpensive, low-power and distributed. Sensor networks have been useful in many fields like military, health, monitoring environment, industry, Science, transportation, civil infrastructure, habitat monitoring and security. While communicating the gathered information, energy conservation is a key issue that has to be taken into consideration. The network is also concerned with providing the required QoS. Due to the resource constrains of wireless sensor nodes, great challenge has been laid on properties such as delay, reliability, fault tolerance and coverage. Data fusion and data aggregation should be done in order to save energy in Wireless Sensor Networks. The communication between the sensor and the base station takes place through intermediate nodes which drains more energy to transmit sensed data over long distance. Many techniques have been developed to reduce the energy consumption in these intermediate nodes. Aggregator node is one such node which can reduce the energy consumption in these intermediate nodes. This process is referred as data aggregation [1-5].

B. Motivation

In WSNs, while communicating the gathered information the network is concerned with providing the required QoS. QoS is the measure of service quality that the network offers to the end user or application. For efficient and reliable transmission of communication of the sensed data from the sensor field to the sink node, the network has to fulfil the required QoS. Few of the QoS parameters include data accuracy, aggregation delay, fault tolerance, optimum number of active sensors, coverage, energy efficiency, responsiveness, reliability, timeliness, robustness Self-Configuration Privacy and Security. QoS is also determined by calculating the throughput, delay, jitter and packet loss rate of the network. As wireless sensors carry severe energy and computational resource constrains QoS support has been challenging task in Wireless Sensor Networks [6]. An energy constraint is one of the main issue in Wireless Sensor Networks since the nodes are energized by battery power. Hence, it is essential to design an energy-aware system to ensure the longevity of surveillance missions and many mechanism have been proposed recently [7-8].

II. LITERATURE SURVEY

Chu-Fu Wang et al., [9] proposes a network lifetime enhancement method for sink relocation and its analysis in Wireless Sensor Networks. He describes the method to conserve network lifetime while performing the sensing and reporting task. He proposed energy-aware sink relocation (EASR) methods for mobile sinks in WSNs. This method of sink relocation was an efficient one in increasing the network lifetime by avoiding the battery energy consumption. This sink relocation method requires mathematical analyses and efficient routing protocols. Özgür B. Akan et al., [10] proposes Event-to-Sink Reliable Transport in Wireless Sensor Networks. He designed reliable event detection using minimum energy usage. This Event-to-Sink Reliable Transport (ESRT) protocol works by controlling the congestion of the network. Multiple event occurrences is accommodated in Wireless Sensor Networks. Here, the main function is run on sink and minimum functionality is shown at the source end. Hui Wang et al., [11] describes Network Lifetime Optimization in Wireless Sensor Networks. In this protocol, design of physical, medium access control and routing layers are done in such a way that their network lifetime can be increased. An iterative algorithm is also proposed for large planar networks. Here, to address the problem of network lifetime Time Division Multiple Access technique is adopted. Kareesh –Kuhn-Tucker (KKT) conditions also provide network lifetime maximization for cross layer network design. A unique algorithm has to be designed which can increase the network lifetime for both small and large planar networks. Hamid Rafiei Karkvandi et al., [12] presents Effective Lifetime-Aware Routing in Wireless Sensor Networks. This method determines the network resource specifications such as the number of available nodes and their sensing spatial coverage. Here, the novel sensing problem is addressed and analysed for various layers of the network. By using the solutions of various linear programming equations, normalized network lifetime can be calculated for various network environments. Jae-Wan Kim [13] describes an Intelligent Agent-based Routing Structure for Mobile Sinks in WSNs. As frequent moving sinks demand for frequent location update, much of the energy consumption is due to these frequently moving and updating sink nodes. It works on data gathering and selection of efficient path techniques. This scheme shows outstanding performance when considering a mobile sink. The proposed algorithm reduces the packet loss and signal overhead in the data communication. Distance comparison is done and new path is selected if original path is considered to consume more power. This scheme demands for fast and accurate path selection technique.

Demin Wang et al., [14] describes Coverage and Lifetime Optimization of Wireless Sensor Networks using Gaussian Distribution. Coverage and lifetime are directly associated with battery power of the network. The sensors employed for this communication follow Gaussian Distribution and different dispersions. By considering various analytical model coverage and lifetime can be increased in Gaussian Distribution. In Gaussian Distribution, energy saving option is not shown for sleep and wake scheduling. So, Gaussian Distribution is not an efficient one for multi hop routing protocol.

Leandro et al.,[15] proposes DRINA: A Lightweight and Reliable Routing Approach for In-Network Aggregation in Wireless Sensor Networks which reduces the energy consumption of various high density nodes. Data fusion and data aggregation methods can remove the redundancy in the data and can reduce the energy consumption and cost. Here, reduced number of messages are used for setting up a routing tree, maximized number of overlapping routes, high aggregation rate, reliable data aggregation and transmission. The proposed algorithm includes the Information Fusion-based Role Assignment (InFRA) and Shortest Path Tree (SPT) algorithms. These algorithm provide good performance in aggregation of data. Ankit Thakkar et al ., [16] elaborates on Cluster Head Election for Energy and Delay Constraint Applications of Wireless Sensor Network and proposes cluster formation that results in good performance with respect to energy and delay constraints of the network. In this cluster formation, cluster head collects and aggregates the data from member nodes and send it to the other cluster head or the base station, thus achieving good scalability. Analysis of the proposed algorithm was done by considering two distances Euclidean distance and multi Hop-count distance. Energy consumption was more for Euclidian distance than the multi hop count distance. The Hop count exhibited higher delay when compared to Euclidian distance.

III. ROUTING MECHANISMS IN WIRELESS SENSOR NETWORKS

Efficient routing protocol should control the energy consumption of the network and they should reduce the complexity of the network. During communication between sensor nodes, these protocols should minimize the transfer delay occurring at the nodes. In this paper, we have compared various energy efficient routing protocols by maintaining better QoS. If the cost is associated with the link length of the network, then the shortest path link will be the efficient path in communicating the data with reduced cost. The Shortest Path is the distance from any given node to the destination node. If there is continues data communication, bandwidth may be a constraint in shortest path route. Such shortest path routing networks should take bandwidth issue as major consideration, otherwise this network will result in highly congested paths. This will also causes increase in delay of the network and packet losses, which in turn results in retransmission of packets and thereby increases energy consumption. So these routing protocols should also concentrate on all these parameters to select the shortest path such that it should increase the network lifetime [17]. The Dijkstra algorithm and the Bellman-Ford algorithm are the two very well known and well-defined algorithms for shortest path routing which can save power consumption. The Event-Sink Reliable Transport (ESRT) protocol scheme can achieve high rate of congestion control which can also conserve energy to large extent. In this scheme, the configuration of the network is chosen very close to the optimal operating point. The main functionality is carried on sink minimal functionality at resource constrained sensor nodes. This method helps to achieve the required reliability with minimum energy consumption. Network congestion can be considerably reduced. Other methods like designing duty cycle scheduling for sensor nodes was adopted to conserve energy. When nodes were idle without doing the sensing job, they were allowed to enter the sleep state to conserve power. This method does not effect the sensing operation of nodes[10]. Energy-Aware

Sink Relocation (EASR) method adopts energy-aware routing technique for message relaying and the network lifetime of a WSN is substantially prolonged [18].

A. Data Aggregation Routing Protocol in Wireless Sensor Networks:-

Data aggregation is basically done to save out from all data collected on sensors and communicates only data that is important for the application. energy consumption and also to increase the data accuracy. Researchers have developed different strategies to deal with the extensive data generated. The frequency of sensing and transmitting the data consumes the most energy in a sensor network. The raw (i.e., sensed data) or processing (i.e., averaged sensed data) data exchanges between sensor nodes in a network. Processing sensor data enables essential information to be filtered Sensor node transmits sensed data to the base station through intermediate nodes. Since base station is too far, it drains more energy to transmit data over long distance, so the better technique is to avoid direct transmission to farthest node and use only fewer nodes to communicate with the base station. These nodes are called as aggregator nodes and the process is referred to as a data aggregation. The aggregator node collects data from multiple sensor nodes of the network, aggregates the data packet using some aggregation function and then sends the results to upper aggregator node that generates the query [19]. In many applications, WSNs encounters some security problems, so the scheme of data aggregation not only optimizes raw data and reduces the amount of transmission for network, but also keeps the network at a high level of security [20]. Data Routing for In-Networking Aggregation (DRINA) protocol uses some key number of messages for setting up the path and a routing tree. It consists of maximized number of overlapping routes, high aggregation rate, reliable data aggregation and transmission. This work can also be extended to consider the spatial and temporal correlation of the aggregated data. In Privacy-preserving Data Aggregation (PDA) protocol, the privacy of both the participants and the keywords are protected. This scheme secures the private data, increases the throughput. The Recoverable Concealed Data Aggregation (RCDA) protocol designs the base station in such a way that, it verifies the integrity and authenticity of all sensing data and also it performs aggregation operations on the data. So, it provides better security, increases throughput and packet delivery rate. Energy- Efficient, Secure, highly accurate and Scalable Scheme for Data Aggregation (EESSDA) scheme establishes secure channel and slicing technology to achieve secure data aggregation. This avoids encryption and decryption operations during data aggregation; instead it saves energy and obtains high accuracy of aggregation results. So, it reduces time for data processing and it is scalable. An overhead is caused due to slicing and assembling technique since, it has to decompose data into pieces, sending data pieces to neighbor nodes and assembling their data pieces.

B. QoS Based Routing Protocol in Wireless Sensor Network:-

Many protocols based on improving the efficiency of various QoS parameters have been designed so far. Deterministic bounds have been given for a node-to-node delay and reliability which provides assurance in terms of delay and reliability. Based on principle of network coding for retransmitting lost packets in a single hop wireless network, efficient latency and bandwidth requirement can be achieved. The loss recovery mechanism called *Active Caching* is used to recover the lost packets from the source to the intermediate node so that intermediate data contains all the data just like source node. This retransmission improves the reliability in the network. In co-operative relay network, transmission is carried out by using a relay node which exploits temporal and spatial diversity and reduces the packet error rates. It also reduces the number of transmissions and improves overall performance using cognitive interference management, the optimal throughput is achieved by the secondary node user when primary node user adopts a retransmission-based error control scheme. Throughput is achieved by secondary node user. In the local cooperative relay for opportunistic data forwarding the best local relay node is selected and additional overhead can be effectively reduced. In one of the technique in cooperative forwarding, receiver can decode only one transmission at a time. These techniques address the collision problem. Modified CSMA/CA protocol and randomized waiting scheme is also addressed to reduce the number of retransmissions. In novel adaptive retransmission algorithm, the misclassification probability of the network can be improved. Here, the error correcting codes is designed to obtain the efficient fault-tolerant classification system. In cooperative retransmission mechanism, a node can retransmit lost packets on behalf of its neighboring node. However, lost packets can be recovered by a neighboring node, a new transmission for each transmission attempt is still required. In GORMA(Group Optimal Retransmission Medium Access Protocol), retransmission with required QoS is designed and evaluated.

C. Security Based Routing in Wireless Sensor Networks:-

A strong security is required in majority of sensor network applications. Major application includes military, banking, applications working with sensitive personal data which may include health, home appliances. Location and energy-aware characteristics for routing is necessary to design a required protocol which gives a better delivery rate, energy balancing and routing efficiency. Some of network layer attacks on Wireless Sensor Networks are Eavesdropping, selective forwarding, denial of service, message tampering, sinkhole attack, wormhole attack, acknowledgement spoofing etc. Eavesdropping is mainly in broadcast network any adversary with a strong receiver could eavesdrop and intercept transmitted data. Information like location of node, Message IDs, Node IDs, timestamps, application specific information can be retrieved by an intruder. Strong encryption techniques are necessary to prevent this attack. In a Denial-of-Service (DoS) attack, an adversary attempts to disrupt, corrupt or destroy a network reducing the performance of the network. Message tampering is the alteration of the information to be forwarded to the destination. The Cyclic Redundancy Code (CRC) check is required at the destination. If the redundancy check fails it would result in dropping

the packet. In selective forwarding attack, malicious nodes may refuse to forward certain messages and simply drop them, ensuring that they are not propagated and reduces performance.

IV. PERFORMANCE EVALUATION OF DIFFERENT ROUTING PROTOCOLS

TABLE. I.:COMPARISON OF ENERGY EFFICIENT AND QOS BASED ROUTING PROTOCOLS

Author	Algorithm/protocol	Concept	Performance
Dong ,W	Efficient code dissemination protocol	Dynamically configures the packet sizes and accurately selects the sender	Shortens the time spent in selection of sender avoids transmission collision and transmission over poor links
Degan Zhang	Energy balanced routing method based on forward aware factor	Next hop node is selected based on the link weight and forward energy density	Guarantees high QoS Prolongs the function lifetime
Leandro	DRINA	Redundant data is aggregated Shortest path is established between the source and the sink	High and reliable data aggregation Maximum number of overlapping routes.
Hamid Rafiei Karkvandi	Effective lifetime aware routing	Sensing spatial coverage is proposed	Improvement in QoS and network lifetime.
Hui Wang	Kareesh –Kuhn-Tucker(KKT)	Optimal design is done on power control at the physical layer The design is based on cross layer approach	Optimization of network lifetime. Power controlling is increased
Demin Wang	Coverage and life time optimization with Gaussian Distribution	Polynomial time complexity and optimal deployment strategy is used. Lifetime and coverage is based on 2D Guassian distribution	Minimizes the network cost under two constraints • coverage • life time.
OZgur B Akhan	Event to sink Reliable transport in Wireless Sensor Networks.	Sink will collect the information of the sensor nodes within the event radius no end-to-end reliability.	Congestion control is achieved. Maximization of reliability and conservation of energy.
D.Antony Arul Raj	Enhanced energy efficient multipath routing	It uses distance vector concept and hop by hop routing. It detects the multipath with loop-free and disjoints using flood-based route discovery.	Increases lifetime of the network Bio inspired methods have several advantages

In a sinkhole attack, malicious sink is created which can not only tamper the transmitted data but can also drop some vital data and lead to other attacks like eavesdropping and selective forwarding. In Wormhole attack, an adversary receives messages by making a tunnel and a low-latency link in one part of the network and replays them in a different part causing some confusion in the network. In acknowledgement spoofing: An adversary can spoof link layer acknowledgment for ''*overheard*'' packets addressed to neighboring nodes to convince the sender that a weak link is strong or that a dead or disabled node is alive. By this attack a routing protocol may select the next hop in a path using link reliability.

VI. SIMULATION

Most of the protocols discussed above can be designed and verified using NS2 simulation tool. This simulation tool can determine the overall performance of the designed protocols and can be compared with other network protocols. other simulation tool includes NS3, op-net, Omnet and many others.

VII. CONCLUSIONS

QoS in any network can be measured using the parameters such as data accuracy, aggregation delay, fault tolerance, optimum number of active sensors, coverage, energy efficiency, responsiveness, reliability, throughput, timeliness, robustness Self-Configuration Privacy and Security. In this paper, many routing protocols in Wireless Sensor Networks are discussed based on cost, security, data aggregation and QoS requirement. Efficient routing protocol controls the

energy consumption of the network and they should reduce the complexity of the network. Different protocols based on reduced energy consumption are discussed. Many protocols can be developed to save energy by efficiently aggregating the data. The protocols discussed in this paper can be evaluated for various parameters using various simulation tools.

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