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QOS Enhancement on Distributed Topology Control for Heterogeneous WSNS

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ABSTRACT

In this paper, Quality of Service Enhancement on Distributed Topology Control (QoS-EDTC) introduces the algorithm called the Disjoint Route Vector (DRV) for heterogeneous wireless sensor networks. The aim of our algorithm is to minimize the total transmission power of the nodes in the network. High QoS route information collection is important in WSN. Therefore, we measure the Packet Delivery Ratio (PDR) for route node to improve the QoS in the network. The DRV algorithm deals the k-degree Any cast Topology Control problem. The resulting topologies are tolerant to k"1 node failures in the worst case. The accuracy of this approach is proved by showing that topologies generated by DRV are guaranteed to super node connectivity. Our simulations show that the DRV algorithm achieves reduction in total transmission power required and increased throughput in the network.

Keywords: Super node, Energy Efficiency, Disjoint Route Vector algorithm, Quality of Service, Heterogeneous Wireless Sensor Network.

1. INTRODUCTION

In recent years, Heterogeneous Wireless Sensor Networks (HWSNs) have gained global concentration for use in different applications. In this network, the sensors having wireless link with different transmission range, sensing range or those sensors may be employed in numerous applications. HWSNs are collection of numerous wireless devices with different transmission and computing capacities. In homogeneous WSNs, where all the wireless devices possess the same transmission and computing capacities but H-WSNs contain a variety of operating environments, wireless devices are equipped with different transmission hence it is useful in many military or civil applications. Also, H-WSNs is utilized in underwater sensor networks that consist of multiple types of sensors deployed at different depths within the water. The heterogeneous wireless devices cooperatively form a scalable multipurpose sensor network and facilitate many sensing tasks, for example oceanographic data collection, pollution monitoring, offshore exploration and tactical surveillance.

Topology control is one of the most vital techniques used for minimizing energy consumption and keeping network connectivity. Topology control in HWSNs consisting of two types of wireless devices such as energy constrained wireless sensor nodes deployed randomly in a large number and smaller number of energy rich super nodes placed at known locations. The super nodes have two transceivers, one is connected to the WSN and the other is connected to the super node network.

The super node network provides better QoS and is used to quickly forward sensor data packets to the user. Data gathering in heterogeneous WSNs has two steps. First, sensor nodes transmit and relay measurements on multi hop paths towards any super node. Then, once a data packet encounters a super node, it is forwarded using super node-to-super node communication towards the user application. In addition, super nodes can process sensor data before forwarding. The heterogeneous results improved network

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performance for example longer network lifetime and lower delay. The topology control has a range assignment problem, for which the communication range of each sensor node must be computed.

In this paper, we propose DRV algorithm for Qos Enhancement on Distributed topology Control Algorithm in HWSN. The objective is to minimize the total transmission power for all sensors while maintaining disjoint communication paths from each sensor to the set of super nodes. The highest PDR path selects the data transmission path to improve the QoS in the network. The rest of this paper is organized as follows: Section 2 presents related work. Section 3 describes the HWSN architecture and introduces the DRV algorithm. Section 4 presents the simulation results and Section 5 concludes our paper.

2. RELATED WORKS

The impact of heterogeneity of nodes is studied in terms of their energy in WSNs that are hierarchically grouped. In these networks, some of the nodes act as Cluster Heads (CHs) and it aggregate the data of their cluster members and finally transmit the data to the sink. A Stable Election Protocol (SEP) [2] for clustered HWSN was proposed that prolong the lifetime. SEP was based on weighted election probabilities of each node to become CH according to the remaining energy in each node. A Distributed Energy Efficient Clustering scheme (DEEC) [3] was proposed in which the CHs are elected by a probability. This probability is measured based on the ratio between remaining energy of each node and the average energy of the network. DEEC achieves longer lifetime and more effective messages in heterogeneous environments.

Developed Distributed Energy Efficient Clustering (DDEEC) [4] overcomes the drawbacks of the DEEC protocol. The CHs are elected by a probability based on the ratio between residual energy of each node and the average energy of the network. DEEC adapt the rotating epoch of each node to its energy. The nodes with high initial and residual energy will have more chances to be CHs than the nodes with low energy. As a result, DEEC can prolong the network lifetime, especially the stability period. Enhanced Distributed Energy Efficient Clustering Scheme (EDEEC) protocol [5] works on the same principle of DEEC but adds super node that has more energy than normal node. In this protocol, CH selection uses the same threshold technique and the advance and normal nodes have same probabilities.

Enhanced Developed Distributed Energy Efficient Clustering (EDDEEC) [6] was a protocol in which the super nodes have more energy than the advanced nodes. The advanced node has more energy than the normal nodes. The probability of the super, advance and normal nodes to be CHs shows that super nodes have high probability to be CH than the advance nodes which have more probability than normal nodes. The energy of super nodes is equal to that of advance nodes because CHs utilized more energy than the other nodes in the cluster. At the moment, the super and advance nodes becomes equal, but due to higher probability, the super nodes will again become CHs. Due to this, the super node die fast and it reduces the lifetime of the network. Balanced Energy Efficient Network Integrated Super Heterogeneous (BEENISH) [7] protocol introduced a new type of node called ultra-super node that has $(1 + u)$ times more energy than normal nodes. This protocol increases both the heterogeneity and stability period and provide reliable information. It uses similar method for CH selection as in previous protocols with the difference only in addition of probability for ultra super nodes.

Fault-tolerant topology control in a HWSN [8] consists of several resource rich super nodes that is utilized for data relaying, and a large number of energy-constrained wireless sensor nodes. The k-degree any cast topology control (FC-ATC) problem has the objective of selecting each sensor’s transmission range such that each sensor is k-vertex super node connected and the total power consumed by sensors is minimized. These topologies are needed for applications that support sensor data reporting, even in the event of failures of up to k-1 sensor nodes. Two solutions are proposed for the k-ATC problem: a k-approximation algorithm, a greedy centralized algorithm that minimizes the maximum transmission range between all sensors. Topology control in large-scale WSNs [9] has the ability of sensor nodes to relay traffic along a given direction field. The degree of information flow is proportional to the traffic flux passing through any point in the network. Path-implement ability requires more nodes than simple connectivity. However, it guarantees existence of enough paths connecting the information source to the sink.

Affinity Propagation Clustering based on Distances and Energy (APCDE) [10] was proposed to solve the problem of uneven clustering in HWSN. The dynamic multi-hop transmission mode was adopted in the process of data transferring. APCDE algorithm can balance network energy consumption and prolong the network life cycle efficiently. Coverage and connectivity for HWSN [11] are the important parameter in HWSN. First, it classifies the HWSN systematically and put forward heterogeneous node model under sensor heterogeneity and transmission heterogeneity. Second, it analyses the coverage calculation under two kinds of heterogeneous nodes. Third, it analyses the simply connectivity and re-connectivity. Finally, it obtains the probability curve between the number of nodes and simple connectivity, re-connectivity.

An Enhanced CH Selection Scheme [12] deals with Distributed HWSN. In WSN, improvements are needed at some critical parameters such as lifetime of network, node readying, fault lenience, dormancy and energy strength. This scheme utilizes heterogeneous node probability model based on energy threshold scheme. This scheme consumes less energy, prolongs the network lifetime and stability. The perceived probability model [13] is used to calculate the perceived probability in the heterogeneous wireless sensor nodes and transform virtual force algorithm. The algorithm moves the heterogeneous wireless sensor nodes to the low perceived probability and achieves the maximum coverage of the monitoring area. It improving the network coverage effect and reduces the nodes movement distance thus extends the lifetime of HWSN.

3. QOS ENHANCEMENT ON DISTRIBUTED TOPOLOGY CONTROL

Quality of Service Enhancement on Distributed Topology Control (QoS-EDTC) introduces the algorithm called the Disjoint Route Vector (DRV) introduces the DRV algorithm to remove the disjoint vertex from the route and makes the topology to route data collected by sensor nodes. The objective of this scheme is to minimize the transmission power of all sensor nodes. We assume a HWSN contains Sensor Nodes and Super Nodes. The sensor nodes are placed randomly and super nodes are placed at known locations manually. The super nodes are not energy constrained and it directly communicates with Base Station (BS). But the sensor nodes are limited battery resources in the network. The figure 1 shows that the architecture of the QoS-EDTC scheme.

In this network, initially the super node broadcast the init message to collects the path information. This init message contains super node ID. The sensor node receives this Init message and it updates its route table. This route table consists of ID of the super node and the cost of the link between the super node and the receiver node. The cost of the link is evaluated based on the DRV algorithm. The disjoint route is defined as a set of routes with common end points that have no other vertices in common.

This network topology is an undirected weighted graph G(V, E). Where V represent the nodes and E represent the Edges. Figure 2 explains the example scenario of Disjoint Route Vector Algorithm. Here the route from source S to destination D contains 3 routes. The route 1 DRV is 2, route 2 DRV is 1 and route 3 DRV is 3. The sensor node constructs the Route Information Message (RIM) and it transmits the RIM to the neighborhood node that contains its ID, route information table, TTL (Time to Live) and PDR.

The sensor node receives this RIM and checks the combination of existing and current received route information through RIM. The DRV is calculated for the existing route and the current route. If the current route decreases the DRV, then the route information table is updated. Otherwise, this route information table is not updated. Every sensor node obtain the RIM while route information collection stage. Then every node send Notify message for each of its selected disjoint route. Every neighbor node in the disjoint route marks each other as required neighbor of its neighbors. If any two neighbor nodes do not mark each

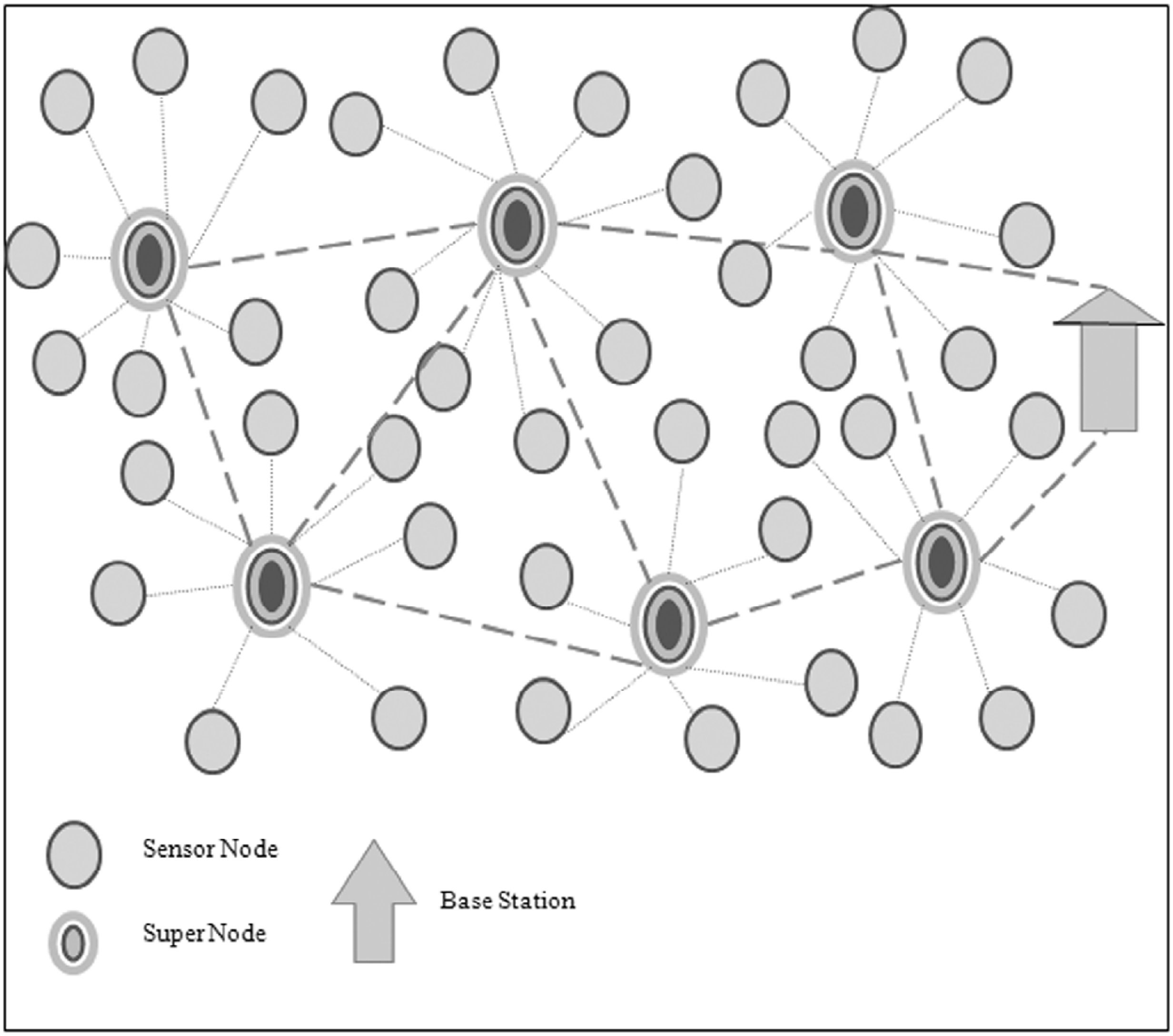

Figure 1: Architecture of the QoS-EDTC Scheme

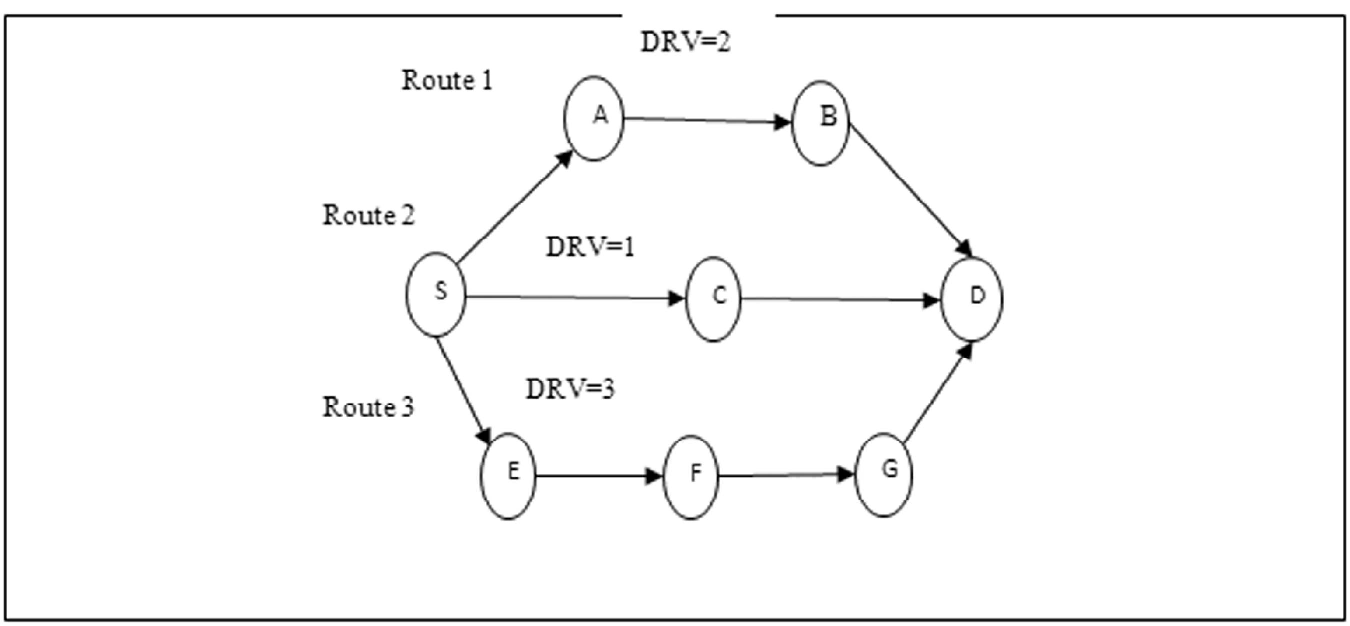

Figure 2: Example Scenario of Disjoint Route Vector Algorithm

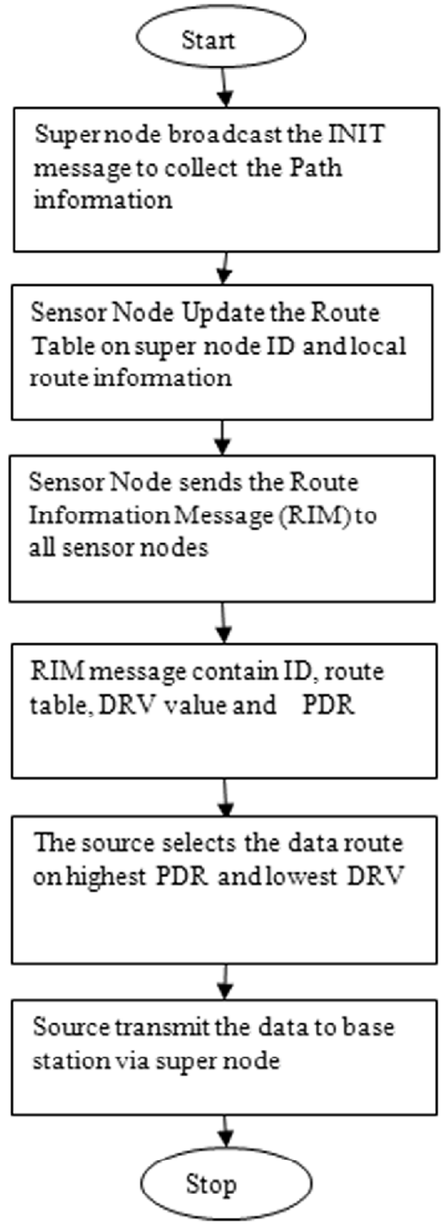

Figure 3: Flowchart of the proposed Scheme

other as required neighbor that link is not necessary and is removed. While data transmission, the highest PDR and the lowest DRV value route is elected by source. This scheme can achieve less transmission power and therefore it reduces the energy consumption and also the excessive control message transmission in the network. The PDR based sensor node election path improves the QoS in the network.

The figure 3 indicates the flowchart of the proposed scheme. The super node sends the INIT message to sensor nodes. The received sensor nodes update their routing tables on super node ID. Then sensor node transmits the RIM to the sensor nodes. RIM message consist of DRV value, PDR and Route table. The source selects the data route on highest PDR and lowest DRV value. Finally, the data is transmitted through selected route to the BS.

4. SIMULATION ANALYSIS

The performance of the QoS-EDCTE is analyzed by using the Network simulator (NS2). The NS2 is an open source programming language written in C++ and OTCL (Object Oriented Tool Command Language).

Table 1
Simulation parameters

Parameter	*Value*
Channel Type	Wireless Channel
Simulation Time	50 s
Number of nodes	50
MAC type	802.11
Traffic model	CBR
Antenna Model	Omni Antenna
Simulation Area	1000 × 600
Transmission range	250m, 180m
Network Interface Type	Wireless PHY

The nodes are distributed in the simulation environment. The parameters used for the simulation of the QoS-EDTC scheme are tabulated in Table 1

The simulation of the proposed scheme has 50 nodes deployed in the simulation area 1000×600. The nodes are communicated with each other by using User Datagram Protocol (UDP). The traffic is handled using the traffic model CBR (Constant Bit Rate). The radio waves are propagated by using the propagation model two-ray ground. All the nodes receive the signal from all direction by using the Omni directional antenna. The performance of the proposed scheme is evaluated by the parameters packet delivery rate, packet loss rate, average delay, throughput and residual energy.

4.1. Packet Delivery Rate

Packet Delivery Rate (PDR) is the ratio of number of packets delivered to all receivers to the number of data packets sent by the source node. The PDR is calculated by Equation 1.

$$PDR = \frac{Total\ Packets\ Received}{Total\ Packets\ Send} \quad (1)$$

Observations from figure 4 indicates that the QoS-EDTC scheme achieve better PDR than the existing method FC-ATC. The greater value of PDR means the improved performance of the protocol.

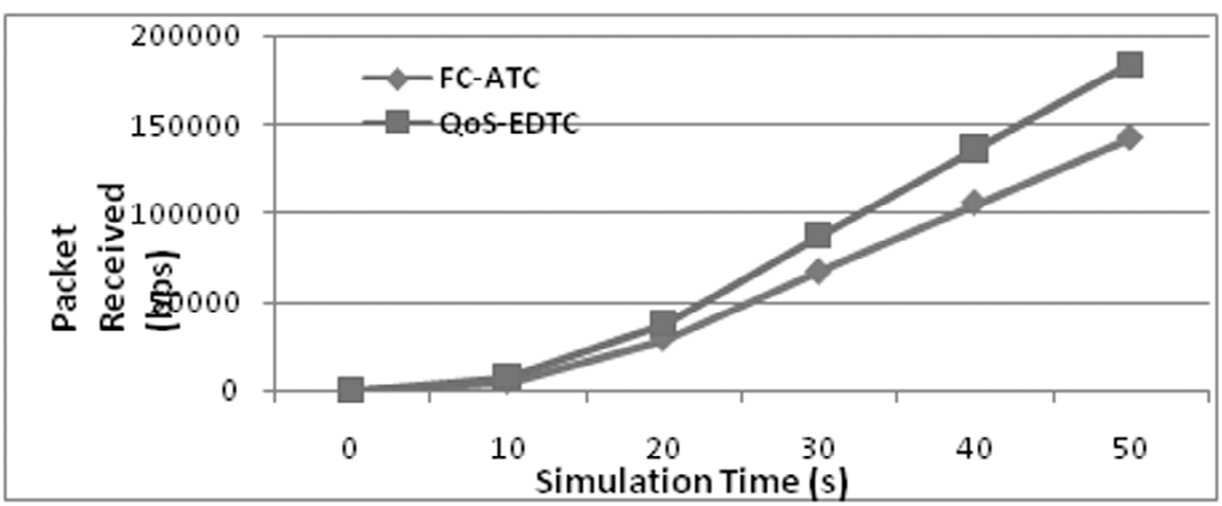

Figure 4: Packet deliveries Rate

4.2. Packet Loss Rate

The Packet Loss Rate (PLR) is the ratio of the number of packets dropped to the number of data packets sent. The PLR is calculated by Equation.2.

$$PLR = \frac{Total\ Packets\ Dropped}{Total\ Packets\ Send} \tag{2}$$

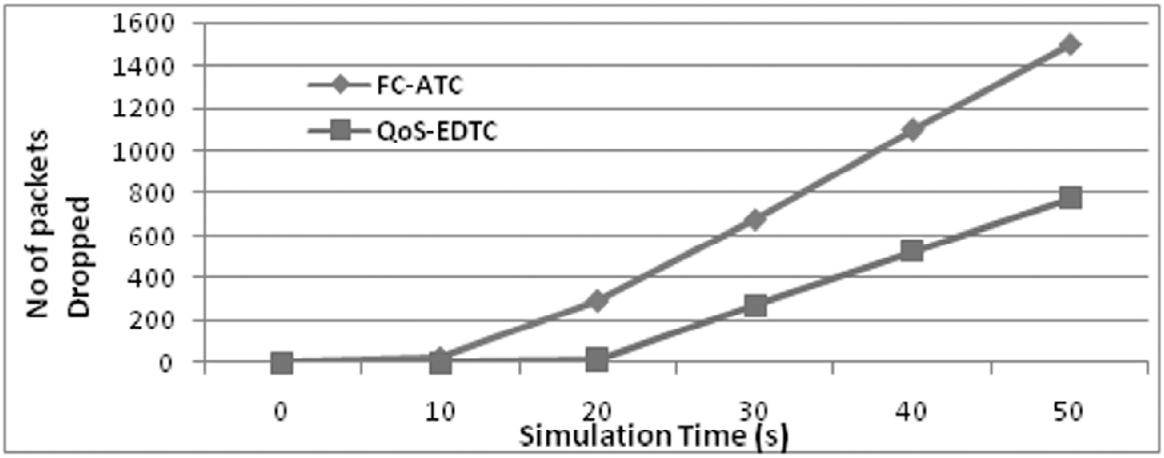

Figure 5: Packet Loss Rate

The PLR of the proposed scheme QoS-EDTC is lower than the existing scheme FC-ATC in Figure 5. Lower the PLR indicates the higher performance of the network.

4.3. Average Delay

The average delay is defined as the time difference between the current packets received and the previous packet received. It is measured by Equation 3.

$$Average\ Delay = \frac{Pkt\ Recvd\ Time - Pkt\ Sent\ Time}{time} \tag{3}$$

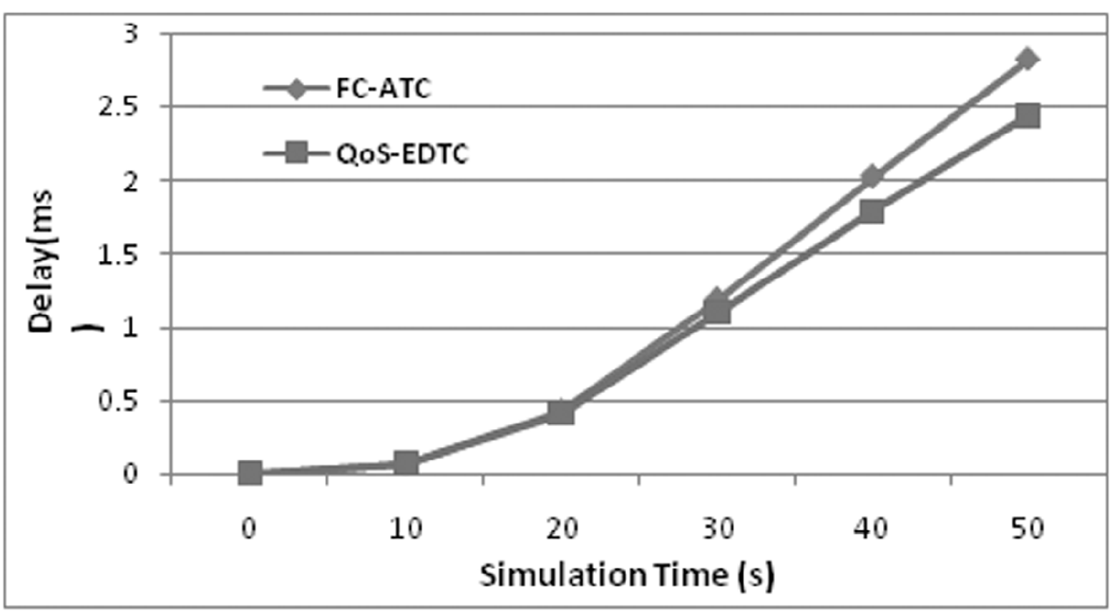

Figure 6: Average delay

Figure 6 demonstrates the performance of delay with respect to the simulation time. The result shows that the QoS-EDTC has minimum delay when compared to the existing scheme FC-ATC. The minimum value of delay means the higher value of the throughput of the network.

4.4. Throughput

Throughput is the average of successful messages delivered to the destination. The average throughput is calculated using Equation. 4.

$$Throughput = \frac{\sum_{0}^{n} Pkts\ Received\ (n) *\ Pkt\ Size}{1000} \tag{4}$$

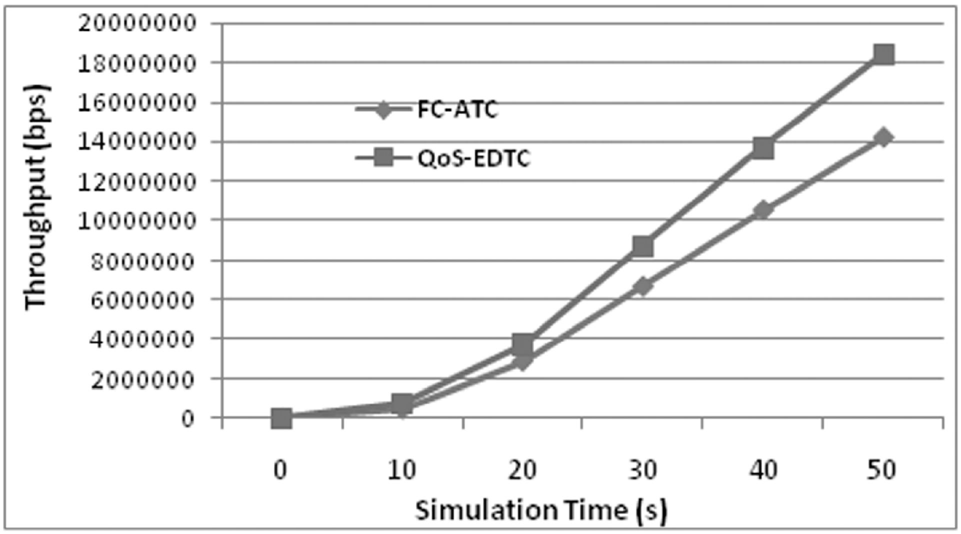

Figure 7: Throughputs

Figure 7 show that the proposed scheme QoS-EDTC has greater average throughput when compared to the existing scheme FC-ATC.

4.5. Residual Energy

The amount of energy remaining in a node at the current instance of time is called as residual energy. A measure of the residual energy gives the rate at which energy is consumed by the network operations.

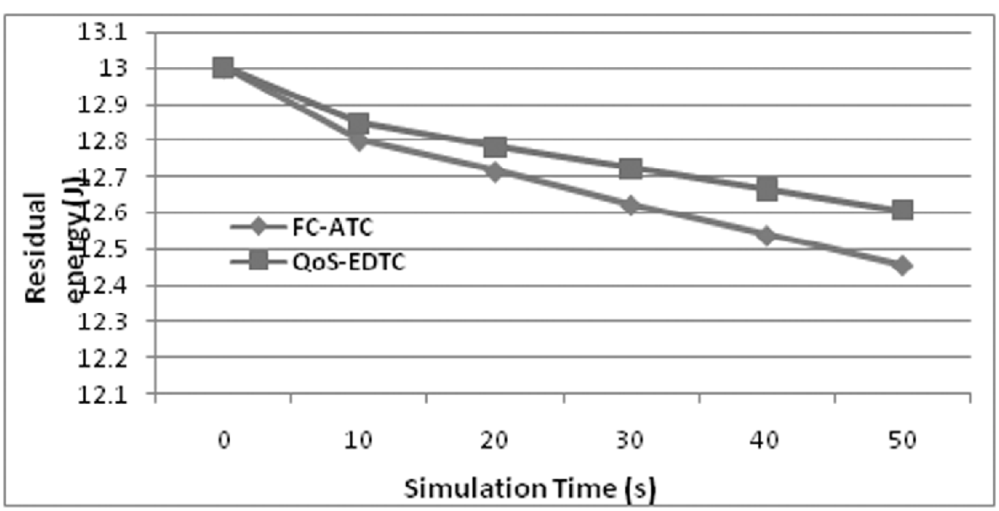

Figure 8: Residual Energy

Figure 8 shows that the residual energy of the network is better for the proposed scheme QoS-EDTC when compared with the existing scheme FC-ATC.

5. CONCLUSION

The benefit of HWSN provides different type of data from different sensors in same network. In this paper, we proposed QoS Enhancement on Distributed topology Control algorithm for HWSN using Disjoint Route Vector (DRV) algorithm. This scheme consists of super nodes and ordinary sensor nodes. DRV algorithm is used to remove the disjoint vertex from the route. We measure the Packet Delivery Ratio for route node to improve the Quality of Service in the network.The goal of the algorithm is to minimize the total transmission power of the nodes in the network. Through extensive simulations, this approach increases residual energy and reduces the packet losses.

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