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REVIEW OF QUALITY OF SERVICE IN ROUTING PROTOCOLS FOR WIRELESS SENSOR NETWORKS

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ABSTRACT

Rapid innovative improvements in wireless communication technology have revolutionized wireless sensor networks (WSNs). A WSN is comprised of self-ruling sensors that are distributed spatially to monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion, or pollutants, and to pass this information through the network to a main area. Sensor nodes in wireless sensor networks experience the ill effects of resource constraints, such as energy deficits, buffers, and bandwidth issues. The expanding demand for real-time services in WSN applications means that interest in quality of service (QoS)-based routing has risen. Offering consistent QoS in sensor networks creates considerable challenges. In real time applications, it is important to deliver data as soon as it is sensed. If the network has multiple real and non-real-time applications, its ability to manage them will be challenging due to different requirements. In this study, we investigate QoS-based routing protocols for WSNs. Metrics of analysis are end-to-end delay, congestion, energy efficiency, and reliability. The aim of the study is to identify the limitations of relevant papers and show research direction in routing. This will not only help new comers to the field of WSN but also will ease the tasks of WSN researchers in developing appropriate routing solutions for WSNs.
Kewwords: *QoS, WSN, End-to-end Delay, Congestion, Energy Efficiency, Reliability, Heterogeneity.*

1. INTRODUCTION

WSN can be described as a network containing a large number of wireless sensor nodes that gather information from their adjacent surroundings and transmit the resulting data to a Base Station or sink node [1],[2],[3]. These sensor devices contain a tiny microprocessor, a small battery, a set of transducers and a radio transceiver [4],[5],[6] as shown in Figure 1.

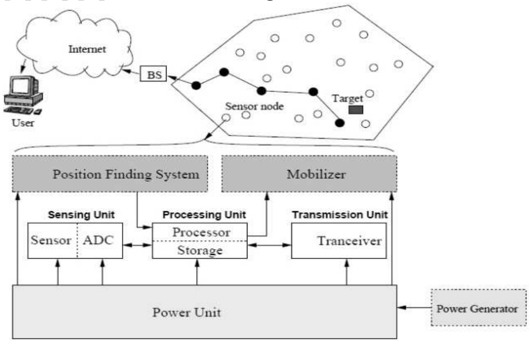

Figure 1.The Components Of Sensor Node

Sensor nodes may significantly impact the proficiency of numerous military and civil applications such as intrusion detection, target field imaging, weather monitoring, security, distributed computing, tactical surveillance, disaster management, inventory control, detecting ambient conditions such as temperature, movement, sound, light, and the detection of specific items [7],[8]. The sending and arranging of a sensor network in these applications can occur in an arbitrary manner (e.g., dropped from a plane) or can be accomplished manually [9],[10]. For instance, in a disaster administration application, several sensors can be dropped from a helicopter [11]. Organizing these sensors can support salvage operations by finding survivors, identifying unsafe ranges, and advising the salvage group of the general circumstances surrounding a hazardous situation. Inquires about how to addresses the capabilities of a joint effort between sensors when gathering information, preparing, and coordinating and administrating

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sensing actions were made. Sensor nodes have a limited energy supply and bandwidth capabilities.

Routing in WSNs is exceptionally challenging due to the inborn qualities of sensor nodes. In certain applications, information must be conveyed by a specific time frame from the minute it is sensed or the information becomes irrelevant. Subsequently, limited latency for information delivery is an essential condition for real-time applications. The delivered information must also be reliable. All these demands increase the challenges of QoS routing.

QoS routing protocols must strike a balance between energy utilization and data quality in QoS-based routing protocols [15]. Particularly, the network must fulfill definite QoS parameters, such as end-to-end delays, bandwidth, energy, jitter, and packet loss rates when transferring information to the base station. Additional congestion contained by the network must be avoided.

In this paper, some QoS methodologies based routing protocols have been presented and analyzed. All the studied protocols in this paper concern about end-to-end delay due to its importance. However, sensor nodes have limitation in energy and memory and there are some metrics that affect end to end delay which is congestion. Also, some WSNs have multiple applications which require reliability and lower end-to-end delay.

This paper reviews some QoS routing protocols that have been proposed for WSNs. Section 2 presents the implementation of QoS in WSN. The issues of QoS routing protocols of WSN are discussed in Section 3. Section 4 discusses the open issues in WSN that can be implemented in the future. Finally, section 5 concludes the paper.

2. THE IMPLEMENTATION OF QOS IN WSN

Sensor nodes are limited by their small energy resources and bandwidth. Routing protocols in WSNs are extremely demanding in terms of the intrinsic specifications of sensor nodes. In many functions, data must be delivered as soon as it is read by the sensor; if it is not, the information may become useless. Therefore, constrained delays for information delivery are a significant factor for time critical applications. Additionally, the information delivered must be reliable. These requirements make QoS based routing very demanding.

A sensor network is a data-centric network. Task-critical applications such as military and disaster management are additionally data-centric [12]. The loss of data and delays, which may occur because of congestion, cannot continue without serious consequences in these applications. At the point when the information rate increases, network load and data traffic increases. This introduces congestion. Congestion occurs because of buffer overflow, channel occupancy, high data rates, packet collisions, and many-to-one-nature. Nodes also become congested because of the deployment area. The nodes that are nearer to the sink have a higher risk of becoming congested because they receive data from numerous nodes and transmit this data to the sink node. Congestion causes increased packet drop rates, delays, and decreased throughput and shortens the lifetime of the node. Consequently, congestion must be reduced to meet a specific end goals that enhance QoS in wireless sensor networks using links, throughput, and decreasing errors and delays. Congestion control also reduces the energy consumption of the sensor nodes.

In addition to being sensitive to congestion, nodes are also affected by the area of the deployed sensor nodes. The nodes nearest the base station are more likely to become congested because they obtain information from several other nodes and broadcast data to the base station. Congestion boosts the delay, packet drop rate and reduces the life span of the node and throughput. Consequently, congestion should be reduced to increase QoS in terms of throughputs, link operations, and delay reduction, in a WSN. Congestion control also enhances the energy efficiency of a WSN.

In WSN, energy is used by communication processes, incorporation, and data processing [13] [14]. However, the amount of energy needed for communication is greatest. Consequently, a great deal of attention has been given to decreasing communication overheads in WSN by deploying an energy efficient routing protocol. There must be numerous corridors to communicate data from the source node to the end node to attain robustness. If all traffic is routed through a minimum energy path, the nodes will aligned with this path and energy resources will be depleted thus quickly rending other nodes ineffective in terms of the network partition even though they can access energy resources. Instead of minimizing the total amount

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of energy used on a path, the attached network should be preserved for as long as possible.

The employment of multi hop routing is normal in WSNs. An increase in the quantity of hops decreases the energy used by the collection nodes as the transfer power of radio and distance squared (or higher) is relative. More hops boost packet delays and decreases the control of delay constrained traffic [16]. Consequently, to address the delivery needs of the constrained traffic, QoS data routing of will sacrifice energy efficiency. Looking only at the number of hops is not an appropriate principle for calculating delays since delays in every node are the result of several factors such as transmission, propagation, and processing delays. In addition, looking at only the hop count depletes the energy in those nodes. Sensor nodes use energy for communication and to make calculations. Communication uses the majority of energy.

As discussed earlier, the energy of transmission is connected to pathway between the transmitter and the recipient; therefore topology control must reduce the distance between neighbor nodes next to a path. The magnitude of confirming latency restrictions and the energy restraints faced by the nodes has generated a number of studies in the area of topology control that attempt to create proficient topology controls that consider delay constraints.

In conventional best-exertion routing, delays and throughputs are the major concerns. There is no assurance that a delay or throughput will be guaranteed during a connection. Nevertheless, in a number of situations where real-time or multimedia data are concerned, quantity of service can guarantee a specific degree of bandwidth, delays, and delay jitters, as required. For example, guarantees can be attained by using particular instruments recognized as QoS routing protocols. Whereas modern best-exertion routing methods tackle unimpeded traffic, QoS routing is typically conducted through resource conditions in connection-oriented communication so as to organize the QoS needs for every individual correlation. The primary design objectives of QoS-based routing protocols are used to guarantee optimized QoS measurements including energy efficiency, delay bound, and low bandwidth consumption while attaining energy efficiency in WSN applications.

More recently, a few projects have endeavored to meet QoS needs in WSNs. In this study, we discussed the state of this research by summarizing published studies and emphasizing the QoS problems considered in those studies as shown below in Table 1.

Table1. The Parameters and Their Definitions.

The Parameter	The Definition
End-to-end Delays	This is the most important factor especially for real time applications that deliver sensed data as quickly as possible.
Energy efficiency	Energy efficiency decreases the amount of energy used while attaining QoS in WSN. This parameter is important because sensor nodes have small, non-rechargeable batteries.
Congestion	Congestion occurs because of buffer overflow, channel occupancy, high data rates, packet collision, and many-to-one-nature.
Reliability	Reliability is the result of confirming that a packet has been received.
Throughput	Throughput is the number of messages successfully delivered per unit of time. Throughput is effected by accessible bandwidth, in addition to the accessible signal-to-noise ratio and hardware restrictions.
Packet Loss	Packet loss refers to the number of packets dropped before they reach their destination.
Bandwidth	Bandwidth is usually calculated in bits per second. It is the fastest rate at which information can be transmitted.

This paper focused on delays, energy efficiency, congestion, and reliability.

3. THE ISSUES OF QOS ROUTING PROTOCOLS OF WSN

Researchers have proposed many different protocols for QoS routing in terms of controlling congestion, timeliness, reliability, and energy efficiency. End to end delay, energy efficiency, congestion, reliability and heterogeneity are concerned in this review. Some protocols is presented and summarized in the coming subsections. Routing protocols in this review

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considered some or all of the mentioned parameters. Table 2 shows several protocols, their parameters, and their drawbacks. The various protocols found in the literature are discussed below.

3.1 End-to-end Delay

An end-to-end delay is the time taken by the packets sent by the source to reach the sink. When sensor node data is used to control a physical procedure, a guaranteed delay is fundamental for successfully controlling activities, such as medical monitoring, fire detection, and traffic lights. The protocol might not be trusted without a bound. End-to-end delays are constrained by path length. Even though the constructed paths are optimal, the number of unsuccessful transmissions at each hop causes more delay. These unsuccessful retransmissions are mainly due to collisions, buffer overflow, and the early depletion of energy. All the protocols in this review were concern with end-to-end delays.

3.2 Energy Efficiency

Energy efficiency is important in wireless sensor networks because they use small non-chargeable batteries. In this section, a few energy efficient protocols will be summarized and discussed.

A previous projected routing protocol that offered a degree of QoS is the Sequential Assignment Routing Protocol (SAR) [17]. SAR is a multi-path routing protocol. It makes routing decisions using three metrics: the QoS on each path, each packet's priority level, and energy resources. Its structure resembles a tree rooted at the source that creates multiple paths. As the paths are constructed, the nodes that contain lower QoS and with little remaining energy are avoided. The majority of nodes will share multiple paths as the tree grows. To broadcast data to a base station, SAR choose a path by calculating a weighted QoS measure as an output of the added substance QoS measure and a weighted coefficient in connection with the previous level of the packet. Using multiple paths boosts fault tolerance but the overhead of maintaining routing tables and QoS measures at every node is a weakness of a SAR protocol

A message-initiated constrained-based routing (MCBR) scheme was developed by [18]. MCBR is a collection of route constraints, constraint-based destinations, QoS needs for messages, and a group of QoS aware meta-strategies. In terms of routing limitations, destinations and routes from the source node to a specific node are recognized. In meta-routing strategies applications, a message is routed from the source to its destination via a path that satisfies the QoS needs for that message. Nonetheless, it suffers overhead because of the high number of control packets. The same researchers that developed MCBR have developed a QoS aware learning-based routing to reduce the difficulty of using the MCBR protocol and to improve its performance [19].

A multi-constrained QoS multi-constraint multi-path (MCMP) routing protocol [20] employs braided routes to transfer messages to the base station depending on delay and reliability QoS needs. The issue of end-to-end delays is seen as an enhancement issue, which is a type of probabilistic programming. An algorithm based approach using a linear integer programming is used to settle the dilemma. The algorithm uses the possibility of connections with delay constraints and reliability as routing parameter choices. However, the requirement of reliability cause redundancy and consumes energy due to sending multiple copies.

The energy-constrained multi-path routing (ECMP) protocol [21] expands the MCMP protocol by preparing the QoS routing dilemma as an energy streamlining dilemma constrained by playback delays, reliability, and geo-spatial path choice constraints. The ECMP protocol balances the lowest number of jumps and least energy consumed by choosing the route that meets QoS needs and reduces energy use. However, it is not suitable for heterogeneous traffic.

One suggested QoS-based routing protocol, specially for WSNs, is an energy-proficient and QoS aware multi-path-based routing (EQSR) protocol [22] that supplies service delineation by offering complete privileged behavior for real time traffic over non-real-time traffic. EQSR uses a multi-path model combined with a forward error correction method to improve node disappointments without conjuring network wide flooding for route-detection. EQSR protocols use remaining energy, node accessible buffer size, and signal-to-noise ratios to forecast the next node during the route building stage. EQSR separates the transferred data into sections of equivalent size, adds alteration codes, and then transfers the data over multiple routes concurrently to increase the probability that a necessary section of a packet is

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obtain and extreme delays are avoided. The EQSR protocol controls all real-time and non-real-time traffic using a queuing model that can differentiate between services. However, it suffers from over head that cause because of updating its routing table.

Improved the minimum hop routing protocol improve the minimum hop routing by preventing some nodes from dying in the network [23]. They were able to do this by selecting hops that had more energy. However, it needs to also concern about congestion to reduce the delay.

ERes-QoS is a narrative Energy Reservation based QoS aware routing protocol [24]. ERes-QoS confirms end-to-end performance for important data on a node-by-node basis in terms of latency and reliability. ERes-QoS builds an angle based router set at every node to obtain in-time accessibility of information. To provide reliability, ERes-QoS employs a decision method at every node that utilizes Multipaths and conserves energy. It also uses a unicast node by node with acknowledgement, devoid of end-to-end route detection and preservation. This protocol offers a prioritized routing check by ranking information packets based on their significance. Its drawback includes the overhead that is generated by broadcasting. They also developed an energy–buffer aware reliable routing (EBARR) [25] protocol that is reliable and delivers critical messages. The EBARR maintains its reliability by prioritizing packet transmissions, conserving energy, and using a proficient buffer administration strategy to alleviate packet drops due to buffer overflows, and node-by-node flow control techniques to decrease the overhead associated with packet retransmission alongside multi-hop paths from the source to the base station. An angle-based router set guarantees the delivery of data that is very time sensitive. However, the EBARR faces challenges in terms of the overhead generated by broadcasting and may cause delay in the queue in case of high traffic.

The QoS-based energy-efficient sensor routing (QuESt) protocol [26] resolves application-precise, close ideal sensory paths by improving multiple QoS factors (latency and bandwidth) and energy consumption using a multi-goal genetic algorithm. The QuESt is capable of recognizing a group of QoS-based close ideal paths using only vague network information. However, congestion is not mentioned in this protocol.

EDEAR [27], (RSSI/energy-CC) [28], and DACR [29] employed reinforcement learning methods in their algorithms. EDEAR stands for Energy and Delay Efficient Adaptive Routing. EDEAR focuses on surveyor representative who are accountable for gathering data in terms of delay and energy use by deploying incessant learning factors to the network and updating routing at every node of the network. EDEAR was improved by developing a novel algorithm based on a multipoint relay for energy usage that decreased overhead generated by examining the packets. A reinforcement learning is used in [28] by rival modeling method that improved and optimized a helpful communication protocol based on RSSI and node energy usage in a spirited context (RSSI/energy-CC). In other words, they created an energy and QoS aware-based mutual communication routing protocol. DACR is a distributed adaptive cooperative routing protocol. DACR uses helpful communication on top of delay and energy-aware end-to-end routes and improved the trade-off between dependability and latency throughout Lexicographic Optimization at each node. They used a lightweight reinforcement learning technique to update routing nodes with information of supposed performances that should be supplied by the candidate relay hops. This helped establish an optimal relay that created very little overhead. In order to enhance and maximize reliability, the choice of transmission mode (i.e., straight or relayed transmission) at every node is considered adaptively. However, the disadvantage of their approach is that reinforcement learning can take a long time to learn and cannot act on unforeseen events.

DGEER is a Delay-Guaranteed Energy-Efficient Routing protocol [30]. In DGEER, time critical packets are transferred using the shortest path to decrease their end-to-end delays while non-time critical are transferred to the subsequent node that is chosen based on its neighbor information, such as residual energy. The quantity wrapped by the length of information in the whole length of the queue and the depth, which eases congestion at congested nodes. However it suffers from the over head that caused by updating the routing table.

RSSI/energy-CC [28] and DACR [29] are compared to MRL-CC [31] and they obtained better results. Based on these results, we noticed that in terms of circle topology RSSI/energy performed better than DACR and MRL-CC. QuESt [26] conserved more energy than SPEED. Based on the

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results in [32], EQSR is found to be more energy efficient than MCMP, MMSPEED, MCBR and SAR because the EQSR protocol easily recuperates from path failures and can reconstruct the source-sent messages using a forward error correction technique. Furthermore, the results discussed in [25] show that significant energy is consume by the control packets in MCMP compared to EBARR and the data packets in MCMP consumed more energy because the nodes in EBARR exchange the request-reply packet only upon reception of the EBRreq packet. In [32] and [25], both EQSR and EBARR saved more energy than any other protocol except for EBARR, which save more energy due to lower control packets since EBARR use angle based scheme that do not require routing tables and have no need for control packets to update the tables.

3.3 Congestion

Congestion causes delays in transmitting data, buffers overflow, and reduces reliability. Consequently, avoiding congestion is critical to decreasing queuing delays and also preventing packet overflow section, a few protocols that provide congestion avoidance are be summarized and discussed.

SPEED [33] is an additional QoS-based routing protocol that offers soft real-time end-to-end guarantees. Every node contains information concerning its neighbors and exploits geographic forwarding to discover routes to its destination. To guarantee packet delivery affected by time restrictions, SPEED facilitates delivery by calculating latency by separating the distance to the base station by the packet delivery speed before it makes any admission decisions. In addition, SPEED can offer congestion evasion when the network is congested. Simulation results [33] have shown that SPEED performs better than other protocols but it does not make allowances for energy in its routing protocol, which raises questions about its energy efficiency.

The multi-path and multi-SPEED (MMSPEED) routing protocol discussed in [34] is one of the main protocols that segregates timeliness and reliability. Numerous QoS levels are provided by MMSPEED in timelines by using various delivery paces. The approach used by the MMSPEED to achieve reliability is a distinctive multi-path forwarding scheme with a number of paths that rely on a degree of reliability for traffic flows. However, MMSPEED lacks an approach for managing information repetition issues, which are the result of excessive energy use [35].

A narrative algorithm is proposed that called the Potential-based Real-Time Routing (PRTR) [36] to maintain time critical broadcasts in WSN that holds mingled traffic composed of time critical and non-time critical flows. In the description of every packet, PRTR deploys a bit flag to recognize if it requires lower delays or not. Particularly, PRTR labels all packets with flags as a “1” or delay receptive, whereas those packets labeled with “0” are non-delay receptive. Furthermore, a supporter apparatus called a priority queue is deployed to reduce the queuing delays for time critical traffic, which reduces end-to-end delays. However, it does not consider the energy efficiency, and this may cause depletion of energy in the shortest paths.

ExtTeGAR is a scheme that is capable of identifying the required data related to each kind of traffic and that can rate data classifications with the intention that every category of traffic guarantees that data demands will be met [37]. ExtTeGAR employs a distance based and a location aware method to make the shortest path for packets with known deadlines and it amplifies the broadcast range to improve the neighborhood sizes for continuous data delivery. However, the drawback of ExtTeGAR is the overhead generated by updating its tables and consuming energy when increasing the range transmission of the nodes.

MCMP, EQSR, ERes-QoS, EBARR, DGEER and QuESt are described in Section 3.1and they can all reduce delays.

Based on the results provided by [38] and [37], PRTR and ExtTeGAR performed better than SPEED in terms of delays but for non-real time packets, SPEED performed better than PRTR. QuESt [26] had lower end-to-end delays than SPEED. The results provided by [36] showed that DGEAR perform better than PRTR. Based on the results published in [22], the end-to-end delays for EQSR was lower than MCMP for real time packets and higher for non-real time packets. The results put forth by [25] demonstrated that there was significant lower end-to-end delays in EBARR compared to MCMP. However, EBARR performed better results due to buffering and energy conservation and its routing abilities that did not need to update routing tables and control packets.

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3.4 Reliability

A few researchers attempted to enhance QoS requirements in WSN. In this section, the protocols the provide reliability are summarized and discussed.

Originally, multi-path-based routing protocols developed in [38] [39] [40] seem to improve the reliability throughout numerous paths. Multiple paths were recognized between the source–purpose pair, before a single path so as to allow QoS. These protocols concentrated principally on fault tolerances, load balancing, bandwidth aggregation and decreased delays. Although these protocols offered these advantages, the faced problems connected with multi-path routing is route coupling. In [41], the issue of route coupling was investigated and a method was offered to couple two routes using an association factor. An N-to-1 multi-path detection protocol was developed in [42]that found diverse node-disjoint paths between a sink and an SN. These alternative routes were deployed to distribute traffic and improve the reliability and the safety of data broadcasts.

SAR, MCMP, EQSR, ERes-QoS, MMSPEED and EBARR, which are described in Section 3.1 and Section 3.2, are used to increase reliability.

Based on the simulation results reported by [22], EQSR was more reliable than SAR, MMSPEED, MCMP and MCBR because EQSR used the remaining energy, free buffer size, and Signal-to-Noise Ratio (SNR) to foresee the best next jump through the way development stage The EQSR protocol used a queuing model to handle both high priority and low priority packets. Additionally, EQSR utilized an error correction scheme that helped expand the delivery ratio to account for path failures. Based on the results provided by [22] and [25], we noticed that EQSR and EBARR are similar in terms of reliability. Overall, EQSR and EBARR perform better than MCMP.

3.5 Heterogeneity

A WSN that typically incorporates heterogeneous applications and all deployed sensor nodes may have multiple sensors (i.e. light, temperature, and seismic). Data generated by each application will have different priorities, characteristics, and requirements in terms of reliability and delivery.

SAR, MMSPEED, EQSR, PRTR, ERes-QoS, EBARR, DGEER and ExtTeGAR provide heterogeneous traffic in their algorithms. PRPT provides priority queue for packets to cut down on delays for real time packets, to use the shortest path for their delivery, and to use the idle path for non real time packets. EQSR chooses the best path for real-time traffic and creates 2 queues. One queue is a queue for high priority packets and the second queue is a First In First Out (FIFO) for low priority packets. DGEER uses the shortest path for high priority packets while low priority packets are sent along an alternative path selected using local neighbor information. EQSR also puts low priority packets at the end of the queue and places high priority packets before all non-real-time packets. ExtTeGAR classifies data traffic into four categories; real-time require reliability and lower delays, real-time require deadline to reach, non-real-time require reliability, and best effort traffic with no specific requirements. SAR and MMSPEED classify traffic based on required reliability and delays. ERes-QoS and EBARR classify traffic based on high and low priority packets and they both conserve energy. EBARR conserves the buffer for real-time traffics to increase reliability and decrease delays.

In WSNs, it is important to consider priority in heterogonous traffic. In some applications (such as fire detection applications), it is more important to know there is a fire than knowing that everything is fine.

4. OPEN ISSUES

Designing routing protocol is challenging because of the limitation of the sensor node such as low energy and small memory. Also there are requirement should be concerned in designing routing protocol in WSN such as low delay and reliability. In designing routing protocol, trade off should be done get acceptable results. Table 3 shows the metrics and the protocols that are not mentioned or covered.

Some WSNs consist of heterogeneous applications and deploy multiple sensor nodes (temperature, light, and seismic). Data is generated by any application will have different priorities, characteristics, reliability and delivery requirements. Consequently, the intermediate nodes will be loaded with time critical and non-time critical packets. In the future work, protocols

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should contain a technique to handle both types of packets.

As mentioned earlier, time critical packets must be delivered as fast as possible so that responsible parties may take some further action. There are factors that affect end-to-end delays such as energy and congestion. For example, if the shortest path from the source to destination is used all the time, the energy of those nodes will be depleted and this path will not remain in use. Therefore, the shortest path should only be used for critical data.

Energy and congestion are important factors that affect end-to-end delays and it is important to design a protocol that is concerned with end-to-end delays. Congested nodes and nodes with low energy should be avoided to reduce end-to-end delays and to avoid dropped packets. Reliability should be a concern, especially for high priority packets. Increasing the reliability by sending multiples copies in parallel may affects queue delays as well end-to-end delays. Therefore, protocols should have low end-to-end delays and furthermore the reliability is required by high priority packets.

Finally, as mentioned earlier, sensor nodes have limited energy resources or memory. A typical network will have thousands of nodes. The control packets that are used to update the routing tables should be reduced because these control packets may cause overhead and consume energy. A technique should be used to find paths to the sink, such as angle based scheme.

Table 3. The Issues Of Routing Protocols

Issue	Protocols
Energy	SPEED [33], MMSPEED [34], MCMP [20], ExTeGAR [37].
Congestion	SAR [17], MCMP [20], ECMP [21], QuESt [26], ERes-QoS [24], EDEAR [27], RSSI/energy-CC [28], DACR [29].
Heterogeneity	SPEED [33], MCBR[18], MCMP [20], ECMP [21], QuESt [26], EDEAR [27], RSSI/energy-CC [28], DACR [29].
Reliability	SPEED [33], MCBR [18], QuESt [26], DGEER [30], EDEAR [27], RSSI/energy-CC [28], ExTeGAR [37].

5. CONCLUSION

Recently, quite a number of QoS methodologies and strategies have been proposed. We have introduced a couple of network layer protocols that concern on QoS. This article principally focuses on end-to-end delays, congestion, energy efficiency, reliability and heterogeneity for wireless sensor networks. End-to-end delays are difficult to determine for occasional driven sensor networks because of their unusual movement designs. Additionally, end-to-end delays are frequently combined with different elements, for example, energy and congestion. In the event that energy efficiency is improved to increase the lifespan of the network, the administration of end-to-end delays will be hindered. Congestion results in long queuing delays in the buffer of the nodes, which leads to longer end-to-end delays. A queuing delay is a significant source of delay for information transmission.

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Table 2. The Existing Protocols And Their Issues

Algorithm	QoS Requirements					The issues
	End-to-end delay	Energy efficient	Congestion	Reliability	Heterogeneous	
SAR[17]	√	√		√	√	Overhead due to the control packets
SPEED[33]	√		√			consume energy and does not support heterogeneous traffic;
MCBR[18]	√	√	√			Overhead of the extra control packets
MMSPEED[34]	√		√	√	√	Data redundancy and consumes energy.
MCMP[20]	√			√		Data redundancy and consume energy.
ECMP[21]	√	√		√		Doesn't support heterogeneous traffic
QuESt[26]	√	√				congestion avoided is not supported
EQSR[22]	√	√	√	√	√	Tables updating
PRTR[36]	√		√		√	consume energy
ERes-QoS[24]	√	√		√	√	Overhead for broadcasting from the source and may cause delay in heavy traffic.
EBARR[25]	√	√	√	√	√	Overhead for broadcasting from the source and may cause delay in heavy traffic.
DGEER[30]	√	√	√		√	Updating tables
EDEAR[27]	√	√				Not suitable for unpredictable events.
RSSI/energy-CC[28]	√	√				Not suitable for unpredictable events.
DACR[29]	√	√		√		Not suitable for unpredictable events.
ExtTeGA*R [37]*	√		√		√	Increase transmission range which cause increase energy consumption.