# Grouping of nodes based on pattern for service among WSN

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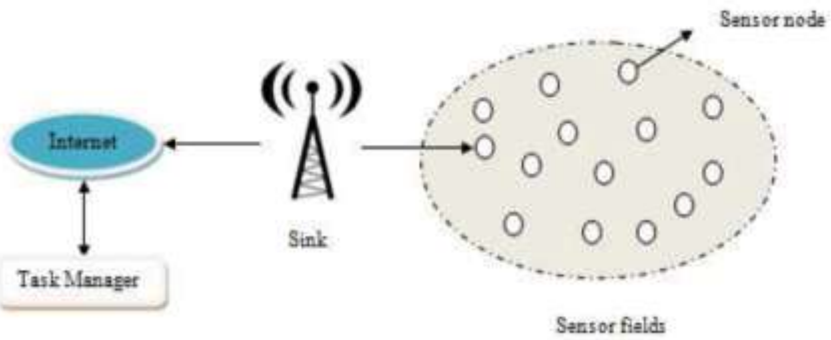
***Abstract:*** Wireless Multimedia Sensor Networks (WMSNs) has made it possible to send multimedia data on small sensing devices. The multimedia content in such networks increase the level of information collected from the monitored field, enlarging the range of coverage, and multi-view support. Wireless Sensors Network is used to monitor agriculture field, traffic signal management & Health Monitoring, Pollution control, Military applications etc. with limited energy resources. Various energy efficient routing schemes are available to send sensed information to Base Station (BS). The sensor nodes have a limited transmission range, and their processing and storage capabilities as well as their energy resources are also limited. Routing protocols for wireless sensor networks are responsible for maintaining the routes in the network and have to ensure reliable multi-hop communication under these conditions. In this paper, i have done a survey of routing protocols for WSNs by summarizing the work on QoS based routing protocols that has already been published and by highlighting the QoS issues that are being addressed. The performance comparison of QoS based routing protocols such as SAR, MMSPEED, MCMP, LEACH, and SPEED has also been analyzed for various parameters It is proved by researchers that the multi-tier network architecture is more beneficial than a single-tier in terms of energy-efficiency, scalability and reliability for multimedia data transmission. In this context, application like intrusion detection appears as a promising application of multi-tier WMSNs, where the lower tier can detect the intruder using scalar sensors, and the higher tier camera nodes will be woken up to send real time video sequences detected from the monitoring area. The multimedia data are quite different from the scalar data generated in Wireless Sensor Networks (WSNs), which demands real time delivery of data to target end to increase the Quality of Service (QoS). In this paper, the QoS aware routing protocols for WMSNs are surveyed with the performance issues and the design challenges of each protocol for WMSNs are discussed.

***Index Terms* – Quality of Service (QoS), Wireless Sensor Networks (WSN), Wireless Multimedia Sensor Networks (WMSNs), Multi-tier architecture.**

## I. INTRODUCTION

A generic wireless sensor network is composed of a large number of sensor nodes. Each of them has the capability of collecting data about an ambient condition, such as temperature, pressure, humidity, noise, lighting condition etc., and sending data reports to a sink node[1]. Wireless networks of smart sensors have become feasible for many applications because of technological advances in semiconductor, energy efficient wireless communications and reduced power budgets for computational devices, as well as the development of novel sensing material. Wireless multimedia sensor networks (WMSNs) has fascinated the researchers to gain the interest due to improvement in CMOS cameras and microphones. There many possibilities of capturing multimedia content for applications like traffic monitoring, telemedicine, intrusion detection and environment monitoring and military applications. Multimedia sensor networks is different from Sensor Networks due to various design constraints in WMSNs[3]. Multimedia contents are delay sensitive, thus, the design of these networks is focused around reducing latency overhead at each layer and fast delivery of information to the destination. Further, these networks are very delicate to packet damages which result in delay and loss of contents in the received multimedia data i.e. image, video or audio data. In multimedia sensor networks, packets received after their given deadline, are considered to be lost and contribute to the overall distortion. In some applications like traffic and habitat monitoring, loss of some information can be tolerated but in other applications, such as, surveillance or battlefield monitoring, real-time delivery of multimedia content is very important. Delay and packet loss are very strictly correlated to each other, and it is necessary to guarantee real time delivery of each packet to the target. Many routing protocols with various routing metrics have been developed for WSNs. However, very less research has been done on Wireless Multimedia Sensor Networks (WMSNs) routing protocols and there is need of improvement in this area. Moreover, multimedia delivery demands high bandwidth, real-time transmission, lower frame loss, tolerable end-to-end delay and jitter[5]. WSNs provide efficient and reliable means for the observation of some physical phenomena which are otherwise very difficult, if not impossible, to observe, and initiation of right actions based on the collective information received from sensor nodes. These sensor nodes communicate over short distance via a wireless medium and collaborate to accomplish a common task. As the Internet has revolutionized our life via the exchange of diverse forms of information readily among a large number of users, WSNs may, in the near future, be equally significant by providing information regarding the physical phenomena of interest and ultimately being able to detect and control them or enable us to construct more accurate models of the physical world.



**Wireless Sensor Networks Model**

## II. OVERVIEW

Typical WSN consists of a number of sensor devices that collaborate with each other to accomplish a common task (e.g. environment monitoring, object tracking, etc.) and report the collected data through wireless interface to a sink node. The areas of applications of WSNs vary from civil, healthcare and environmental to military. Examples of applications include target tracking in bat-tlefields, habitat monitoring, civil structure monitoring, forest fire detection and factory maintenance [1]. However, with the specific consideration of the unique properties of sensor networks such limited power, stringent bandwidth, dynamic topology (due to nodes failures or even physical mobility), high network density and large scale deployments have caused many challenges in the design and management of sensor networks. These challenges have demanded energy awareness and robust protocol designs at all layers of the networking protocol stack [2]. Efficient utilization of sensor's energy resources and maximizing the network lifetime were and still are the main design considerations for the most proposed proto-cols and algorithms for sensor networks and have domain. However, de-pending on the type of application, the generated sensory data normally have different attributes, where it may contain delay sensitive and reliability demanding data. Furthermore, the introduction of multimedia sensor net- works along with the increasing interest in real time applications have made strict constraints on both throughput and delay in order to report the time-critical data to the sink within certain time limits and bandwidth requirements without any loss. These performance metrics (i.e. delay and bandwidth) are usually referred to as Quality of Service (QoS) requirements [3]. Therefore, enabling many applications in sensor networks requires energy and QoS awareness in different layers of the protocol stack in order to have efficient utilization of the network resources and effective access to sensors readings. Many routing solutions specifically designed for WSNs have been proposed [4,5]. In these proposals, the unique properties of the WSNs have been taken into account. These routing techniques can be classified according to the protocol operation into negotiation based, query based, QoS based and multi-path based. The negotiation based protocols have the objective to eliminate the redundant data by include high level data descriptors in the message exchange. In query based protocols, the sink node initiates the communication by broadcasting a query for data over the network. The QoS based proto- cols allow sensor nodes to make tradeoffs between the energy consumption and some QoS metrics before deliv-ering the data to the sink node [6]. Finally, multi-path routing protocols use multiple paths rather than a single path in order to improve the network performance in terms of reliability and robustness. Multi-path routing establishes multiple paths between the source-destination pair. Multi-path routing protocols have been discussed in the literature for several years now [7,8]. Multi-path routing has focused on the use of multiple paths primarily for load balancing, fault tolerance, bandwidth aggre- gation and reduced delay [9]. Data gathering is a typical operation in many WSN applications and data aggregation in a hierarchical man-ner is widely used for prolonging network lifetime. Data aggregation can eliminate data redundancy and reduce the communication load. Hierarchical mechanisms (especially clustering algorithms) are helpful to reduce data latency and increase network scalability [10]. Clustering techniques have emerged as a popular choice for achiev-ing energy efficiency and scalable performance in large scale sensor networks.

## III. APPLICATIONS OF WSN

The invention of low power computational and low cost audio sensor created many new applications, which enhance the functionality if an existing WSNs. Some of those applications are classified as follows [9][10].

### 1. Multimedia Surveillance System

Surveillance sensor networks is used to improve the performance of existing systems to prevent crime. Multimedia data like image, video captured from cameras can be used to find the missing persons and identify criminals.

### 2. Traffic Avoidance and Control

This can be used to monitor the traffic in big cities or on highways which offer better traffic routing advice. Also, allow to find the available spaces for parking and guide the driver through automated parking system.

### 3. Health Care Delivery

Telemedicine sensor networks can be used to provide health care services. Patients will be carrying the medical sensors and remote medical centres can easily monitor the condition of patients to provide medical facility in emergency situations.

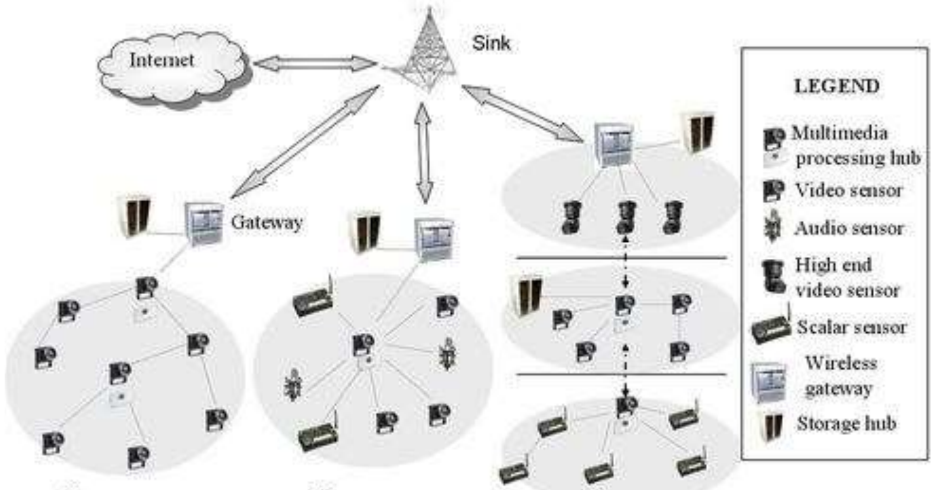
### 4. Environmental Monitoring

Multimedia sensors can be used to continuously monitor the environment and also are used to monitor the bridges or other civil structures.

### 5. Industrial Process Control

Multimedia content such as video, image can be used for industrial process control. In automated manufacturing processes, WSNs help the system to make it simple and add flexibility for visual inspections and automated services.

## ARCHITECTURE



(a)
Single-tier flat,
homogeneous sensors,
distributed processing,
centralized storage

(b)
Single-tier clustered,
heterogeneous sensors,
centralized processing,
centralized storage

(c)
Multi-tier,
heterogeneous sensors,
distributed processing,
distributed storage

## VI. QOS AWARE ROUTING PROTOCOLS FOR WSN

The network layer is an important layer to provide QoS for multimedia application because it is responsible for providing energy efficient path that meets QoS requirements.[2] The QoS-aware routing protocols are to be the most suitable protocols for WMSN. Many QoS aware routing protocols have been proposed for WMSN. However, still lots of improvement is needed in these protocols in order to meet the multimedia requirements. This section discusses the various routing protocols proposed for WMSN along with features and limitations of each protocol.

### A. Sequential Assignment Routing (SAR)

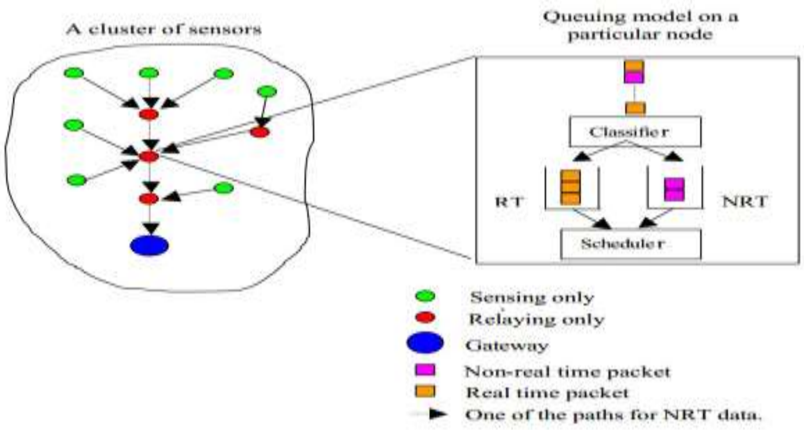
Sequential Assignment Routing (SAR) [11][12] is the first routing protocol which consider the QoS and energy for sensor networks. The main objective of the SAR is to make the network energy-efficient and fault tolerant. SAR uses multihop routing and routing tables to store the information about its neighbors. To form the multiple paths from each node to the sink, multiple trees are constructed, and all these paths will be rooted from one-hop neighbor of the sink. To select the appropriate path, it takes into account the energy resource, the QoS on each path, and the priority level of an each packet. For each packet in a network, SAR calculates the weighted QoS metric, which is the product of the additive QoS metric and a weight coefficient which is associated with the priority level of that packet. The lower that the average weighted QoS metric is, the higher the QoS level will

be. It handles the failures within network, by a handshaking process, which enforces routing table consistency between the upstream and downstream neighbors on each path. The limitation of this protocol is that the overhead to maintain the tables and storing the information about the status of each sensor node most importantly when the number of nodes are more in the network.

### B. Energy-aware and QoS-based protocol (EQSR)

EQSR [7] is an energy-aware and QoS-based protocol that finds a least cost and energy efficient path and guarantees certain end-to-end delay. Figure , shows the differentiated traffic classifier with best effort and realtime queues. It supports both types of traffic using a queuing model shown in the Figure 2, that permit sharing of service between both types of traffic. The scheduler ensures that best-effort traffic should not reduce resources that are required for real-time traffic. This protocol is based on a multipath approach that uses enhanced version of Dijkstra's algorithm to find a list of least cost paths and chooses the path which meets the desired requirements. The performance EQSR is good in terms of QoS and energy metrics. But, it only considers one real-time priority class which is only suitable for a single real-time application and for multiple applications because it requires several priority classes for different real-time traffic.

**Fig. Queuing model for Energy-aware QoS routing protocol [7]**



### C. A Stateless Protocol for Real-Time Communication in Sensor Networks (SPEED)

SPEED [4] is a QoS routing protocol for WSNs that provides soft real-time end-to-end guarantees. It maintains the desired delivery speed across the network so that the end-to-end delay is minimized. Each node keeps information only about its immediate neighbors and geographic location information is used to make localized routing decisions. So, the protocol is called "stateless," as it does not use routing tables, which result in minimal memory usage. Stateless Non-Deterministic Geographic Forwarding (SNGF) is the routing module responsible for choosing the next hop neighbor and it works with 4 other modules i.e. Beacon Exchange, Delay Estimation, Backpressure Rerouting, and Neighborhood Feedback loop at the network layer to achieve the desired delivery speed across the sensor networks. The neighbor beacon exchange module provides the geographic location of the neighbors. The delay estimation module calculates the delay in each node and helps the SNGF to select the node meeting speed requirements and also to determine the occurrence of congestion. If a node meeting desired speed requirement can’t be found, the relay ratio of that node is checked. The relay ratio is provided by the Neighborhood Feedback Loop (NFL) module to determine whether the packet is to be relayed or dropped The backpressure rerouting module is used to prevent voids at holes i.e., when a node fails to find the next hop node or if congestion occurs, it sends the message back to the source nodes so that they can take new routes.

SPEED protocol perform well in achieving end-to-end delay ratio and the miss ratio. The main limitations of the SPEED protocol is that it does not provide any packet differentiation service. It gives the same preference to both real time and non-real time packets. Also it is not scalable, as it maintains desired speed for each packet, so the performance of SPEED degrades, if the parameters are changed.

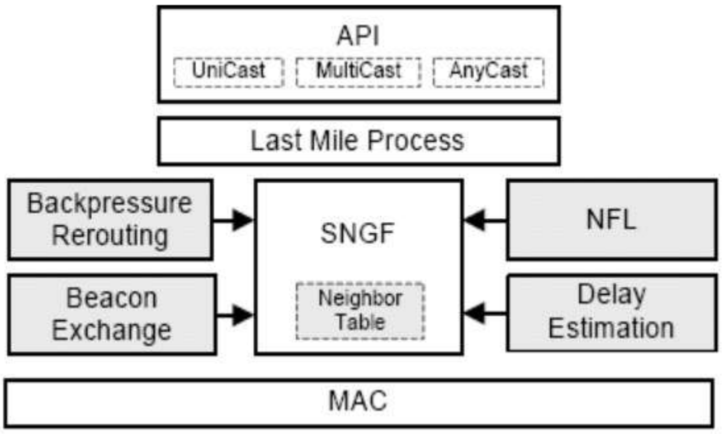


**Fig. 3. SPEED Protocol [4]**

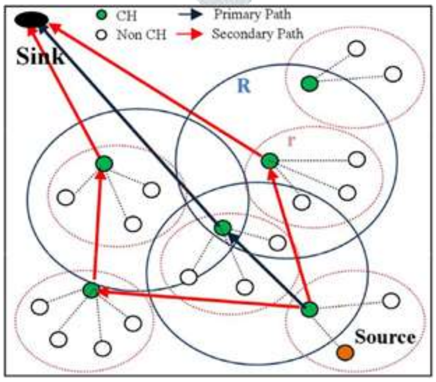
### D. REAL-TIME POWER-AWARE ROUTING (RPAR)

Real-time Power-Aware Routing protocol (RPAR) [5][15] support energy efficient and real-time communication in wireless sensor network. It is different from the other existing protocols in many ways :

- It uses the power control and real-time routing for supporting energy-efficient and real-time communication.
- It better control the trade-off between energy uses and communication delay by giving deadline to each packet.
- The novel neighbourhood management mechanism used by this is more efficient than the periodic beacons scheme adopted by protocols such as SPEED and MMSPEED.
- It minimizes the miss ratios by using dynamic transmission power adjustment and routing decision.

## V. PERFORMANCE EVALUATION

We used NS-2 to implement and simulate QEMH and compare it with the EAP and MCMP protocols. Simula-tion parameters are presented in Table 1 and obtained results are shown below. We investigate the performance of the QEMH in a multi-hop network topology. The metrics



### Impact of Packets Arrival Rate

We change the packet arrival rate at the source node from 5 to 50 packets/second. The generated traffic at the source node is mixed traffic of both real-time and non-real-time traffic. The real-time traffic is set to 10% of the generated traffic.

**1) Average end-to-end delay**

The average end to end delay is the average time re-quired to transfer a data packet from source node to the sink node. The Average end to end delay is an important metric in evaluating QoS based routing protocols. The average end to end delay of QEMH, MCMP and EAP protocols as the packet arrival rate increases is illustrated in Figure 6. From the results, it is clear that QEMH suc-cessfully differentiates network service by giving high real-time traffic absolute preferential treatment over low priority traffic. The real-time traffic is always combined with low end-to-end delay. MCMP protocol outperforms QEMH in the case of non-real-time traffic, because of the overhead caused by the queuing model. Furthermore, for higher traffic rates the average delay increases be-cause the our protocol gives priority to process real-time traffic first, which causes more queuing delay for non-real-time traffic at each sensor node. Performance of EAP protocol has reduced because of the overhead caused by the creation spanning tree.

**2) Packet delivery ratio**

Another important metric in evaluating routing proto-cols is the average delivery ratio. The average delivery ratio is the number of packets generated by the source node to the number of packets received by the sink node. Figure 7 shows the average delivery ratio of QEMH, MCMP and EAP protocols. Obviously, QEMH outper-forms the MCMP and EAP protocols; this is because in the case of path failures, our protocol uses forward error correction (FEC) technique to retrieve the original mes-sage, which is not implemented in the MCMP and EAP protocols. Implementing a FEC technique in the routing algorithm enhances the delivery ratio of the protocol as well as minimizes the overall energy consumption espe-cially in the case of route failures.

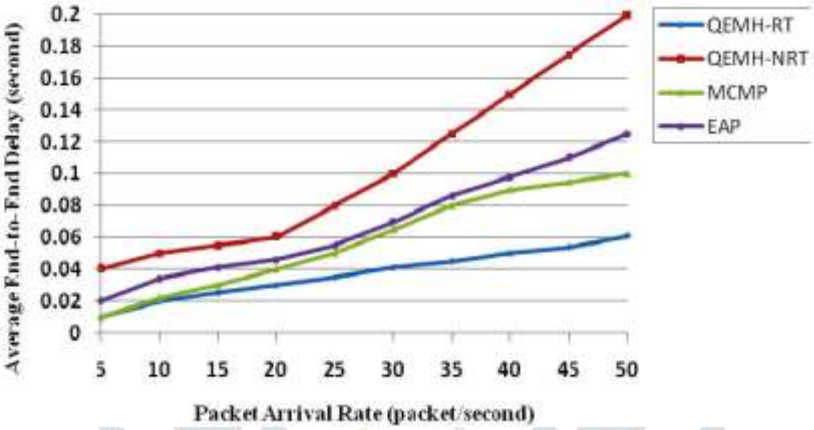


**Figure 6. Average end-to-end delay.**

**.3) Average energy consumption**

The average energy consumption is the average of the energy consumed by the nodes participating in message transfer from source node to the sink node. Figure 8 shows the results for the energy consumption; we ob-serve that QEMH achieves more energy savings than MCMP and EAP protocols. This is because our protocol easily recovers from path failures and be able to recon-struct the original messages through the use of the FEC algorithm while the other protocols needs to initiate a data retransmission to recover lost data, which leads to a significant increase in the energy consumption. Further-more, because of adding multi-path capability with hier-archical techniques, energy consumption is reduced.

**Impact of Node Failure Probability**

In this experiment, we study the behaviour of the proto-col in the presence of node failures and change the node failure probability from 0 to 0.05.

**1) Average end-to-end delay**

The average end to end delay of QEMH, MCMP and EAP protocols as the node failure probability increases is illustrated in Figure 9. We observe that, the MCMP and EAP protocols are very sensitive to the increase in node failure probability. On the other hand, QEMH (either for real-time or non-real-time traffic) is not as sensitive to the increase of node failure probability as MCMP and EAP protocols. The FEC technique implemented in QEMH

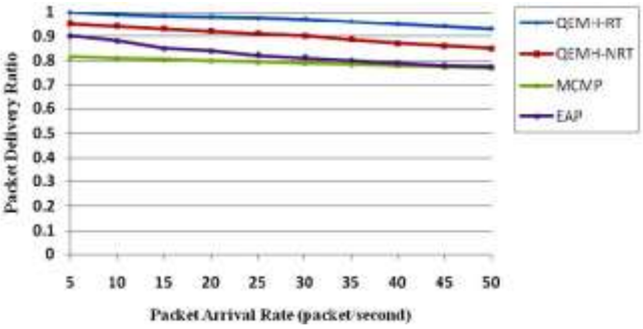


Figure 7. Packets delivery ratio.

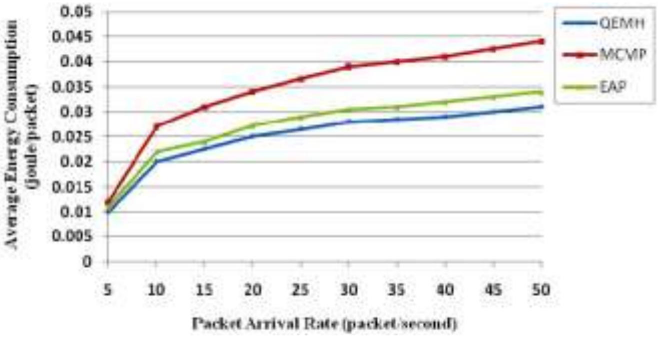


Figure 8. Average energy consumption.

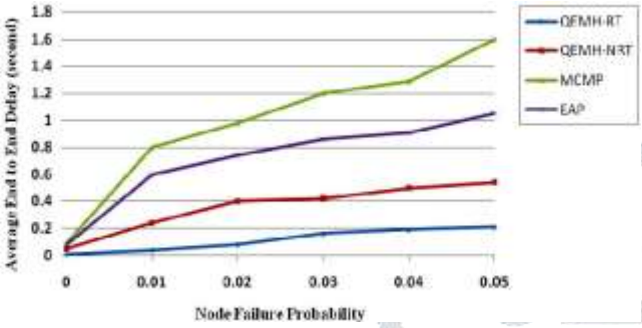


Figure 9. Average end-to-end delay

protocol achieves more energy savings than MCMP and EAP protocols. This is because QEMH protocol easily recovers from path failures and be able to reconstruct the original messages through the use of the FEC algorithm. While the MCMP and EAP protocols needs to initiate a data retransmission to recover lost data, which leads to a sig-nificant increase in the energy consumption.

**Impact of Number of Nodes**

In this experiment, we study the behaviour of the proto-col from perspective of number of nodes and change that from 100 to 500.

1) **Network lifetime**

**Figure 12** shows the network lifetime between QEMH, MCMP and EAP protocols. As seen in figure, in our protocol, number of rounds is significantly extended due to the reasons .First cluster head roles are rotated, so en-ergy consumption among cluster members is balanced. Second, data transmission across multiple paths as load balancing that caused energy consume uniformly throughout the network.

**2) Time of nodes dead**

Time of every node dead for three protocols is illus-trated in **Figure 13** . In MCMP and EAP protocols, each node has to spend more energy to communicate with other nodes and manage the cluster, so the network life-time decreases and nodes die earlier. In contrast, QEMH improved time of nodes dead due to each node has lower energy consumption. protocol makes the protocol very effective and more resi-lience to node failures. Furthermore, the delay is not affe-cted too much as the node failure probability increases.

**2) Packet delivery ratio**

Average packet delivery ratio for three protocols is ill-ustrated in **Figure 10**. As the node failure probability in-creases, the average packet delivery ratio of MCMP and EAP protocols drops significantly. On the other hand, the QEMH protocol is slightly affected by the increase in the node failure probability. This is because of QEMH emp-loys an error correction scheme which contributes in inc-reasing the delivery ratio in the case of path failures by reconstructing the original message using the generated XOR codes without the need to initiate data retransmis-sions.

**3) Average energy consumption**

**Figure 11** shows the results for the average energy consumption under node failures. We observe that QEMH

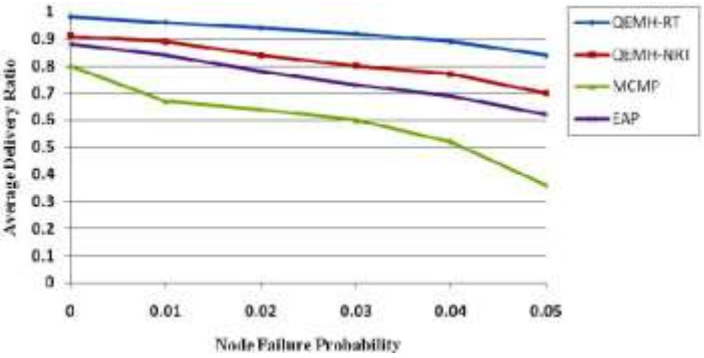


Figure 10. Average delivery ratio

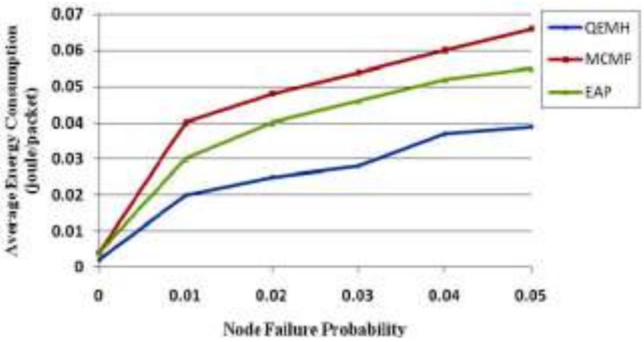


Figure 11. Average energy consumption.

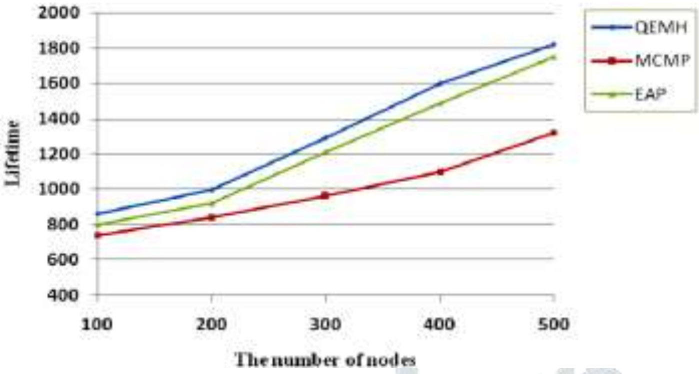


Figure 12. Network Life time.

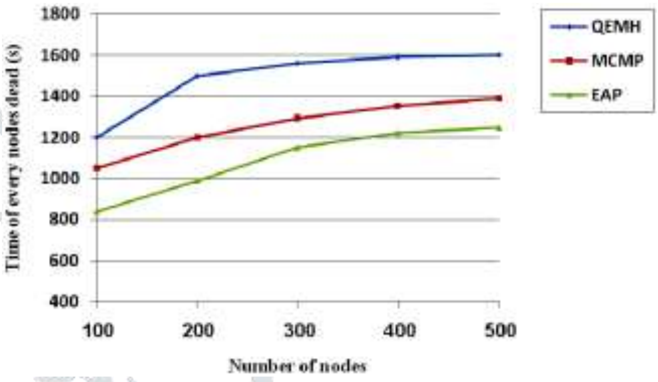


Figure 13. Time of the 100% nodes dead.

## CONCLUSION

We analyzed the QoS requirements imposed by main applications of WSNs, and highlighted some of the challenges posed by the unique characteristics of wireless sensor networks. We have reviewed some of the QoS aware routing protocols for WSNs. A comparative study of some of QoS aware routing protocols and taking few important parameters in context of WSNs is done. Finally, we are convinced that the QoS support in WSNs should also include QoS control besides QoS assurance mechanisms and some exciting open issues are identified in order to stimulate more creative research in the future..

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