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Different Techniques Towards Enhancing Wireless Sensor Network (*WSN*) Routing Energy Efficiency and Quality of Service (*QoS*)

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Abstract: Wireless Sensor Networks WSN's become more popular nowadays, researchers community is trying to get best use of its different applications by means of utilizing its maximum energy efficiency. Routing is a main energy demanding operation when nodes become ready for transfer of data to the sink, an ample amount of research has been conducted to overcome routing energy issues. However QoS of sensor application have very important role specially in critical applications, where the accuracy and guaranteed data transfer timely is an important issue such as defense, chemical and healthcare. Hence besides energy efficiency, QoS based routing is also required to ensure best use of nodes. in our work, we try to focus on operational and architectural challenges of handling QoS routing traffic in sensor networks and propose a new mechanism for QoS based routing protocol, by applying different techniques simultaneously. Results show a significant improvement towards networks efficiency and QoS.

Key words: WSN · QoS · Gateway · Secondary Route · Energy efficient · WSN routing protocol

INTRODUCTION

WSN is a wireless network consisting of small nodes with sensing, computation and wireless communications capabilities [1], operating in an unattended environment, with limited computational and sensing capabilities. Normally nodes routs data back to the base station BS [2]. Data transmission is usually a multi- hop, from node to node toward the base station or gateway. Sensor nodes are equipped with small, often irreplaceable batteries with limited power and computation capacity. Important concern is the network lifetime and QoS as nodes run out of power, congestion may caused, the connectivity decreases and the network can finally be partitioned and become dysfunctional [3-5]. The minimum energy routing problem has been addressed in [6-11]. The service is bound to the data and to the application QoS vs. QoI (Quality of Information), QoSu [12] (Quality of Surveillance) and data delivery can be continuous, event-driven, query-driven, or hybrid. An important concern is the QoS of network. QoS model can be defined as under, what the users have required from the network. User demands for guaranteed data transfer timely, guaranteed bandwidth in case of image and video data, data accuracy timely in case of military or health application. Resulting sensor nodes' network must satisfy almost all requirements of users as shown below in QoS simple model.

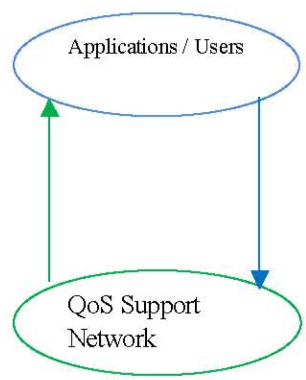

Fig. 1: QoS Model of WSN [40]

WSN has specific requirement comparable to wired and ad-hoc networks, particularly when switching between non IP to IP network. WSN requires different approaches for energy efficient and QoS based routing.

Related Work: QoS always have very important role in all types of network, including conventional, wireless ad hoc and wireless sensor network. QoS routing is performed usually through resource reservation in a connection oriented communication in order to meet the QoS requirement for each individual connection. While couple of different mechanisms have been proposed for routing QoS constrained image and video type of data in wire based network [13-17], they cannot be directly applied to

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wireless network, because of its different architecture, structure and resource constraints. Therefore several new protocols have been proposed for QoS routing in wireless networks taking the dynamic nature of the network into account [18-22]. Some of the proposed protocols consider the imprecise state information while determining the routes [18,19]. While specially in wireless sensor network, many QoS based routing protocols have been proposed but they normally make their primary metrics to energy consumption and they can be grouped on the basis of the problem they solve, like Prioritization: Differentiate services on the basis of the definition of classes of traffic (Q-MAC [33], SAR [39] Timeliness: Guarantee delivery within a given time (MMSPEED [28], SPEED [29], DEED [31], Data Relaying in Hierarchical WSNs [25] Reliability: Support probability of delivery (MMSPEED [30], REINFORM [27] In Network Processing: Improve the performance of the network by processing data along the path from the source to the destination (Q-DAP and LADCA [39] Scheduling: Coordinate sensors in accessing channel or in sensing the environment (CoCo [32], MAC Coding [36], Scheduling with Quality of Surveillance [30], EAD [26], QoS Reliability of Hierarchical Clustered WSNs [37] Node relocation: Change node position in order to increase efficiency (Sink Repositioning [24], SAFER [38] Generic metric minimization: Improve the performance of the network with respect to some cost function (Energy-Aware QoS Routing [23], Dynamic Routing [34], DAPR [35].

Research Objectives:
The main objectives of the research is:

- To investigate the QoS performance of WSN routing protocol
- To design new approach for energy efficient and QoS routing protocol for WSN
- To increase the overall life cycle of WSN
- To, enhance the (QoS) by enhancing its real time data transfer in WSN

Problem Statement and Network Model: Routing in WSNs have a primary task for transfer of data from source (sensor node) to the sink. Routing is also most energy expensive operation of WSN and at the same time more concern with QoS of network, in case data is available for transfer in resulting of any physical event occur or time driven query run at the sensor node. Initially routs defined by the nodes then nodes become able to send or receive the data by using those routing paths.

Problem Statement: An ample number of different routing protocol had been designed by the researchers, all protocols lays under different categories, based up on the network application and topologies. On the basis of topologies routing protocols may lays on following types.

- Flat routing Protocols
- Hierarchal routing Protocols
- Location based routing Protocols

Among all topologies based routing protocols, hierarchal routing protocol technique is more popular regarding the power saving and QoS of sensor nodes. This technique works on the formation of several clusters (a sub network within network). Cluster are responsible to transfer data from node to the sink, while direct data sending approach from each node is not supported with this method. Clusters communication works on the basis of cluster leader which can be known as cluster head. Communication with sink can be done with the help of cluster head, they collect data from neighboring nodes and send it to another cluster head, who is responsible for any other cluster, this mechanism continuous until the data reaches to the sink. the current energy efficient routing protocols including LEACH, PEGASIS and HEED is also designed on the basis of clustering. The main issue with this method is cluster heads normally remain active for more time than other nodes in the cluster and resulting they lose their energy before other nodes. Another important concern is that it is hard to maintain the energy level of all sensor nodes at same level and if cluster head loose it energy first then in that case, it is possible that we might lose one segment of network from our main network topology. Even though those routing protocols works fine up to a limited size of sensor network, but they are not suitable for large amount of networks, as they broadcast the message to find out their neighbors and also to form new clusters by finding new cluster heads. In this process they lose an ample amount of energy and also cause congestion with routing paths, that congestion rises more in case if any unusual event is occurred. In this way congestion actually decreases the energy of the node along with QoS of network in the form of low data rate transfer within a specified time period. Even assumptions which they made or not possible normally in real, such as LEACH assumes that all nodes are homogenous and equal in power while it is not in actul.

Hence it is high need to design an QoS based energy efficient routing protocol with better assumptions which will be more closer to real, we are proposing new approaches based QoS protocol which will be more energy efficient than the existing one protocols.

Network Model: For testing the energy efficiency and the QoS of sensor network nodes, we tested it with simulation and our assumption for sensor network model are, such as sensor nodes are randomly distributed over an area of 200 x 2000 meters with following network properties.

- Network is static and nodes are distributed in random format, while area is divided in equal square grid format while we consider randomly one region.
- There exists only one base station or gateway, which is deployed at a fixed place in the center of the Area.
- Sensor nodes are not rechargeable.
- Data aggregation will be considered, while nodes are not aware about their position.
- The radio power can be controlled, i.e. a node can vary its transmission power.
- Unusual events can be occurred at any time.

Above all assumption are on wide scope, assumption fifth is becoming the cause of energy saving, as nodes will be aware about their location and sink too, hence the amount of energy which normally network always use to find out the initial location will be save. This amount will be very considerable as a whole for small and large sensor network and become reason for enhancing its energy level.

Simulations and Results with Graphs:

Tested Topologies and Scenarios: The entire simulation tests were conducted through research community well know simulator NS2, by applying different topologies and different assumptions/approaches. The few of those are shown and discussed with this section. All distribution topologies were basically cluster based topologies, sensor nodes were distributed within a area of 200X200 meters and then tested their routing capabilities in two ways, initially it was tested with a normal cluster distribution without any assumption, where the QoS of network in term of data transfer and the nodes energy life were observed low because of the congestion occurred due to unusual events occurring during routing, comparatively with cases after our different assumptions applied. With our first approach we try to focus on networks congestion issue and consider two different routing paths to handle the two different events individually, in which a secondary routing path has been considered to handle any traffic if any un usual event may occurs (Consider the case of battle field), while the regular normal events can be handled with regular primary routing path.

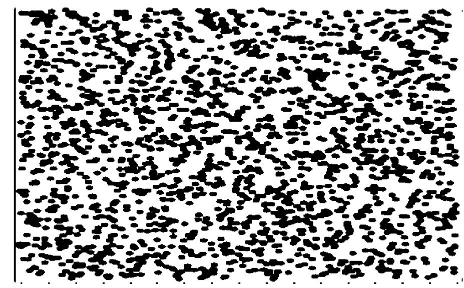


Fig. 2: Simple Topology (Nodes distributed in simple fashion)

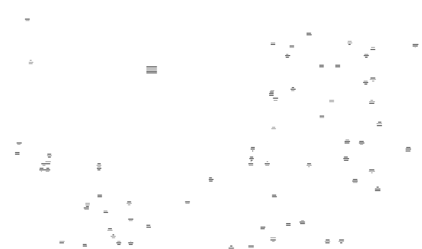


Fig. 3: A Section of Sensor Nodes with it Gateway

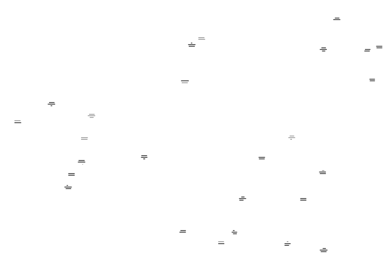


Fig. 4: A Section shows the routing paths of Sensor Nodes

While with our second approach it has been considered that, in case a situation may comes across in which the gateway drained his energy because of its continuous operations and in case of its losing power and connection, nodes may required to built their routing paths from scratch. We proposed a secondary gateway will take the charge and become active for transferring of data. Hence the transfer of data will be continue after a bit delay without losing that part of sensor network and without losing its fully routing paths. Those approaches for the routing was tested more excellent in terms of it QoS and power saving, the details for these approaches will be tested and discussed with coming section of results with the help of simulation graphs. The scenarios and our proposed assumptions/solutions scenarios are shown in following figures ranges from Fig. 02 to Fig. 08.

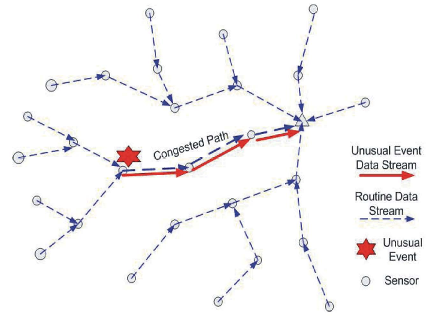


Fig. 5: Congestion Caused by unusual events with roting paths.

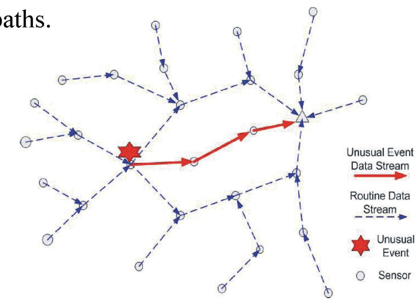


Fig. 6: Different Routs for un usual and routine event.

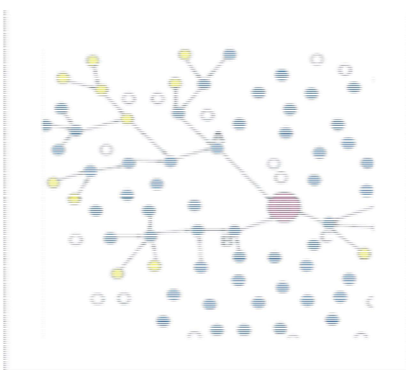


Fig. 7: Primary Gate way (G) for receiving response of the sensor nodes.

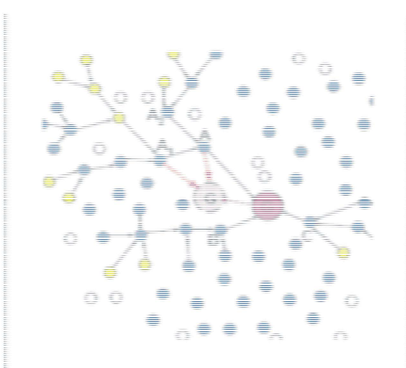


Fig. 8: Secondary Gate way (G) for receiving response of the sensor nodes.

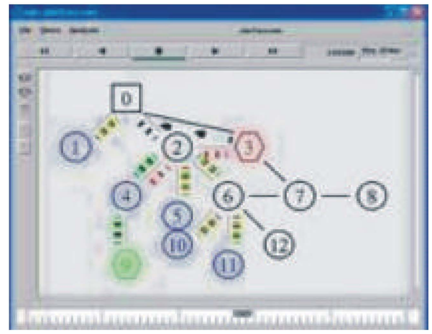


Fig. 9: Screen shots of NS2 simulation for wireless sensor network

Figures ranging from (02-04) are showing the distribution of the sensor nodes in three different fashions. As in figure 02 shows overall sensor nodes distribution for the entire area of 200X 200 meters. While the figure 03 is showing a selected area or a cluster only and the figure 04 is showing the initial possible paths of the routing within the sensor nodes.

Figures ranging from (05-06) are showing the normal data paths and congestion caused by the un usual event occurrences. While the figure 06 particularly showing our proposed approach in which two different routing path are suggested such as the primary path which is normally assigned for normal data carrying for the normal event occurrence case, however another routing path is shown with red color is assigned to rout the data resulting if any usual event is occurred.

Figures ranging from (07-08) are showing second proposed approach such as figure 07 is showing only one gateway, while with figure 08 a proposed secondary gateway is also clearly indicated. Secondary gateway G will be active in case if primary gateway will stop working because of energy drain. Hence data transfer will be continue after a bit delay.

Simulation: Simulations has been done with the help NS2 simulator. NS-2 includes a tool for viewing the simulation results, called NAM. Screen shot show the animated tool NAM, which is commonly used for NS2 simulator for showing the graphical simulations and helping to generate trace files. NAM is a graphical interface in which simulation controlling events are available during the active session of wireless simulation.

Table 1: Simulation Parameters.

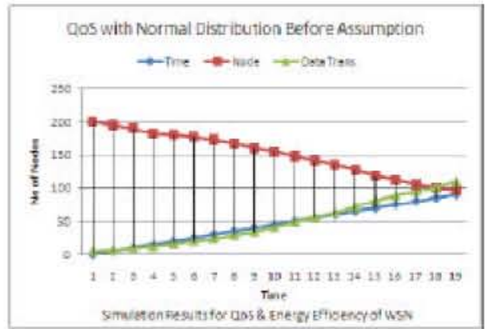
Net work area	200m*200m or 400m*400m
Number of sensor	100 or 400
Sensor distribution	Uniform random
Location of sink	Center of area
Radio range	40m
MAC layer	IEEE 802.11
Unusual event sources	4
Routine data source probability	p
Failure rate	f
Time-out constant ζ	$1/r$
Delay for retransmission M	0.02s
Data rate of unusal events	λ_U
Data rate of routine data	λ_R

Simulation Parameters: Standard Simulation parameters are shown in below in table no 1, as described earlier.

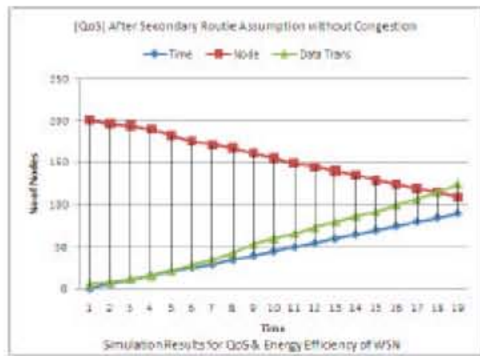
Results with Graphs: Case I: WSN Nodes with normal condition (Before any assumption):

The WSN QoS routing was tested in four different phases, with first phase it was tested with the normal random distribution of the sensor nodes over an area of 200X200 meter without any assumption, while the area was divided in to clusters and the gateway/sink G was placed in the center of the network to collect the data in case of any event occurs. Graph 01 shows the results for this simple distribution approach where the number of live nodes remains approximately 97 out of 200 sample node after a certain period of time, while the network becomes able to transfer the data of 110 Bytes within same time. The less data and the more number of sensor nodes were died due to the congestion caused in the network as shown in graph 01.

Case II: WSN Network Performance after Secondary Route and Secondary Gateway Assumption: With second case we apply our two assumptions one after one and our new simulation results after the assumption shows significant improvement in energy level along QoS of network as shown in following graphs 02 and 03 respectively. With first assumption we assigned two different routing paths in case of any un usual event is occurred (consider the case of the battle field), the secondary path will be active to handle that request, without disturbing the primary path and by avoiding any possible congestion within the network. As the congestion resultant the loss of energy along with reducing the data rate for sensor node and become the reason of decreasing the QoS of network. Simulation



Graph 1: Simulation Results under normal conditions data with congestion.

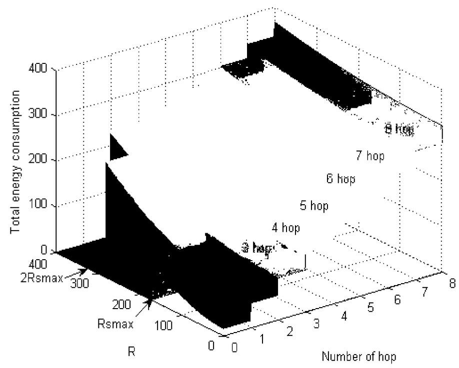


Graph 2: Simulation Results After Secondary Route Path assumption for un usual events.

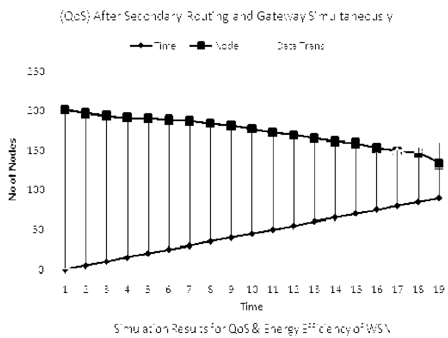
Graph 3: Simulation Results After Secondary Gateway (G) assumption

results are showing that after a certain period of time a larger number of live node were there such as 109 nodes out of 200 while the data rate of 125 Bytes, as shown in graph 02.This positive change was occurred because of assigning a separate secondary path for any un usual events.

In same way with second approach, whose results are shown in Graph 03, we consider a secondary gateway G, which will be active in case if the first gateway is not able to respond the requests because of its energy drain after a some time period. Activation of secondary gateway



Graph 4: Simulation Results show Energy Consumptions over number of hop.



Graph 5: Simulation Results After the Secondary Route and Secondary Gateway assumption simultaneously.

become more suitable for network, which supports network to continue the data transfer in case if any physical event is occurred. This activation of another gateway makes sensor network more reliable by enhancing nodes life along with its transfer rate which results the enhancement of QoS of network. Simulation results are showing that after a certain period of time a larger number of live node were there such as 121 nodes out of 200 while the data rate of 140 Bytes, as shown in graph 03.This positive change was occurred because of assigning a secondary gateway for the sensor network.

Number of Hopes vs Energy Consumption: Graph 04shows the result for entire energy loss process for all hopes with the help of different colors, as sensor network collects data in different hopes. It shows that during the initial hopes the energy level of the nodes were sufficient enough and it was shown with blue color. However when the numbers of hopes were going to be increased the energy level also drastically going down as shown it with graphs in different colors which were indicated in light blue and then yellow and finally towards red, which is the last level of energy and almost total energy were lost at this stage, while nodes almost died at this stage.

Case III: WSN Nodes after Secondary Route and Gateway Assumption Simultaneously: With case III, we applied our both assumptions simultaneously and test the results through simulations. Results shows an ample improvement comparable with first two cases. By applying both assumptions together it helps a lot in reducing network congestion and enhances its energy along with networks QoS. Simulation results are showing that after a certain period of time a larger number of live node were there such as 134 nodes out of 200 while the data rate of 159 Bytes, as shown in graph 05.This positive change was occurred because of assigning both assumptions simultaneously. Which shows a significant change towards its energy efficiency and QoS comparable with its normal case, where the number of live nodes were remain after the same time period was 97 along with 110 Bytes of transfer data within the same time period. It shows a clear difference of approximately 18% towards node energy saving while an ample difference toward its data transfer rate too, which shows the enhancement in QoS of network.

CONCLUSION

Wireless Sensor Networks WSN's become more popular nowadays, research community is trying to get best use of its different applications by means of utilizing its maximum energy efficiency. Routing is a main energy demanding operation when nodes become ready for transfer of data to the sink, an ample amount of research has been conducted to overcome routing energy issues. However QoS of sensor application have very important role specially in critical applications, where the accuracy and guaranteed data transfer timely is an important issue such as defense, chemical and healthcare. Our proposed research assumption shows a significant improvement in sensor network's energy efficiency and QoS simultaneously and fulfill our research objectives. A remarkable improvement of approximately 18% noticed towards energy efficiency and almost same toward QoS by increasing its data transfer rate within specified time period, after applying our both assumptions with sensor network through simulations.

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