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Designing of energy efficient routing protocol for Wireless Sensor Network (WSN) Using Location Aware (LA) Algorithm

Mansoor-uz-Zafar Dawood*
Institute of Business &Technology, Biztek, Pakistan
Noor Zaman*
Abdul Raouf Khan*
Mohammad Salih*
King Faisal University Saudi Arabia

ABSTRACT

Development of energy efficient Wireless Sensor Network (WSN) routing protocol is nowadays main area of interest amongst researchers. This research is an effort in designing of energy efficient Wireless Sensor Network (WSN) routing protocol, under certain parameters consideration. Research report discusses various existing WSN routing protocols and propose a new Location Aware (LA) WSN energy efficient routing protocol. Results show a significant improvement in life cycle of the nodes and enhancement in energy efficiency of WSN.

INSPEC Classification : B6150, B1130, C5640, D5020

Keywords : WSN, Energy efficient, WSN routing protocol, Location aware

1. INTRODUCTION

Wireless Sensor Network (WSN) is a wireless network consisting of small nodes with sensing, computation, and wireless communications capabilities (Karaki, 2004). Each sensor collects data from the monitored area (such as temperature, sound, vibration, pressure, motion or pollutants). Then it routs data back to the base station BS (Akyildiz, 2002). Data transmission is usually a multi- hop, from node to node toward the base station.

As wireless sensor networks consist of hundreds to thousands of low-power multi functioning sensor nodes, operating in an unattended environment, with limited computational and sensing capabilities. Sensor nodes are equipped with small, often irreplaceable batteries with limited power capacity. WSN consist of hundreds or thousands of small, cheap, battery-driven, spread-out nodes bearing a wireless modem to accomplish a monitoring or control task jointly. An important concern is the network lifetime: as nodes run out of power, the connectivity decreases and the network can finally be partitioned and become dysfunctional (SU, 2002).

* The material presented by the authors does not necessarily portray the viewpoint of the editors and the management of the Institute of Business and Technology (Biztek) and King Faisal University, Al-Hassa Saudi Arabia.

*Mansoor Uz Zafar Dawood : dr.mzdawood@biztekian.com
*Abdul Raouf Khan : raoufkhan@kfu.edu.sa
*Mohammad Salih : salihmk@kfu.edu.sa
*Noor Zaman : nzaman@kfu.edu.sa

Routing in WSNs is a very challenging problem due to the inherent characteristics which differentiate such networks from other wireless networks such as ad hoc networks and cellular networks (SU, 2002; Cao, 2007). In recent years, many algorithms have been proposed for the routing issue in WSNs. The minimum energy routing problem has been addressed in (Ettus, 1998; Rodoplu, 1999). The minimum total energy routing approaches in these papers are to minimize the total consumed energy. However, if all traffic is routed through the minimum energy path to the destination, the nodes along that path will run out of batteries quickly rending other nodes useless due to the network partition even if they do have available energy. Instead of trying to minimize the total consumed energy on the path, the objective is to maintain the connected network as long as possible. If sensor nodes consume energy more equitably, they continue to provide connectivity for longer, and the network lifetime increases. (Bhardwaj, 2002; Chang, 1999; Chang, 2004; Zussman, 2003).

Good surveys of the sensor networks have been given in (Rentala) and (Estrin, 1999). Crucial to the success of ubiquitous sensor networks is the availability of small, lightweight, low cost network elements, called Pico nodes. These nodes must be smaller than one cubic centimeter, weigh less than 100 grams, and cost substantially less than 1 dollar (US). Even more important, the nodes must use ultra-low power to eliminate frequent battery replacement. A power dissipation level below 100 microwatts would enable self-powered nodes using energy extracted from the environment, an approach called energy scavenging or harvesting (Haq, 2003).

As sensor networks have specific requirements on energy saving, data-oriented communication, and inter-connection between non-IP and IP, therefore sensor network dedicated routing protocols may be required, for energy efficient routing scheme.

In WSN there are the routing protocols that minimize the used energy, extending subsequently the life span of the WSN (Sadek, 2007). Energy awareness is an essential in routing protocol design issue. Depending on the network structure, routing in WSNs can be divided into:

a) Flat-based routing
b) Hierarchical-based routing
c) Location-based routing

Depending on the protocol operation, routing in WSNs can be divided into:

a) Multipath-based routing
b) Query-based routing
c) Negotiation-based routing
d) QoS-based routing
e) Coherent based routing

2.RESEARCH OBJECTIVES

The main objectives of the research is :

- to investigate the performance of WSN routing protocol
- to design new energy efficient routing protocol for WSN
- to increase the life cycle of WSN
- to enhance the power efficiency of WSN
- to enhance the reliability of WSN
- to enhance the real time data transfer in WSN

3 Methodology

The methodology involved in this research is of 4 phases:

3.1. Deep investigation

For achieving reliable results and excellent efficiency of the problem solution, further in depth literature review has been done.

3.2. Designing & Development

In this phase, solution of the identified problem was developed for onward analysis, efficiency and reliability measures during modeling and simulation. The proposed solution was reconsidered, based on the analysis of the results of simulations, for further improvement of the solution.

3.3. Modeling & Simulations

As Simulation, is "the process of designing a model of a real system and conducting experiments with this model for the purpose either of understanding the behavior of the system or of evaluating various strategies (within the limits imposed by a criterion or set of criteria) for the operation of the system" (Chang, 1999). Therefore Modeling & Simulation was the main part of this research in which application of different simulations techniques was developed using the following simulators.

1. NS-2
2. OMNET
3. Tossim
4. WSNSim
5. Jsim

4. PROBLEM STATEMENT NETWORK MODEL

Routing in WSNs have a primary task for transfer of data from source (sensor node) to the sink, 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.

4.1 Problem Statement

An ample number of different routing protocols had been designed by the researchers, On the basis of topologies routing protocols may lays on following types.

1. Flat routing Protocols
2. Hierarchal routing Protocols
3. Location based routing Protocols

Among all topologies based routing protocols, hierarchal routing protocol technique is more popular regarding the power saving of sensor nodes. This technique works on the formation of several clusters (a sub network within network). Cluster is 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, which is responsible for any other cluster, this mechanism continuous until the data reaches to the sink. the current energy efficient routing protocols including LEACH 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 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 actual.

Hence it is highly needed to design an energy efficient routing protocol with assumptions closer to the real, we are proposing Location Aware (LA) WSN routing protocol which is more energy efficient than the existing protocols.

4.2. Network Model

Our assumptions for sensor network are such that, sensor nodes are randomly distributed over an area of 100 x 100 meters with following network properties.

1. Network is static and nodes are distributed in random format, while area is divided in equal square grid format.
2. There exists only one base station, which is deployed at a fixed place outside A.
3. The energy of sensor nodes cannot be recharged.
4. Sensor nodes are location aware, with the help of GPS
5. The radio power can be controlled, i.e., a node can vary its transmission power.

Above all assumption are on wide scope, assumption no. 5, 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 saved. This amount will be very considerable as a whole for small and large sensor network and become reason for enhancing its energy level.

5. SIMULATIONS & RESULTS WITH GRAPHS

5.1 Tested Topologies and Scenarios:

The entire simulation tests were conducted by using a very well known simulator by the research community NS2, by applying different topologies and approaches. The few of those topologies are shown below as under including Simple, Random, Grid, Vertically distributed and Horizontal topologies. In the entire topologies sensor nodes were distributed within a area of 250 meters and then tested their routing capabilities in two ways, initially it was tested with a normal distribution, while in second phase it was tested through Location Aware (LA) Algorithm, in which each node was aware about its neighbors' location. The second approach for the routing was tested more excellent in terms of it power saving or in terms of nodes life, which we discussed with coming section of results with the help of simulation graphs. The entire scenarios screen shots are shown in Figures 1 - 5.

Figure 1
Simple Topology (Nodes distributed in simple fashion)

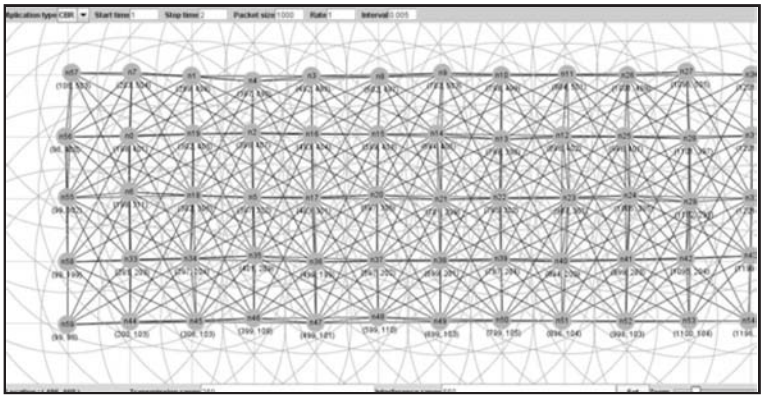


Figure 2
Random Topology (Nodes distributed in Random fashion)

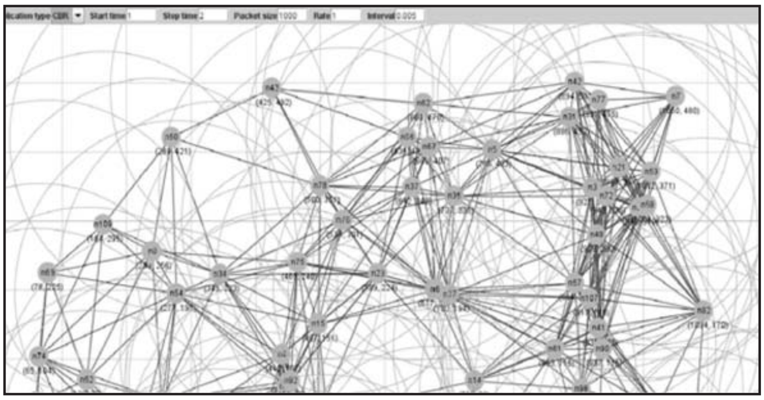


Figure 3
Grid Topology (Nodes distributed in Grid format)

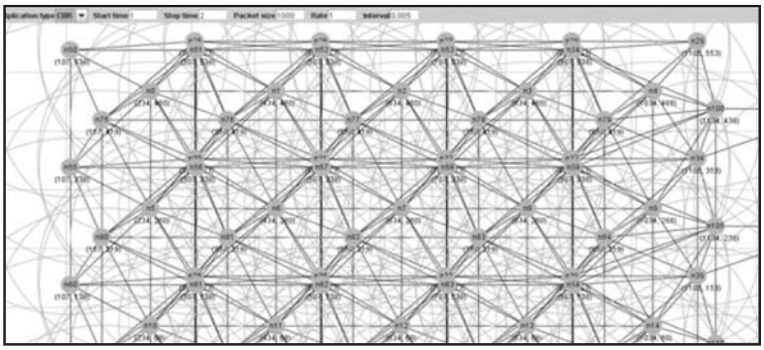


Figure 4
Vertical Topology (Nodes distributed in Vertical fashion)

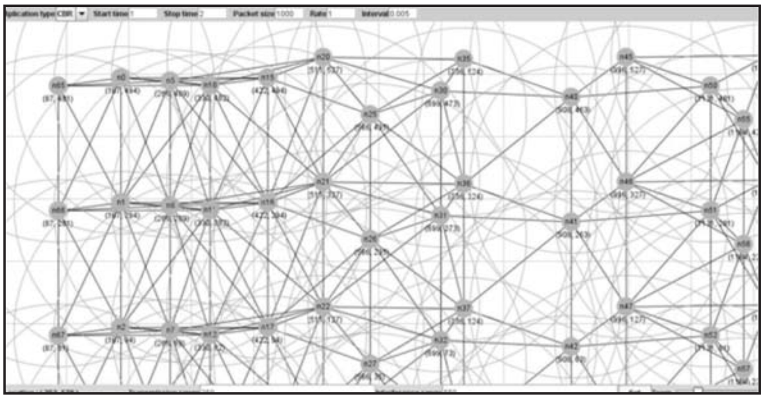
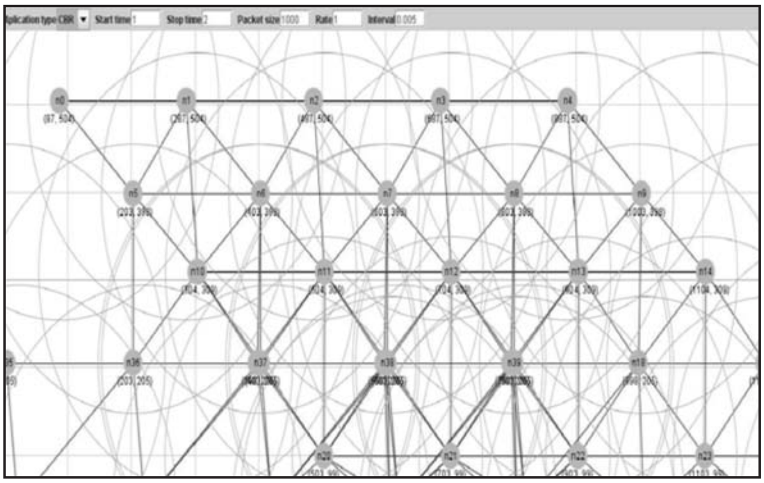


Figure 5
Horizontal Topology (Nodes distributed in Horizontal fashion)



6. SIMULATION

Simulations has been done with the help of well known and worldwide acceptable NS2 simulator, NS2 is a discrete event simulator targeted at networking research NS2 is an object-oriented, discrete event driven network simulator developed at UC Berkely written in C++ and OTcl (Tcl script language with Object-oriented extensions). It implements network protocols such as TCP and UPD, traffic source behavior such as FTP, Telnet, Web, CBR and VBR, router queue management mechanism such as Drop Tail, RED and CBQ, routing algorithms such as Dijkstra, and more. NS also implements multicasting and some of the MAC layer protocols for LAN simulations.

NS-2 includes a tool for viewing the simulation results, called NAM. NAM is a Tcl/TK based animation tool for viewing network simulation traces and real world packet trace data. The first step to use NaM is to produce the trace file. The trace file should contain topology information, e.g., nodes, links, as well as packet traces. Usually, the trace file is generated by NS. During an ns simulation, user can produce topology configurations, layout information, and packet traces using tracing events in ns. When the trace file is generated, it is ready to be animated by NaM. Upon startup, NAM will read the trace file, create topology, pop up a window, do layout if necessary, then pause at the time of the first packet in the trace file. Through its user interface, NAM provides control over many aspects of animation. This simulation tool has worldwide acceptability with very high acceptance of result.

6.1 Simulation Parameters:

Standard Simulation parameters are shown in Figures 6, 7and Table 1.

Figure: 6
Simulation Parameters.

Channel type	Channel/WirelessChannel
Propagation model	Propagation/TwoRayGround
Phy type	Phy/WirelessPhy
Mac protocol type	Mac/802_11
Queue type	Queue/DropTail/PriQueue
Link layer type	LL
Antenna type	Antenna/OmniAntenna
Max packet in queue	50
Routing protocol	DSDV
Agent trace	ON
Router trace	ON
Mac trace	ON
Movement trace	ON

Figure: 7
Simulation Parameters (contd.)

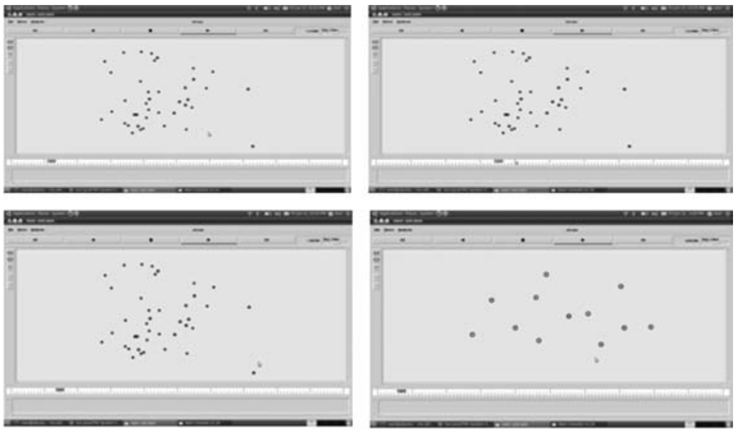
Gt_	1
Gr_	1
L_	1.0
freq_	2.472e9
bandwidth_	11Mb
Pt_	0.031622777
CPThresh_	10.0
CSThresh_	5.011872e-12
RXThresh_	5.82587e-09
dataRate_	11Mb
basicRate_	1Mb

Table 1
Simulation Parameters.

Network Filed	(100 x100) in meters
Node numbers	100~300
Cluster radius	r 30 m
Sensing radius	rs 10 m
Initial energy	2 J
Data packet size	50 Bytes
Broadcast packet size	25 Bytes
Ethreshold	0.01 J

As mentioned earlier, the entire simulations were done using NS2 simulator, hence few screenshot of the NS2 simulator during simulation shown in Figure 8. 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. such as, to stop run, fast forward or slow motion available as under,

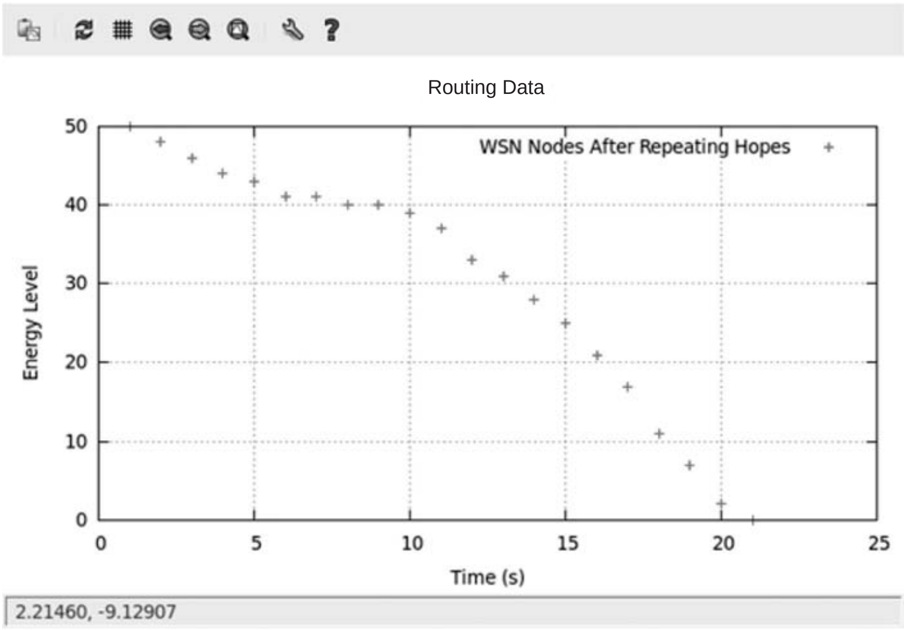
Figure 8
Screen shots of NS2 simulation for wireless sensor network



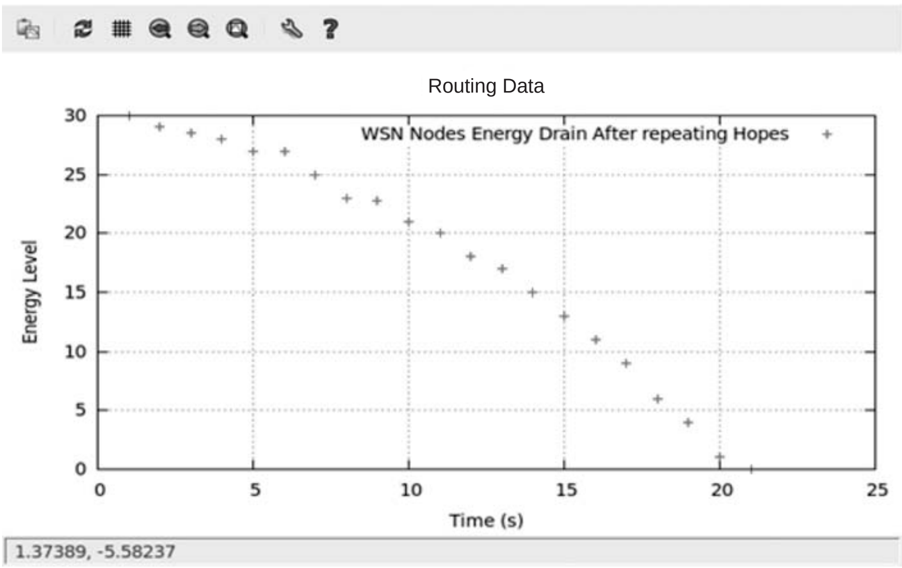
6.2 Results with Graphs:

A: WSN Nodes after Repeating Hopes:
Graphs ranging from 1 to 3 are actually plotted between two parameter such as, graph 1 is X-axis for time while Y-axis for cumulative energy level for sensor nodes. Three different cases were taken in account with initial assumption that nodes are not aware about their location and are scattered in random fashion over an area of 100 x 100 meter. Case number one (Graph 1)is showing the comparison between time and energy level for routing before occurring hoping, while second case (graph 2) showing the comparison for routing data between time and energy level but after few number of hopes. In case three Graph 3) is also showing the comparison for routing data but after a maximum number of network hops. All graphs showing the clear understanding about the net results of the simulated routing and sensor nodes energy. Graph 1 show that almost 5o nodes means 100% nodes were alive when the process started and all nodes were drain their energy almost within 21 second of active operation. In the same fashion the different results were shown with different comparison including with graphs 2 and 3.

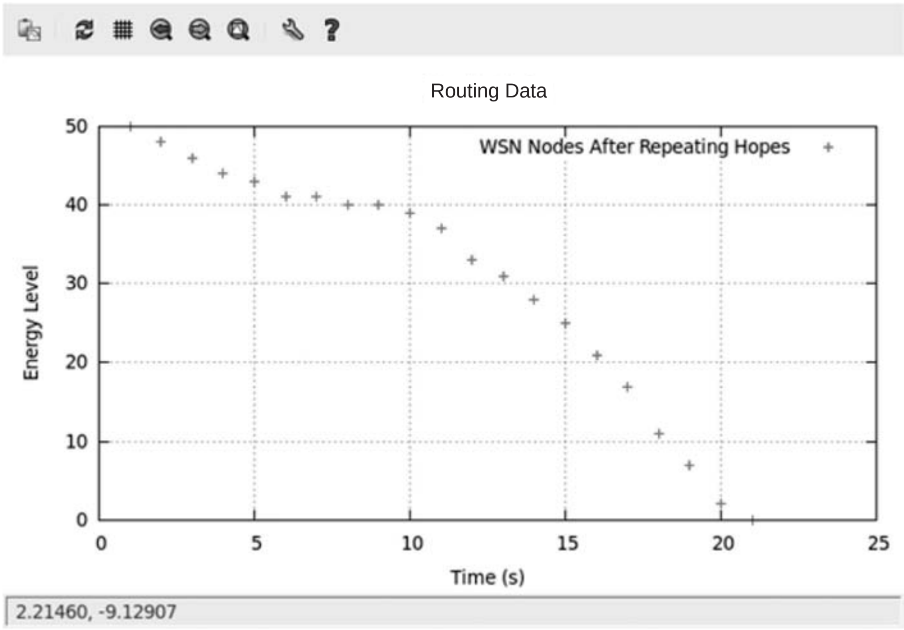
Graph 1
WSN Nodes Energy Drain after Repeating Hopes



Graph 2
WSN Nodes Life with respect to Time after Repeating Hopes

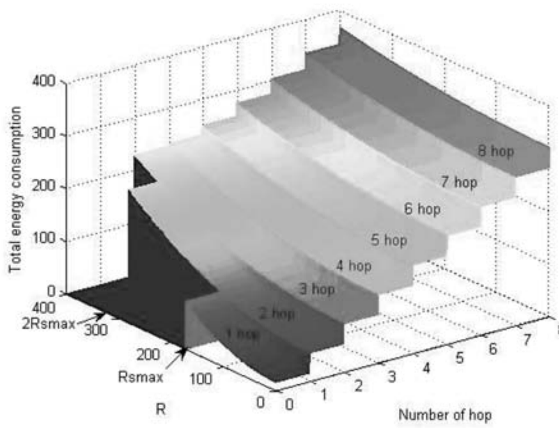


Graph 3
Number of Hopes VS Energy Consumption

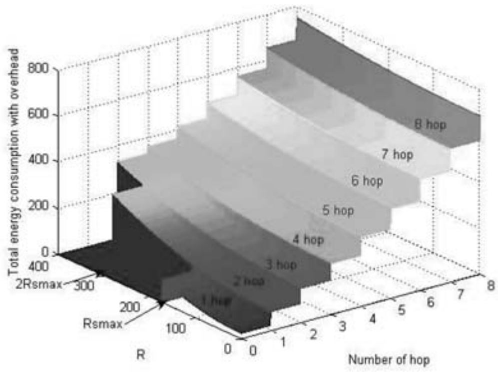


Graphs 4 and 5 shows the result for entire energy loss process for all hopes with the help of different colors, it shows that during the initial hopes the energy level of the nodes were sufficient enough and it was shown with blue color. However when the numbers of hopes were going to be increased the 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 and node were lost at this stage.

Graph 4
Number of Hopes VS Energy Consumption

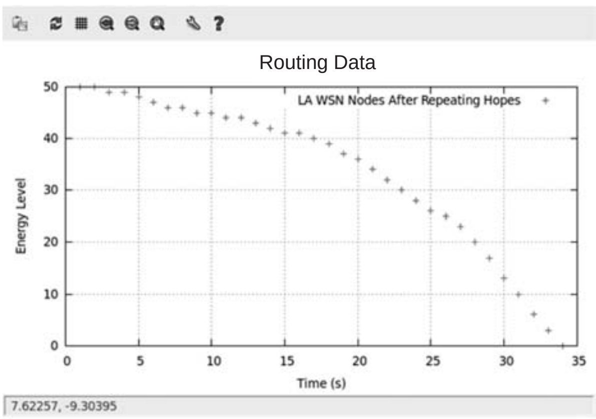


Graph 5
Location Aware LA WSN Nodes after Repeating Hopes

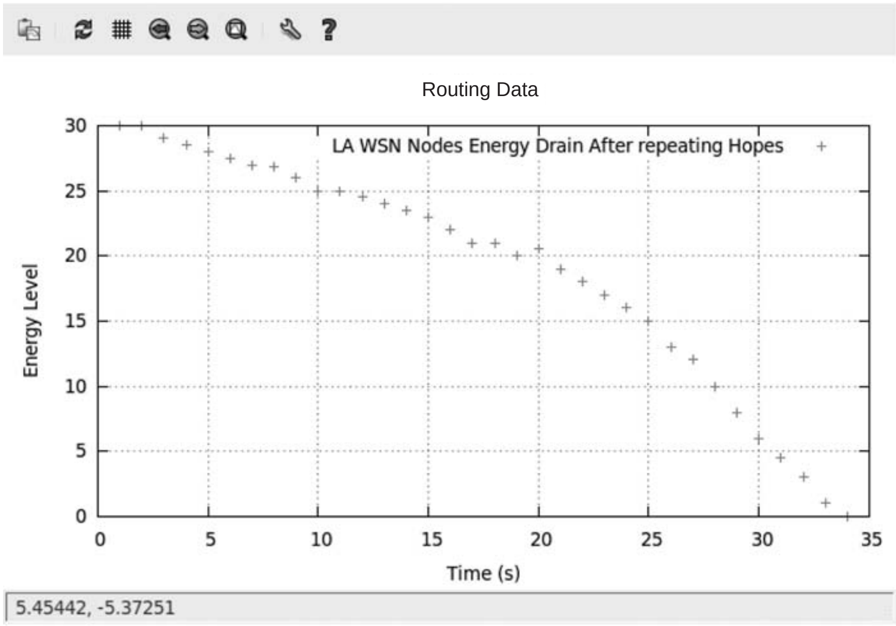


Graph ranging from 6 to 8 is actually again plotted between two parameter such as graph A is X-axis for time while Y-axis for cumulative energy level for sensor nodes. Again three different cases were taken in account with assumption that nodes and sink are aware about their location and are scattered in random fashion over an area of 100 x 100 meter. Case number one (Graph 6)is showing the comparison between time and energy level for routing before occurring hoping, while with second (Graph 7) case it is showing the comparison for routing data between time and energy level but after few number of hopes. In case three (Graph 8) is also showing the comparison for routing data but after a maximum number of network hops. Following graphs shows the clear understanding about the net results of the simulated routing and sensor nodes energy. The result shown in the graphs ranges from (6 to 8), is totally different than the graphs ranges from (1 to 3), as at this stage we consider the location aware algorithm in which we consider that all the neighbor nodes are already aware about their neighbor nodes location with the help of GPS system, in this way each node save his energy level as there is no need to send the initial data packets to the neighbor to find out the sink. In this way nodes life enhanced from approximately from 22 seconds to almost 35 seconds and during this life enhancement period the network also enable to work for more data transfer and remain live for more time period. This technique is more suitable as show in the following graphs again the result of different simulations.

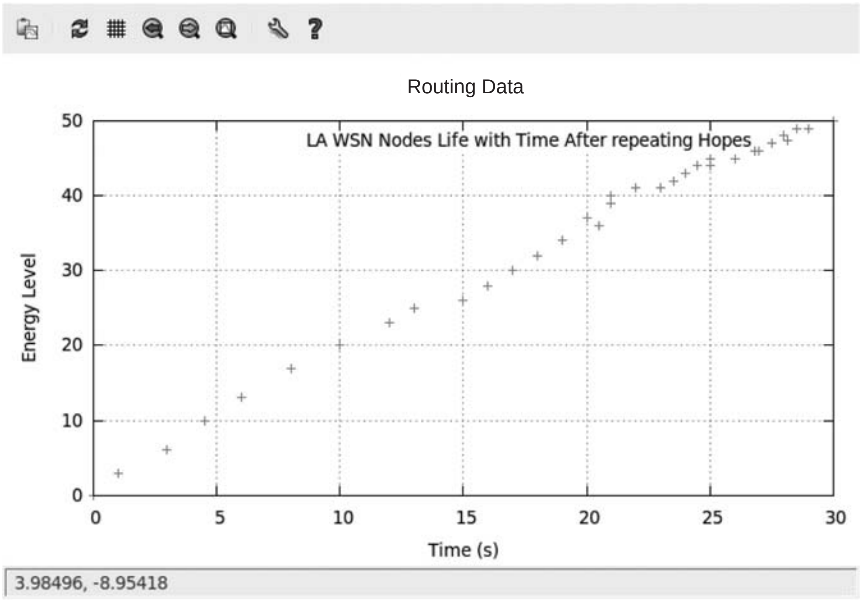
Graph 6
Location Aware WSN Nodes Energy Drain after Repeating Hopes



Graph 7
Location Aware WSN Nodes Life with Time After Repeating Hopes

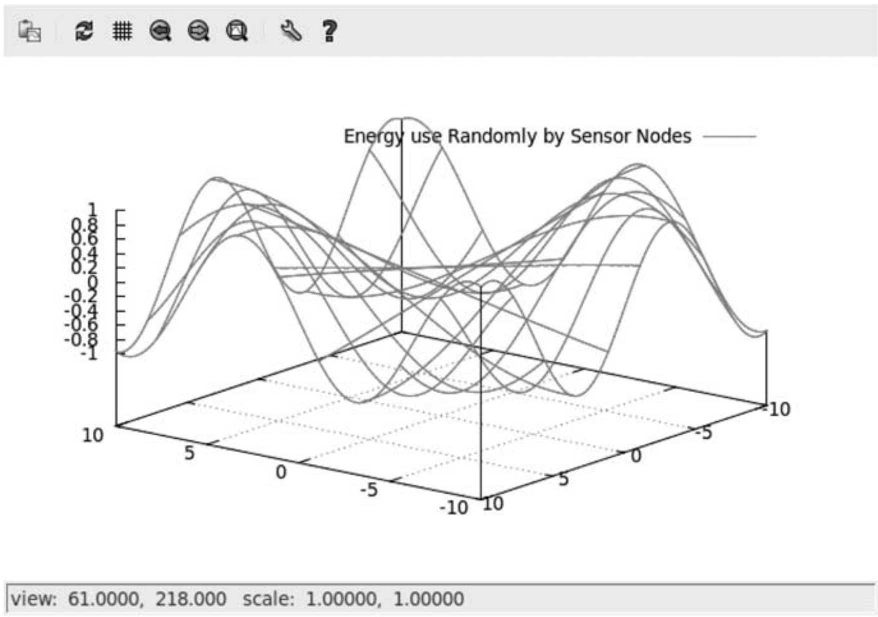


Graph 8
Generally Energy Consumption for all nodes

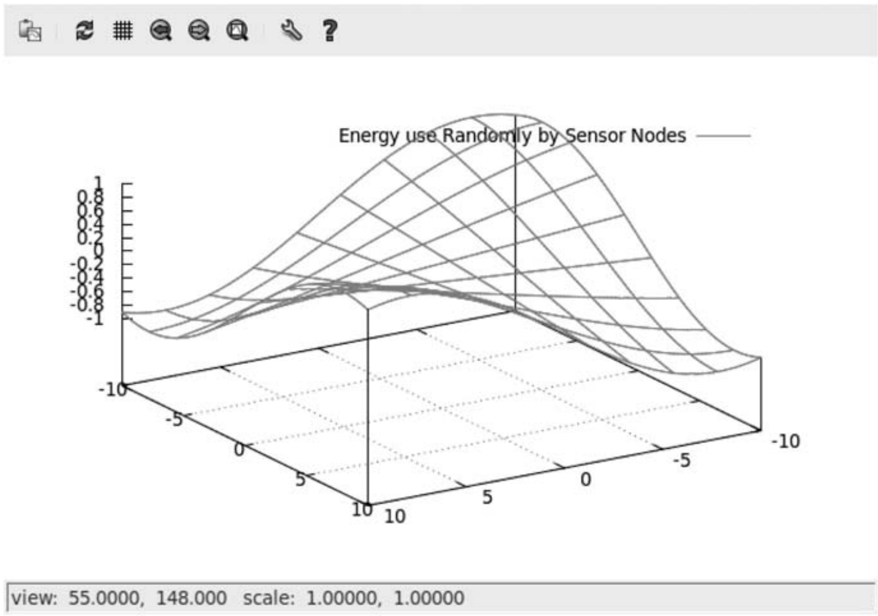


The graphs 9 and 10 shows the random energy level for the WSN network before location aware (LA) node position and after location Aware (LA) node position

Graph 9
Energy level for the WSN network before location aware (LA) node position



Graph 10
Energy level for the WSN network AFTER location aware (LA) node position



7. CONCLUSION

A new Location Aware LA WSN protocol has been proposed during this research and results show a great improvement in energy enhancement and WSN life cycle. Many new routing and MAC layer protocols and different techniques have been proposed for WSN network and most of them trying to resolve the resource constrained for unattended wireless sensor environment, The majority of all the protocols mainly Concentrate on energy efficiency of sensor nodes, however sensor application have very important role specially in critical applications like the defense and health where the accuracy and guaranteed data transfer timely is an important issue. In the same way with some more specific sensor applications where the data type is mainly image and movie is suppose to be transfer, we required more accuracy and guarantee for timely data transfer. Hence transfer of data in such cases mainly requires QoS aware routing network management in order to ensure efficient usage of the sensor nodes. We already start working on a proposed and approved project from Deanship of scientific research, KFU, related to the QoS of WSN as it has a very key role for enhancing WSN efficiency and even its life, with that project we will focus on operational and architectural challenges of handling QoS routing traffic in sensor network and will propose a new mechanism for QoS based routing protocol to further enhance WSN life.

On other hand, as we know that wireless sensor network (WSN) becomes more attractive area for the researchers now day, due to the wide range of its application areas and due to the distributed and deployment nature of these networks in remote areas, these networks are vulnerable to numerous security threats that can adversely affect their proper functioning. This problem is more critical if the network is deployed for some mission-critical applications such as in a tactical battlefield. Random failure of nodes is also very likely in real-life deployment scenarios. Due to resource constraints in the sensor nodes, traditional security mechanisms with large overhead of computation and communication are infeasible in WSNs. Security in sensor networks is, therefore, a particularly challenging task in handling secure routing traffic in sensor network.

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