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Performance Evaluation and Effect of Jamming on Energy Efficiency Routing Protocols in Wireless Sensor Networks

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Abstract

Wireless Sensor Networks comprise of loosely bound interconnected mini devices deployed over a large geographical area containing a huge number of sensors, which are spatially distributed over the network. They form a network of low power, low cost and intelligent systems having at least one base station. The pre-eminent issue for wireless sensor networks is that they consume a lot of energy during the routing process while monitoring a physical phenomenon such as speed, pressure, motion etc. Since the lifetime of the Sensor networks is limited and energy resources are scarce hence an efficient routing system of routing protocols needs to be developed which would minimize the energy consumption during the routing process. A lot of research has been carried out in this domain however a generic system of routing needs to be developed. This research paper evaluates some of these energy efficient routing protocols and compares their ability on various parameters. Furthermore the effect of jamming has also been analyzed on these routing protocols.

Keywords: *Internet of Things (IoT), Wireless Sensor Networks, Jamming, Energy Efficient Routing Protocols*

1. Introduction

Internet of Things (IoT) has revolutionized the digital world with the advent of powerful microprocessors and wireless technologies. The smart embedded systems networked together in the form of small, inexpensive sensor nodes which communicate wirelessly form a Wireless Sensor Network [1]. A typical WSN constitute large number of small, cheap, resource constrained sensor and few base stations or sinks [2]. These sensor nodes form a densely, scattered environment which can be monitored from a base station. These tiny sensors are equipped with transceivers, processor, memory elements and battery [3]. Below given figure 1 shows a simple sensor node with its associated components. These devices are deployed to monitor and collect the data after sensing physical activities in a specific area. The collected data is delivered to the base station which is a gateway to the outside world and where more intricate processing takes place. The sensing unit is typically outfitted with non-rechargeable batteries which put a constraint in battery life [4]. The wireless sensor networks are designed to use the energy efficiently because the limited battery life of the tiny sensors is matter of great concern [5]. If the sensor node goes down, the entire network will be dead that will ultimately reduces the network performance [6]. Employment of renewable energy sources in WSNs is being investigated but it has been found that the energy utilization throughout the communication process is far larger than the energy consumed in processing information at the node level [7]. Therefore researchers are largely interested in developing resource sensitive routing protocols for Wireless Sensor Networks.

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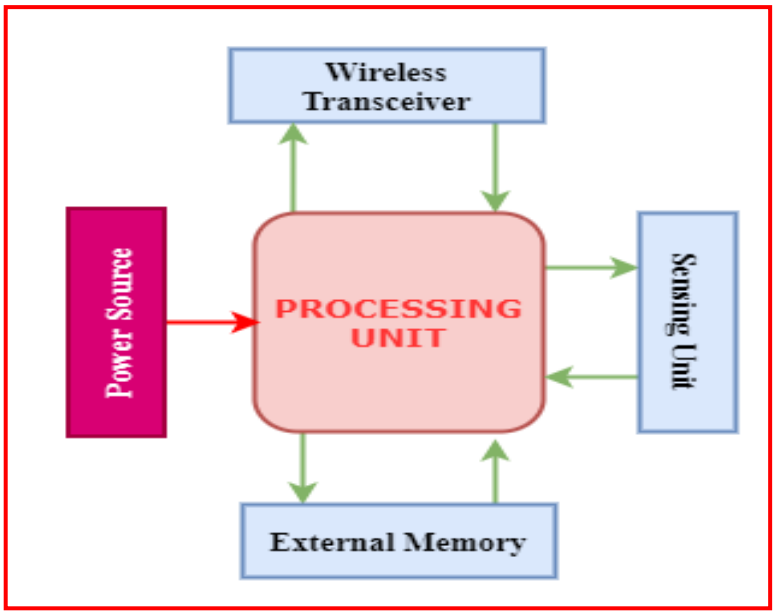

Figure 1: A Typical Sensor Node

2. Classification of Routing Protocols and their Routing process in WSN

In Wireless Sensor Networks (WSNs), the routing protocols can be generally classified into four different types like routing paths, network structure, communication initiation and protocol operation [8].

- The routing path category can further be subdivided into three main types like proactive, reactive and hybrid routing paths. In proactive routing case all routes are predefined and updated in the routing table, in reactive case paths are created when they are needed and in hybrid routing path the combination of these two ideas is used [9].
- The network structure based routing protocols are further subdivided into flat, hierarchical, and location-based routing protocols. In flat network all nodes are equivalent, in hierarchical routing protocols every node assume various jobs and in location based routing the location of the sensor nodes is exploited [10].
- In Communication initiation based routing, the routing initiation can take place at the source or the destination.
- The WSN protocol operation are subcategorized into query based, negotiation based, QoS based and Coherent based routing techniques. In query based routing the destination node transmits a query into the network and the concerned node sends back the data required. Negotiation based routing protocols eliminate redundant data using descriptors, thus suppressing the duplicate information [11]. QoS based routing satisfies some predefined metrics which can delay energy etc [12]. In coherent routing data processing plays a major role.

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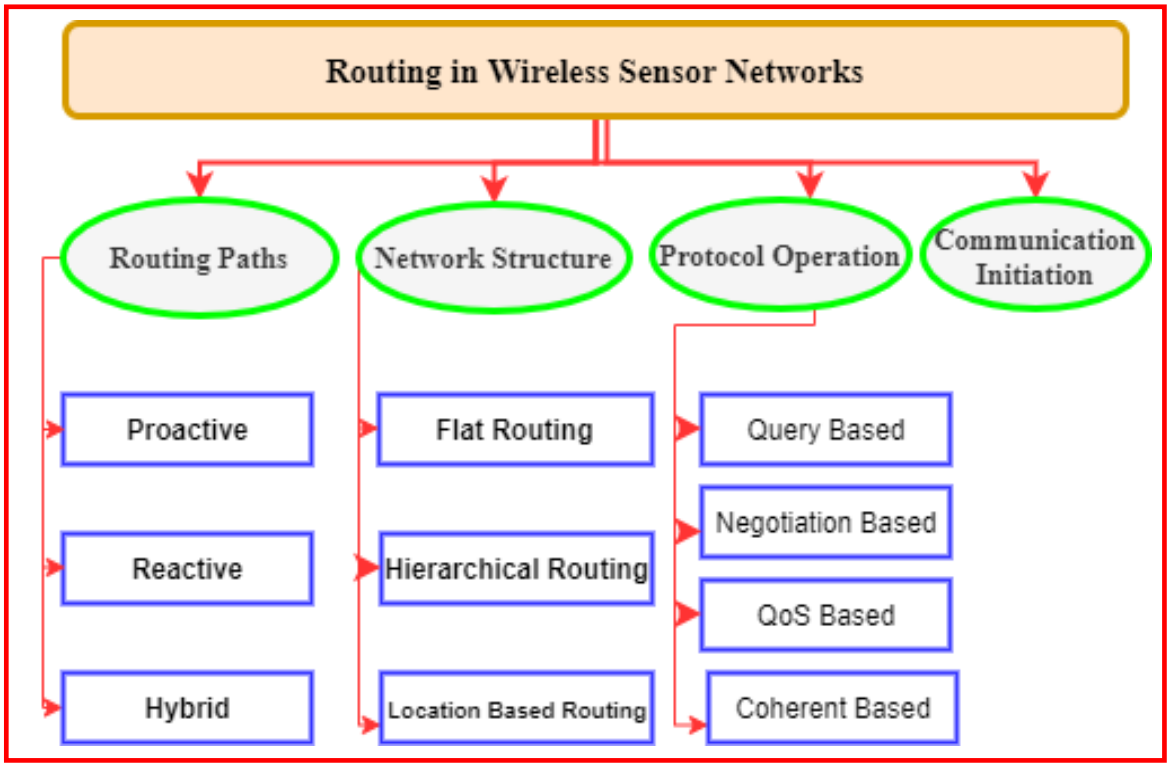

Figure 2: A General Classification of Routing Protocols in WSN

3. Energy Efficient Routing in WSN

Routing protocols deployed in sensor networks need to consider the problem of efficient use of power resources. All nodes in a network communicate with each other and the energy needed to transmit a message is about twice as great as the energy needed to receive the same message. Consequently, the route of each message destined to the base station is really crucial in terms network lifetime: e.g., using short routes to the base station that contains nodes with depleted batteries may yield decreased network lifetime [13]. Different researchers designed various techniques to save energy because the energy resources in the sensors make a major contribution in determining the duration of the Wireless Sensor Networks. These techniques include duty cycle scheduling [12], energy efficient routing [14], energy harvesting [15], energy balance etc. All of these techniques have considered hardware and software techniques for energy conservation. It has been found that most of the energy is consumed in the routing process however a very less amount of energy is utilized during the processing time. Therefore devising energy considerate routing protocols will surely lessen the energy consumption. Different researchers devised many energy efficient routing protocols intermittently. In this research work we selectively chose some of the efficient routing protocols like temporally ordered routing algorithm (TORA), Ad Hoc On-Demand Distance Vector (AODV), Distance Routing Effect Algorithm for Mobility (DREAM), Optimized Link State Routing Protocol (OLSR) and Geographical Routing Protocol (GRP) and also carried out a comparison of performance metrics. Along with these routing protocols we also studied the effect of jamming on these routing protocols.

4.Performance Evaluation of Energy Efficiency Routing Protocols in Wireless Sensor Networks

We devised Application and Profile configuration object named Pro1 and allowed network traffic to flow. The FTP packets are allowed to flow just when an application definition is tuned to ftp. The sensors are permitted to get ftp traffic from the Wireless LAN server. We define the paths by means of

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mobility configuration object and allow sensors to send and receive the packets or traffic through these paths. The complete setup of WSN is shown in below given figure 3 which comprises of 17 wireless sensor nodes (workstations), Application Configuration object, Profile Configuration object and a Mobility Configuration object.

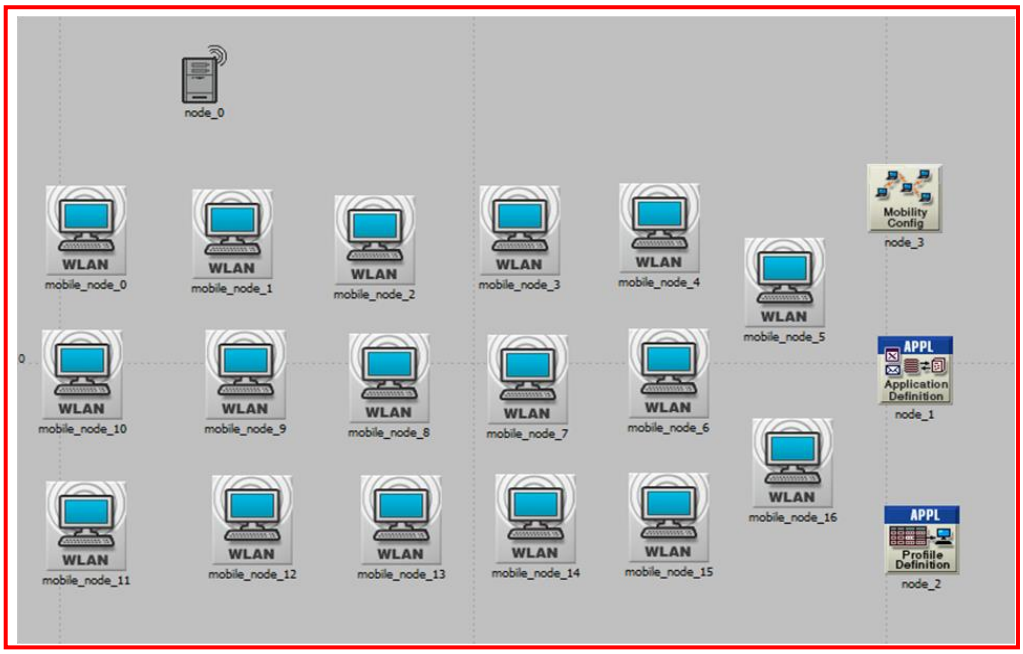

Figure 3: Wireless Sensor Network Setup

4.1 Comparison of Media Access Delay

On heavy traffic traffic it was found that the DREAM routing protocol has the least media access delay of 0.0025 bits per second. This delay has remained almost constant for longer duration of time making it the best performing routing protocol in comparison to the other selected routing protocols. The GRP Routing protocol performs worst athe beginning with 0.0085 bits per second delay but normalizes with time. The AODV and TORA routing protocols show comparable results with delay of 0.005 and 0.0032 bits per second. They have retained this delay with time. The figure 4 shows the comparion of results.

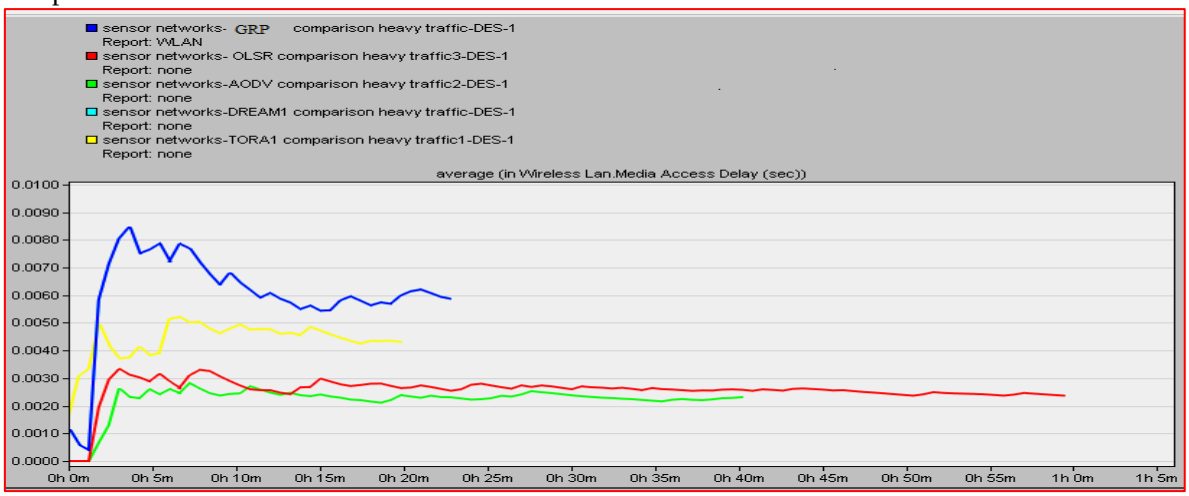

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Figure 4: Comparison of Media Access Delay

4.2 Comparison of Retransmission Attempts

The results shows that DREAM routing protocol works efficiently for retransmission attempts if the packet is not transferred in the first attempt. The retransmission rate for DREAM routing protocol is 200 packets per second intially and it falls with time as the no of packets which need to be retransmitted also falls down with time. The OLSR routing protocol perform worst having only 98 packets per second retransmission rate and which falls to below 30 packets per second with time. The TORA and AODV routing protocols have comparable retransmission rate which is 62 and 65 packets per second respectively. The figure 5 shows the results below.

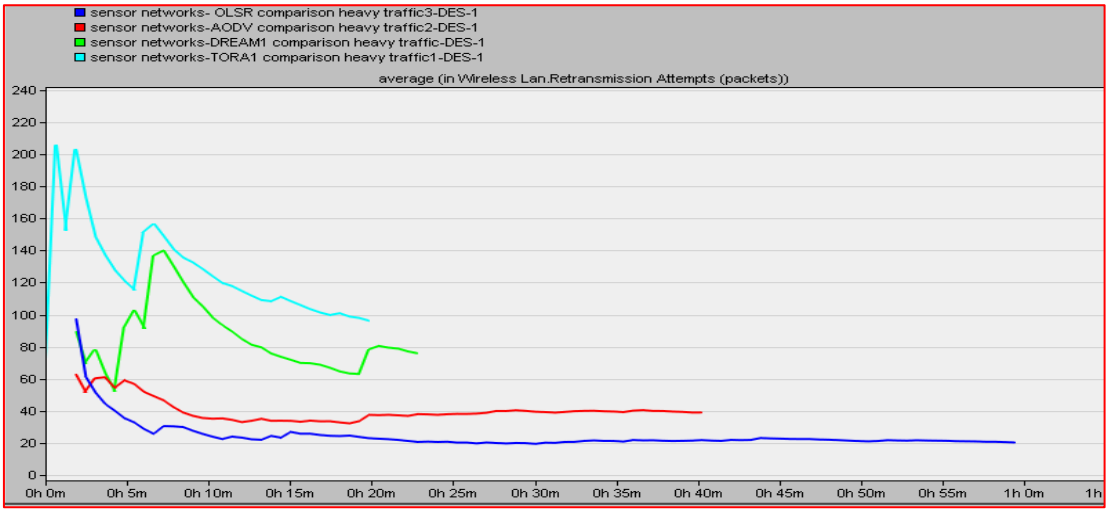

Figure 5: Comparison of Retransmission Attempts

4.3 Load

The results in figure 6 show that DREAM routing protocol performs well in comparison to other routing protocols taking close to 100000 bits per second and normalizing to over 60000 bits per second later. The other routing protocols show a comparable result TORA and OLSR having the maximum load of 60000 bits per second and AODV having 30000 bits per second load.

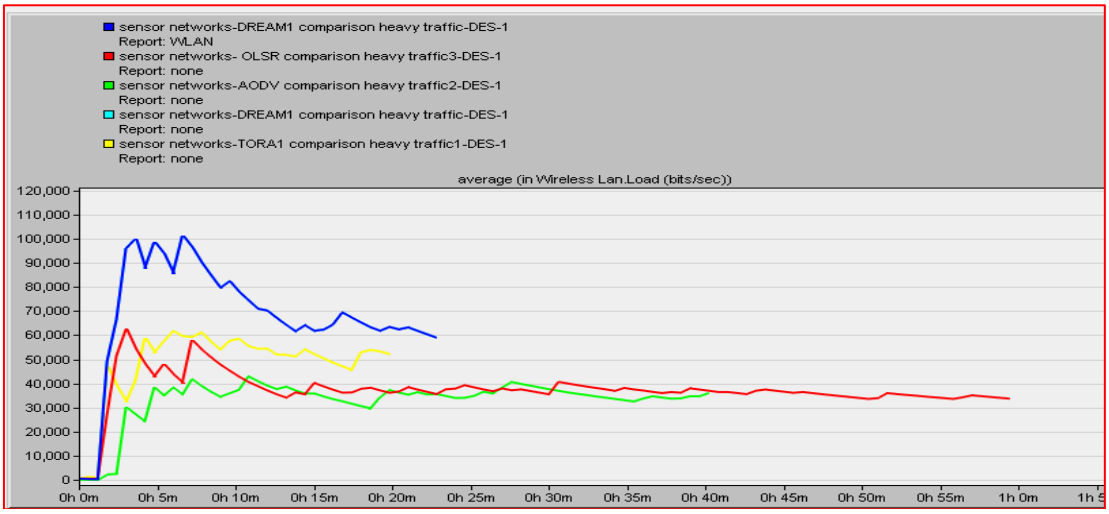

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Figure 6: Comparison of Load

5. Effect of Jamming on performance of Routing in WSNs

On the same network we evaluated the performance of the selected routing protocols in Jamming and non-jamming mode of operation. We studied throughput, load and data traffic received for TORA and DREAM routing protocols. To study the effect of jamming a jamming node was introduced into the network. The jammer used is a jam pulsed model with jammer band base frequency of 60Mhzand a jammer bandwidth of 100Mhz expected to jam selected nodes in wireless sensor network. The graphs obtained are for the selected node casesof the jammed networks. The networks were simulated for 1 hour and the resulted were obtained on the basis of the parameters given below.

5.1 Throughput

The graphs shown in below depict the result obtained for throughput on both jammed and un-jammed networks; the graph result of un-jammed is represented in figures 6.1a while the jammed one is shown in below given figure 6.1b. As we can see the graph obtained for un-jammed network is somewhat linear for both the scenarios with little fluctuations in the throughput patterns while as in jammed network the graph is receding and there are a lot of fluctuations in the throughput pattern. In case of jammed network throughput of both the scenarios starts at a high and then recede back for rest of the simulation time. While the values of throughput keep on increasing for un-jammed network, it keeps lowering for jammed network.

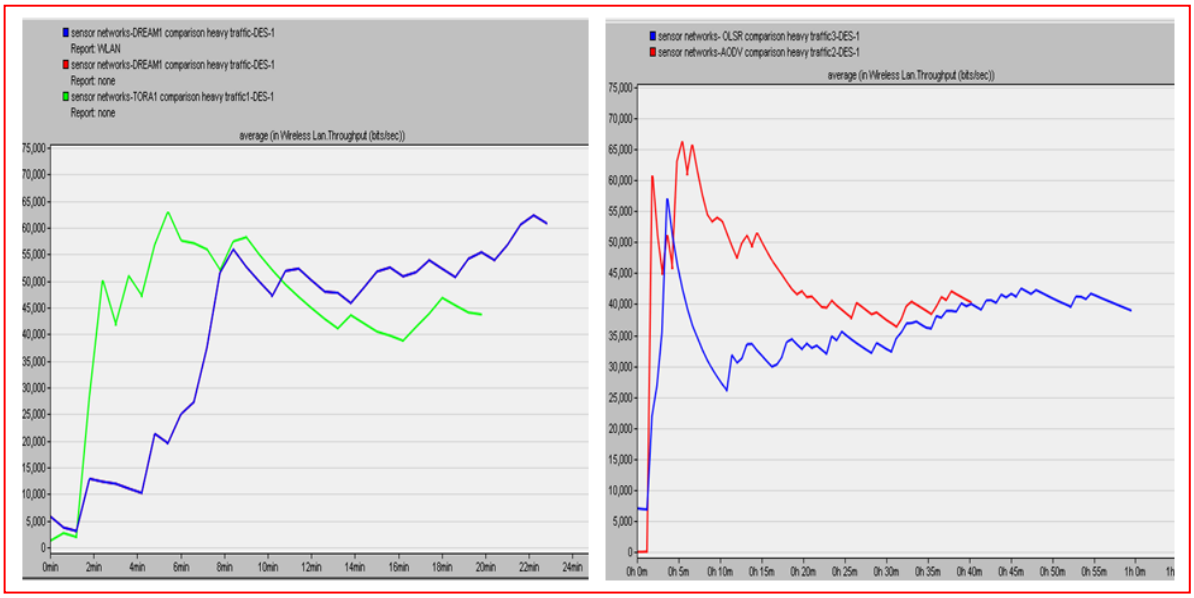

Figure 6.1a Throughput on Random Sensor without Jamming in bits/sec

Figure 6.1bThroughput on Random Sensor with Jamming in bits/sec

5.2 Load

Below given figures 7.2a and 7.2b show the trends of load in jammed and un-jammed networks. From the study of both the graphs we come to the conclusion that there are a lot of fluctuations in jammed network for the parameter of load, since jammer jams the node not at once, the load starts at a high and then reduces back to low. Load in case of un-jammed wireless sensor network follows the same trend

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as that of throughput, starts at low then goes up and then for the rest of simulation time remains constant at an average value.

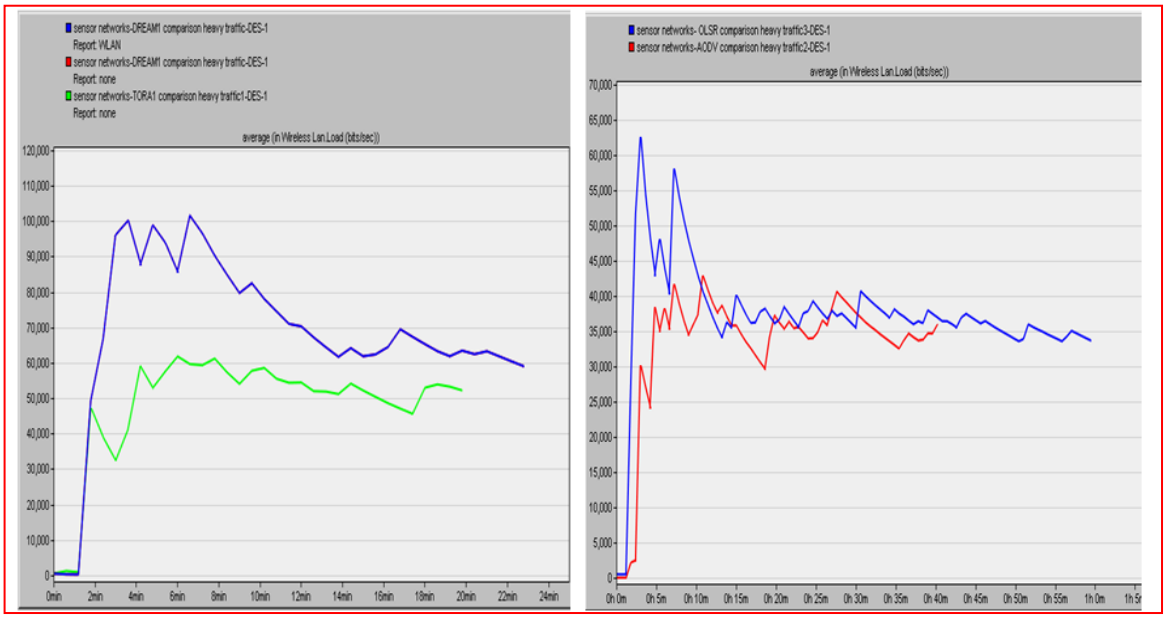

Figure 6.2a: Load on Random Sensor without Jamming in bits/sec

Figure 6.2b: Load on Random Sensor with Jamming in bits/sec

While the jammed node load reduces to a value of less than 35000 bits/sec form initial value of 55000 bits/sec, the un-jammed network keeps a constant value of almost 60000 bits/sec.

5.3 Data Traffic Received

The figures 6.3a and 6.3b below depict the result obtained for data traffic received on both jammed and un-jammed networks; the graph result of un-jammed is represented in below given figure 6.3a while the jammed one is shown in figure 6.3b. As we can see the graph obtained for un-jammed network is somewhat linear for both the scenarios with little fluctuations in the throughput patterns while as in jammed network the graph is not linear but constant and there are a lot of fluctuations in the Data packets received. The jammed network received data at a constant rate of 500,000 bits per second and 650,000 bits per second for both the scenarios. But for un-jammed network the value doesn't settle for a particular value.

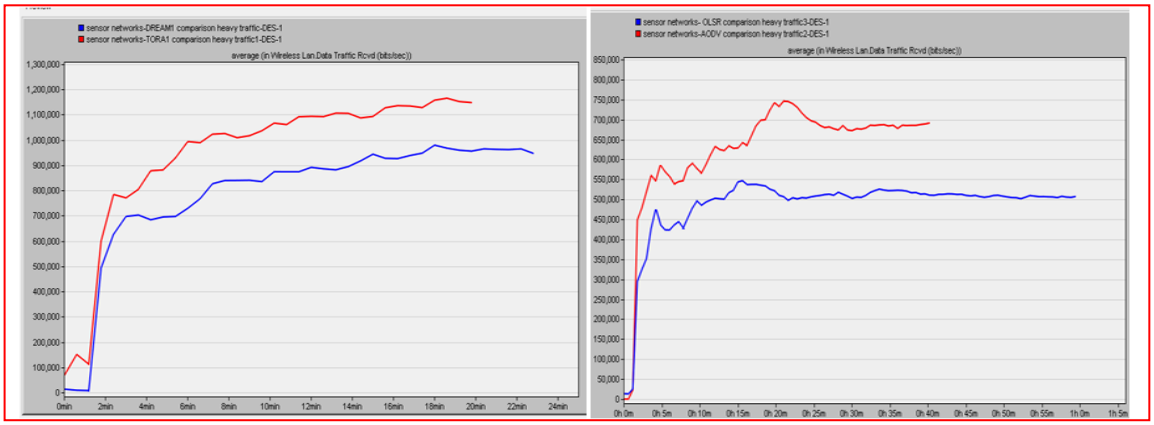

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Figure 6.3a Data Traffic Received on Random Sensor without Jamming in bits/sec

Figure 6.3b Data Traffic Received on Random Sensor with Jamming in bits/sec

Conclusion

This research work compares the performance of energy efficient routing protocols in Wireless Sensor Networks. Some selected protocols were selected for comparison purposes. It was found that although TORA routing protocol performs well on light traffic but DREAM routing protocol has high performance metrics on heavy traffic. The paper also studies the effect of jamming on routing performance. The results were compared for DREAM and TORA routing protocols and it was observed that DREAM routing protocol performs well under jamming conditions.

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