Comparison of Energy-Efficient Data Acquisition Techniques in WSN through Spatial Correlation

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***Abstract*— In last year's, the number of wireless sensor network implementation for real life applications has rapidly increased and gain increasing attention from both the research community and actual users. As sensor nodes are generally, battery-powered devices, the critical aspects to face concern how to reduce the energy consumption of nodes, so that the network lifetime can be extended to reasonable times. But, the energy problem remains one of the major barriers that prevent the complete implementation of this technology. Sensor nodes are usually powered by batteries with a limited lifetime. Energy Efficiency is a key requirement for design of a wireless sensor network. In this paper, we study the clustering technique for energy efficient data acquisition and then compare them with different parameters to evaluate results.**

***Keywords*—** *clustering, PDR, acquisition, WSN, throughput.*

1. Introduction

A wireless sensor network (WSN) consists of a large number of tiny sensor nodes deployed over a geographical area also referred as sensing field; each node is a low-power device that integrates computing, wireless communication and sensing abilities. Nodes organize themselves in clusters and networks and cooperate to perform an assigned monitoring (and/or control) task without any human intervention at scales (both spatial and temporal) and resolutions that are difficult, to achieve with traditional techniques. Sensor nodes are thus able to sense physical environmental information (e.g., temperature, humidity, vibration, acceleration or whatever required), process locally the acquired data both at unit and cluster level, and send the outcome to the cluster and/or one or more collection points, named sinks or base stations.

Sensor networks are used for a variety of applications including wireless data acquisition, machine monitoring and maintenance, smart buildings and highways, environmental monitoring, site security, safety management, and in many other areas.

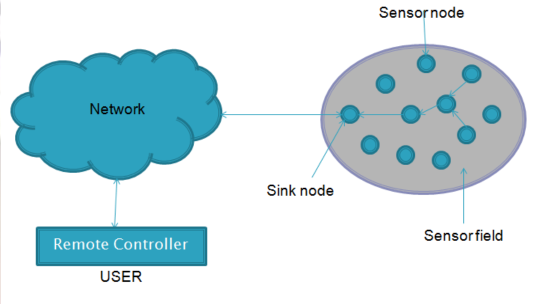

Figure 1: Sensor Network Architecture

However, energy consumption still remains one of the main obstacles to the diffusion of this technology, especially in application scenarios where a long network lifetime and a high quality of service are required. Energy conservation schemes have to reduce the number of acquisitions (i.e. data samples). Energy-efficient data acquisition techniques reduce the energy consumption of the sensing subsystem and decrease the number of communications as well. There are several parameters that also influence the data acquisition of sensor nodes. The study of various parameters should be done so that efficient data acquisition techniques for sensor networks will be developed.

2. Simulation model and topology

Using Castalia simulator, a sensor network application was created through which, number of nodes are deployed in a sensor field. The duty of sensor nodes is to sense the environment and then send the packets to a sink node. The simulation is performed in form of two different topologies as :

- *Uniform deployment without clustering*: In this topology, sensor nodes are deployed in a field using a random uniform distribution. The performance evaluation is done for different collision models and different number of nodes.
- *Uniform deployment with clustering*: Through this topology, sensor nodes are deployed in a field using a random uniform distribution. Several WSN applications require only an aggregate value to be reported to the observer. In order to support data aggregation through efficient network organization, nodes can be partitioned into

a number of small groups called clusters. This phenomenon of grouping sensor nodes into clusters is called clustering.The metrics and parameters used for simulation are listed in the Table I.

TABLE I
SIMULATION PARAMETERS

SIMULATION PARAMETERS	VALUES
SIMULATION TIME	20 sec
SIMULATION FIELD	70 * 70 METERS
PACKET SIZE	2000 bytes
PACKET RATE	1 packets per second
MAC FRAME SIZE	2500
SENSOR DEPLOYMENT	UNIFORM
TX POWER	-5 dbm
NUMBER OF NODES	100

3. Evaluation metrices for evaluation

In order to evaluate the performance of Castalia simulator, we introduce some metrics which best describe nominal WSN configurations. These configurations are widely used in real world WSN applications as well as simulation-based studies. The performance metrics which we consider for our simulation scenarios are in the following:

- *Throughput:* Throughput is a measure of the total packets received by the application. Equation 1 shows the calculation for throughput TP, where Packet RX_i is the total packets receive by the sink node, Packet TX_i is the total packets transmitted by all sensor nodes other than sink node.

$$Throughput = \frac{packets\ RXi}{packets\ TXi}\ (bytes/sec) \quad (1)$$

- *Packet Loss:* Packet loss affects the perceived quality of the application. Several causes of packet loss or corruption would be interference between nodes or packets not send due to end of simulation time.

$$\text{Packet loss rate} = \frac{\square\ \text{lost packets}}{\square\ \text{total packets}}\ 100 \qquad (2)$$

- *Energy Consumption:* Energy Consumption would be the amount of energy taken by a node to transverse packets from the sensor nodes to the sink node. It is also the energy consumed by sink node to receive the packets from all sensor nodes in the sensor field.
- *Packet Delivery Ratio:* This parameter shows the PDR packet delivery ratio on the sink node. As we know that all the sensed data should be delivered to the sink node in a Wireless sensor network.

4. Simulation Results

Various parameters defined are illustrated for the comparison of a netwok with clustering and without clustering . And from the results conclusions are made. The comparisons are made one by one below.

- *Throughput* **:** Fig 2 shows the throughput result using clustering and without clustering in the network. As the results shows that throughput of the simulation without clustering is between 20 to 30 packets whereas with clustering it is 50 to 80 packets per nodes .This change in throughput is because throughput depends on the packets received and no of packets received depends on deployment i.e. where the nodes are placed.

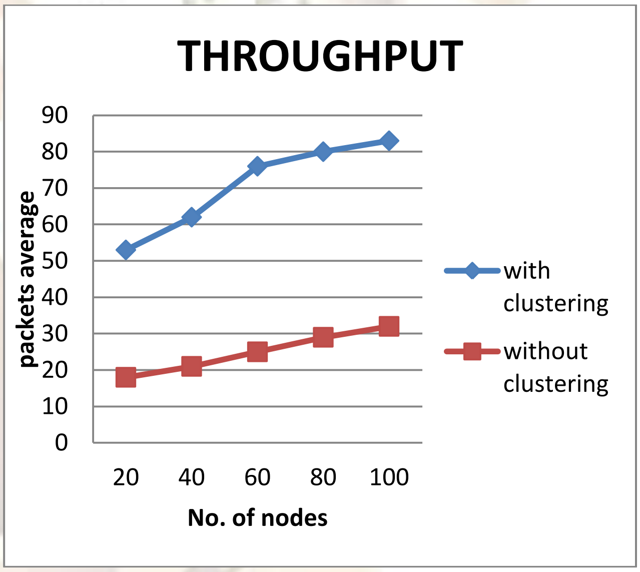

Figure 2: Throughput of packets

In clustering every node send packets to the cluster head rather than to the sink node. So the distance between them is less and due to this rate of packet fail decreased. Whereas in network without clustering every node has to send packets to the sink node. So packets are more failed due to large distance and collision between them.

- *Packet loss Rate***:** Packet loss rate depends on the total packets lost by nodes due to various factors like interference, non receiving state and below sensitivity. In Fig 3, difference in packet loss is shown with two types of deployment i.e. with clustering and without clustering. The number of nodes i.e. 100 is constant. Packet loss rate in deployment without clustering is more than the deployment with clustering as shown in figure. In deployment without clustering , it is above 80 percent whereas in deployment with clustering, it is 20 percent. The simulation results show that deployment of nodes affect the packet loss rate.

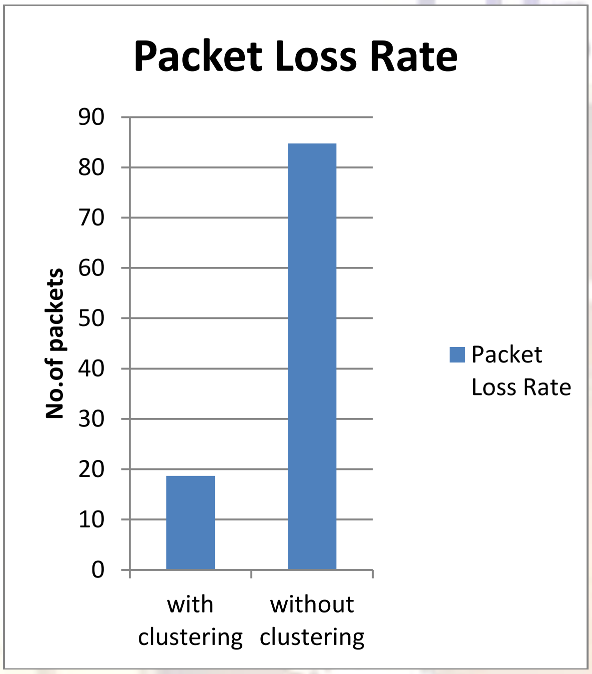

Figure 3: Packet loss rate i.e with clustering , without clustering

The above results come because in clustering the distance between the node and cluster head is less. And because of less distance the rate of packet loss due to various parameters is decreased as compared to the deployment without clustering in which this rate is more.

- *Energy Consumption:* Fig 4(a) shows the Energy consumption result with clustering. In the network with clustering, the energy consumption of cluster head is more as compare to sender nodes i.e 1.3 and 0.3 joules approximately.

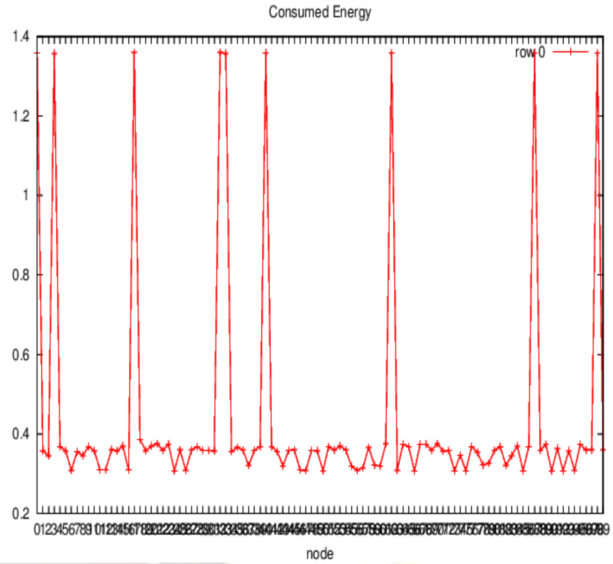

Figure 4(a): Energy consumption with clustering

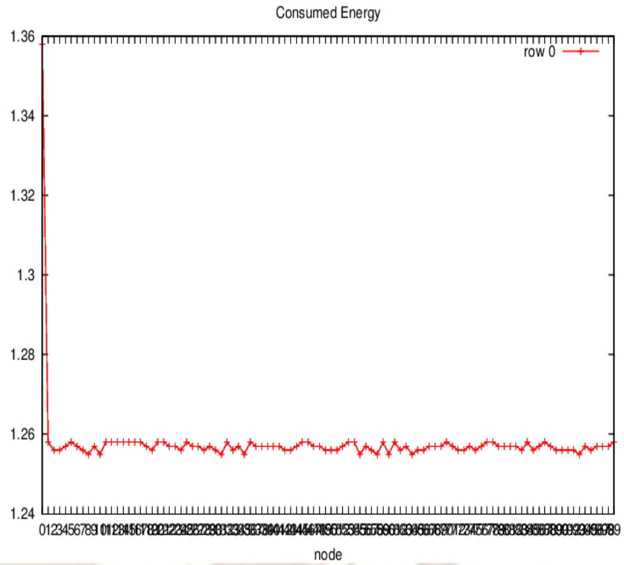

Figure 4(b): Energy consumption without clustering

whereas in network without clustering it is 1.36 joules for sink node and 1.26 joules for other nodes as shown in fig 4(b). The results shows that energy consumption in the network with clustering is less rather than the network without clustering. This is due to various reasons like distance, less burden on sink node, less collision.

- *Packet Delivery ratio:* Fig 5 shows the packet delivery ratio for both with clustering and without clustering network. As shown in results, with clustering packet delivery ratio is 80-90 percent whereas without clustering it is 40 percent. In clustering, the number of packets delivered to the sink node are more as compare to the network without clustering. Because in clustering every node has to send packets to its nearer node called cluster head whereas in network without clustering every node has to send packets to the sink node which is far in distance. And due to this large number of packets failed.

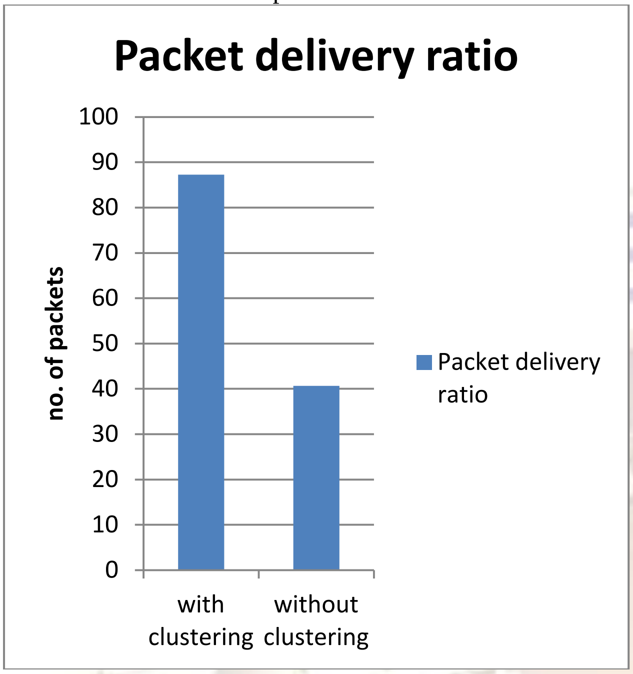

Figure 5: Packets delivery ratio

5. Conclusion

Efficient Data Acquisition was analyzed using a simulation based on network simulator, OMNET++. The comparison of a simple network and a network with clustering is performed. In order to support data aggregation through efficient network organization, nodes can be partitioned into a number of small groups called clusters. This phenomenon of grouping sensor nodes into clusters is called clustering. Results are taken from the simulation based on different parameters like throughput, packet delivery ratio, energy consumption, packet loss rate. The overall conclusion is that a network with clustering gives better performance as compare to the network without clustering. The network with clustering is also more energy efficient rather than without clustering.

Clustering also supports network scalability and aggregate the data collected by the sensors in its cluster. The Cluster Head can also implement optimized management strategies to prolong the battery life of the individual sensors and to maximize the network lifetime.

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