Design and Implementation of In-network Multilevel Data Aggregation in Wireless Sensor Networks

M Mathankumar, P.Thirumoorthi

Abstract: ***In Wireless Sensor Network (WSN), the role of data computation and communication among the sensor nodes are noteworthy. At the instant of covering a huge area, lot of issues faced like lifetime of nodes, energy consumption, redundancy of data, faster data communication etc. To prevail over these issues, the multilevel data aggregation within the network is designed and implemented with the help of PIC and ARM microcontrollers. The multilevel aggregation superintends the redundancy of data effectually in contrast to single or two level data aggregation. It is appended to intensify the lifetime of the network by decreasing the amount of data transmission to Base Station (BS) and aggregating the similar as well as near similar data packets in an effective methodology. By exploiting this in a wide agriculture fields, diverse parameters can be easily monitored such as temperature, moisture, soil and water levels etc. Using the BS data, the required actions can be performed in the field.***

Keywords - Wireless sensor network, In-network, Multi level data aggregation, Microcontrollers, Lifetime, Energy, Agriculture.

I. INTRODUCTION

Wireless sensor networks (WSN) is encapsulated with prodigious amount of sensor nodes with unchangeable and non chargeable batteries. These cramped devices are spatially distributed to examine environment or physical conditions in remote as well as pernicious environment. Hence wireless sensor networks have manifest their advantages in many applications like Agriculture, Military field, Industry, Health care etc [1]. Even though the merits found to be appreciable, the setup of sensor nodes for various kinds of application is still strenuous. These sensor nodes have low energy, less memory, lack of communication and computational power; also they have simple and erratic hardware which results in lapse of sensor nodes before the expected network lifetime [2] [3]. Data redundancy is another big critic occurring in the network. The sensor nodes which are placed at closer distance can send the similar data but that is not needed. Thus the unwanted redundant data wastes energy, reducing lifetime etc. These issues can be eliminated by implementing effective multilevel data aggregation technique which can be implemented for improving network performance, conserving energy, eliminating redundancy, increasing network lifetime, efficient utilization of bandwidth, enhancing accuracy, providing robustness, reducing traffic etc [4] [5].

There are three general approaches used to perform data aggregation they are centralized approach, decentralized approach and in-network approach [6]. This paper proposes the in-network multilevel data aggregation technique that executes aggregation at different levels in order to reduce redundant transmission and intensify the operational lifetime of the network. The aggregation may involve sum, average, median, min and max values etc. Depends upon the need, aggregation function can be chosen [7] [8] [9] [10].

II. PROPOSED SYSTEM

The proposed system consists of two different wireless sensor networks which include BS, Main aggregator, sub aggregator and sensor nodes to perform in-network multi level data aggregation. Multi level aggregation refers that multiple levels such as grid, cluster and network level aggregation process are performed. Consider a large scale network, In that multiple sensor nodes are widely distributed over the network. It forms a grid and selects a sub aggregator node. Sensor nodes sense the specified environment parameters and forwards to sub aggregator. Other grids also followed the same process. For many sub aggregators there will be one main aggregator thus forms the cluster within the network. Then sub aggregators aggregate all the values which are comes from the sensor node and sending the aggregated value leads to the main aggregator. Finally the aggregated value of main aggregators from different networks reaches the BS. According to the final value from BS, the needed action carried out in the environment. The Proposed network illustration is given in the Fig.1.

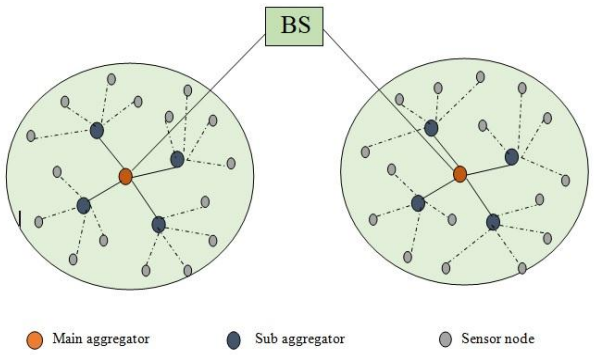

Fig.1 In-network Multilevel Data Aggregation

Revised Manuscript Received on December 08, 2018.

M Mathankumar, Assistant Professor, Electrical and Electronics Engineering, Kumaraguru College of Technology, Coimbatore, India

Dr.P.Thirumoorthi Professor, Electrical and Electronics Engineering, Kumaraguru College of Technology, Coimbatore, India

III. EXPERIMENTAL TESTED

The aggregation of data can be implemented in the hardware by the use of PIC microcontroller, LPC2148 processor and PC. Here the sample illustration is given by using two normal sensor nodes and one aggregator node. PC is considered as Base Station. For setting up a large scale network, the count of sensor nodes and aggregator nodes should be increased. For objective implementation, 2 PIC microcontrollers that act as sensor nodes and LPC2148 which acts as an aggregator node are used. Let temperature (LM35) and moisture sensor (DIP type) nodes are considered for evaluation to grab temperature and moisture level in the environment. Temperature sensor detects any physical changes happens in the environment temperature and moisture sensor detects the amount of water vapor present in the air. When both the sensor nodes have acquired the values, it sends those values to the aggregator node that finds the sum of the collected values and sends to the PC. The block diagram of the hardware setup is represented in Fig.2 and Fig.3.

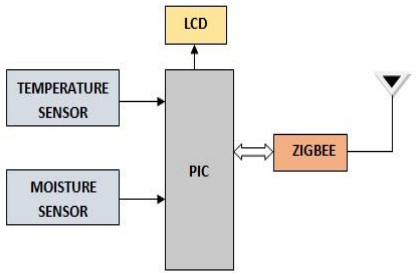

Fig.2 Sensor Node

Fig. 2 represents a sensor node which has temperature and moisture sensors as sensing unit and PIC microcontroller as processing unit. Max232 as well as Zigbee considered as communication unit. LCD is recommended for displaying the result to the user.

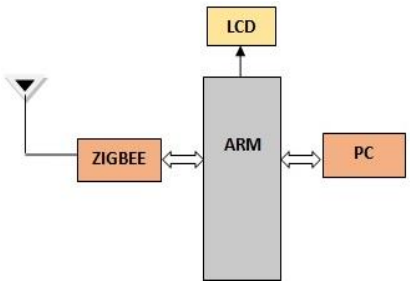

Fig.3 Aggregator Node

For the proposed network, aggregator nodes are classified into main and sub aggregator nodes. Here for sample, ARM processor performing as an aggregator node. It aggregates the values comes from the sensor nodes. Zigbee used for both transmitting and receiving the data from sensor nodes. Thus the summed up value will reach the PC for further actions.

IV. TEST CASE IMPLEMENTATION AND DISCUSSIONS

A. Result of Sensor Nodes

Here two PIC16F877A microcontrollers are used to act as sensor nodes for sensing the analog data from the environment. The sensors which are embedded with the sensor nodes are temperature sensor and the moisture sensor. The sensed data by the sensors are displayed in the 2x16 LCD display. For example TEM value: 33 and MOI value: 54. Similarly, the sensor node 2 is also fixed with the sensor which is kept at a distance apart produces the temperature and moisture value of that location. Fig.4 given below is the sensor node 1.

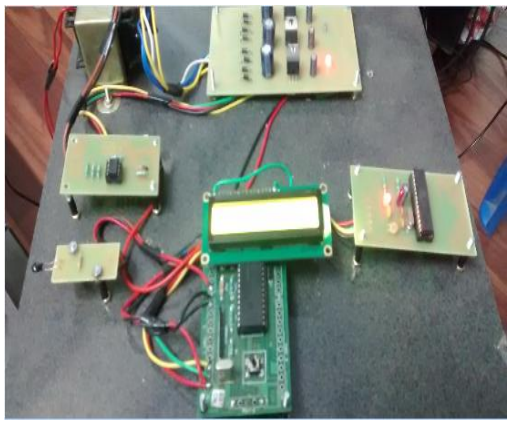

Fig.4 Sensor node 1

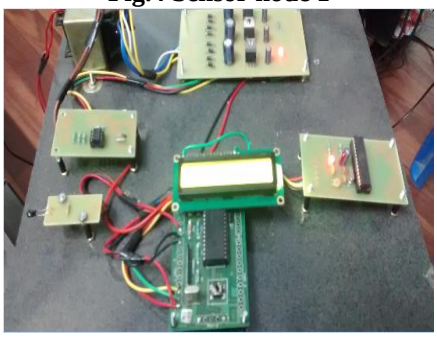

Fig.5 Sensornode2

Fig.6 Values of sensor node 2

The Fig.5 and Fig.6 show the sensor node 2 and its measured values. It also displays the values of the sensor node 1 before they are aggregated in the aggregator node.

B. Result of Aggregator Node

Here the LPC2148 processor is used as the aggregator node which aggregates the data from the sensor nodes as shown in the Fig.7.

The data from the sensor node is received by Zigbee in the aggregator node, then aggregation takes place and the results are displayed in the LCD display as in Fig.8.

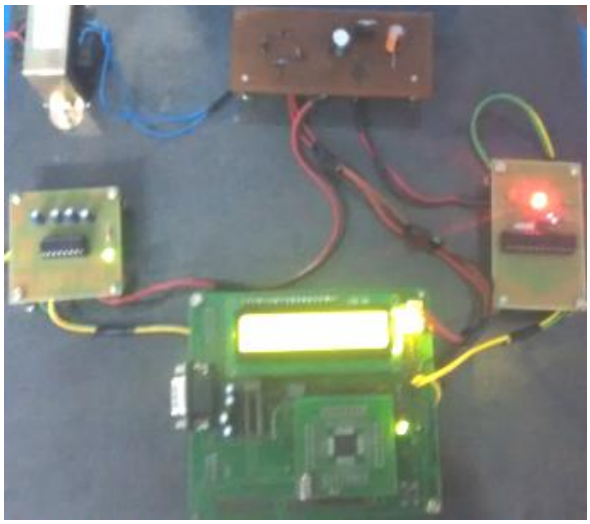

Fig.7. Aggregator node

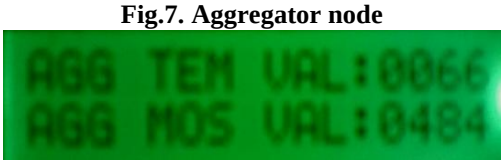

Fig.8. Values of aggregator node

NODES	MEASURED TEMPERATURE (^{0}C)	MEASURED MOISTURE (m^3)
SENSOR NODE 1	33	245
SENSOR NODE 2	33	240
AGGREGATOR NODE	66	485

Table1.Measured Parameters

C. Graph Representation

The packet delivery ratio is the ratio of packets that are successfully delivered to a destination compared to the number of packets sent by the sender. Hence with the proposed result the packet delivery ratio seems to be increasing for every interval of time. In Fig. 9 the graph represents the packet delivery ratio.

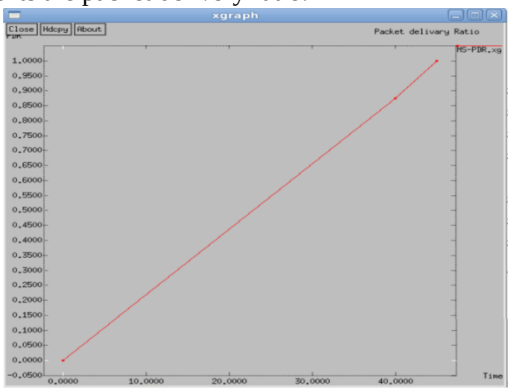

Fig.9 Packet delivery ratio

Over a communication channel the rate of successful message delivery is throughput. Here the throughput is found to be increased when it reaches the destination. In Fig. 10 the graph represents the network throughput of the proposed system.

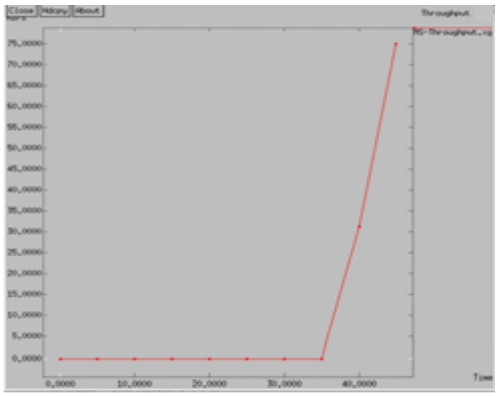

Fig. 10 Network throughput

Packet drop occurs when some data packets fail to reach their destination. Here the packet drop decreases when it reaches the destination. In Fig. 11 the graph represents the Packet drop of the system.

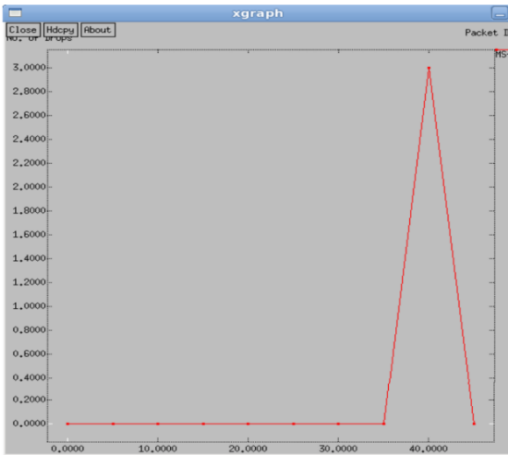

Fig.11 Packet drop

V. CONCLUSION

Thus the design of Multi level data aggregation is implemented by using PIC and ARM microcontrollers. Hence the life time of the network seems to be increased effectively and the battery degradation of sensor nodes is reduced, thus there is no need for rapid change of sensor nodes. Aggregation in each cluster intensifies the life time of the wireless sensor networks. This can be suitable in different applications where networking exhibit in vast area. Here In-network multilevel data aggregation is performed for decreasing the redundancy of data. So the data repetition can be easily avoided and the required useful data transmitted to the BS.

This methodology greatly decreases the cost of computation as well as communication.

REFERENCES

1. Ajay Jangra Swati and Priyanka, "Wireless Sensor Network (WSN): Architectural Design issues and Challenges", International Journal on Computer Science and Engineering Vol. 02, No. 09, pp. 3089-3094, 2010.
2. Vaibhav Pandey, AmarjeetKaur and Narottam Chand, "A review on data aggregation techniques in wireless sensor Network", Journal of Electronic and Electrical Engineering Vol. 1, Issue 2, pp. 01-08, 2010.
3. Rajkanna U and Manivannan D "Status monitoring and control in industrial application using mobile relay node – LPC2148", International Journal of Engineering and Technology, Vol. 5, No. 2, pp.1178–1182, 2013.
4. Devendar Mandalat, Fei Dait, Xiaojiang Dutand Chao Yout,"Load Balance and Energy Efficient Data Gathering in Wireless Sensor Networks" IEEE computer engineering, 2006.
5. Sugandhi N and D Manivannan, "Analysis of Various Deterioration Factors of Data Aggregation in Wireless Sensor Networks", in International Journal of Engineering and Technology (IJET), Vol 5 No 1, 2013.
6. M Preethi, M Mathankumar, N Sugandhi, "Elucidation of Effectual and Immune Multipath Routing with Multilevel Data Aggregation in Wireless Sensor Networks", in International Journal of Applied Engineering Research (IJAER), Vol. 10 No.20, 2015.
7. Mathankumar M, Viswanathan T, Dineshkumar T, "Implementation of Data Gathering System Using Mobile Relay Node in Wireless Sensor Network", International Journal of Pure and Applied Mathematics (IJPAM), 116(11), pp. 111-119, 2017.
8. Abhijith H.V, Dr M Dakshayini, "Efficient Multilevel Data Aggregation Technique for Wireless Sensor Networks," in IEEE conference publications, 2013.
9. Bilal Jan, Haleem Farman, Huma Javed, Bartolomeo Montrucchio, Murad Khan and Shaukat Ali, "Energy Efficient Hierarchical Clustering Approaches in Wireless Sensor Networks: A Survey" in Hindawi, Wireless Communications and Mobile Computing, 2017.
10. Sathya D, Ganesh Kumar P, "Secured data aggregation in wireless sensor networks" in Sensor Review, Vol. 38 Issue: 3, pp.369-375, 2018.