

Intelligent data gathering in distributed wireless sensor environment - A Real Scenario

Bhat Geetalaxmi Jayram, Dr. D.V.Ashoka

Abstract- In Wireless Sensor Network (WSN), gathering sensed information and relay it to the Base station using multi-hop communication in an energy efficient manner is of prominent importance [1]. A novel approach for Intelligent Data Gathering in WSN is proposed in this paper. This scheme implements sensing of the intelligent data by sensor nodes and Data Gathering at the Base station using respective algorithms. Hardware implementation results prove that proposed scheme is effective to collect Intelligent Data at the Base station. The proposed algorithm is implemented using JN5148 microcontroller based Base Station (Access Point). Future work focuses on tackling with the undesirable situations like Data Redundancy and Congestion to improve the life time of the WSN.

Index terms – Congestion, Data Gathering, Distributed nodes, Energy Conservation, Intelligent data, Redundancy, Reliability.

1 INTRODUCTION

1.1 Wireless Sensor Networks (WSN)

A sensor network normally constitutes a wireless ad-hoc network, it means that each sensor supports a multi-hop routing algorithm (several nodes may forward data packets to the base station). A wireless sensor network (WSN) consists of spatially distributed autonomous sensors to cooperatively monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants. They are now used in many industrial and civilian application areas, including industrial process monitoring and control, machine health monitoring, environment and habitat monitoring, healthcare applications, home automation, and traffic control. But sensor network have the following unique characteristics and constraints as shown in Fig 1.1. This presents many new challenges in the design of sensor networks. Here authors have elaborated more on data Redundancy constraint.

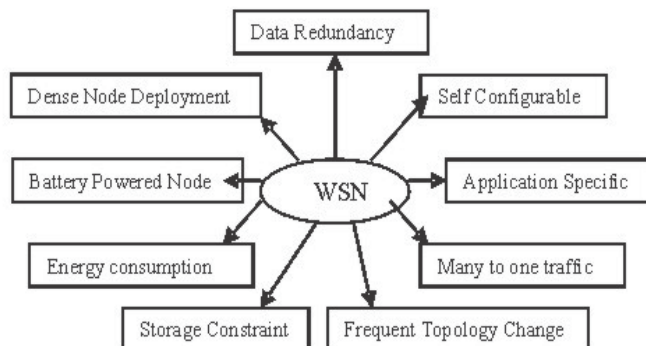


Fig.1.1 Characteristics and Constraints of WSN

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2 DATA GATHERING IN WSN

Data gathering is recognized as one of the basic distributed data processing procedures in wireless sensor networks for saving energy and reducing medium access layer contention.[2]. A common function of sensor networks in which the information are sampled at sensor nodes and are transported to central base stations for further processing and analysis is called data gathering [3].The time sensitive data needs to be transmitted back to the station in a near real time fashion for many data gathering applications such as object tracking and intrusion detection. The applications like acoustic sensor networks, underwater or ocean sensor networks and environmental monitoring do not need real-time data transmission and access. It can be used in scientific applications by domain scientists to collect scientific data for further analysis [4]. The three major stages of data collection are namely the deployment stage, the control message dissemination stage and the data delivery stage. The issues regarding the deployment of the network is in the sensing field is addressed by the deployment stage. The network setup/management and/or collection command messages are disseminated from the base station to all sensor nodes in the control message dissemination stage. Here the challenge is to disseminate messages to all the sensor nodes with small transmission costs and low latencies. The main task of the sensor data collection is fulfilled by the data delivery stage [5].

2.1 Importance of Data Gathering

1. Data gathering mechanism performs in-network aggregation of data which is needed for energy-efficient information flow.[6]
2. Data gathering protocols can reduce the communication cost, thereby extending the lifetime of sensor networks.

3. The inherent redundancy in raw data collected from the sensors can often be eliminated by in-network data gathering.[7]
4. Data gathering can reduce the number of data packets transmitted and the data conflict thus raises the data accuracy and data collection efficiency through dealing with the redundant data in-network.

3 PREVIOUS RESEARCH

Wireless Sensor Networks is the latest technological research perspective in the networks.

A. Seetharam et al [8] proposed an energy efficient data gathering protocol, which enhances the performance of LEACH, PEGASIS. In this scheme each node only communicates with a close neighbor and takes turns in transmitting to the base station depending on its distance from it. This helps to iron out the unequal energy dissipation by the individual nodes of the network and results in superior performance as compared to LEACH and PEGASIS.

Min Xiang et al [9] proposed energy-efficient intra-cluster data gathering. Their mechanism is designed for reducing the energy consumption and prolonging the network lifetime. First, each cluster head acts continuously as local control center and will not be replaced by the candidate cluster head until its operation times reach its optimum value, thus the energy consumption ratio of gathering data to broadcasting message is improved.

Khaled Almi'ani et al [10] proposed a novel cluster-based algorithm to find efficient tours for mobile elements used for data collection in WSN. To further maximize the network lifetime; the heuristic used in their algorithm can be extended to take the nodes residual energy into account during the establishment of the tours. In addition, to cope with unexpected delays in the network, the heuristics can be modified in a straightforward manner to allow the mobile element to pause and wait at nodes along the tour, as long as the overall deadline constraint can be met.

But in this work, only one Mobile Element approaches the cache points, and drawback is that Single Mobile Element won't be able to collect data's from entire sensor nodes. Moreover if a Mobile Element fails due to a fault, data gathering gets affected. Secondly, the cache size is not considered, which will lead to overflow of data's. And energy aspects for these cache points to gather data from the sensor will lead to the problem.

Fang-Jing Wu et al [11] –proposed data gathering by Mobile Mules in a spatially separated WSN. It considered the data gathering scenario where a mobile mule or mobile data collector (MDC) will start from any one node in the sub-

network in which sink node is located, traverses any node of each isolated sub-network to gather sensing data. When the MDC is within the communication range of a landing port, the latter can collect all sensing data in its sub-network and forward to the MDC. When returning, the MDC will relay all sensing data to the sink via the starting sub-network.

But in this work, since the landing node has to collect all sensing data in its sub-network to forward to MDC, it results in early drain of battery and energy resources. But the energy level of the landing node is not considered in this work. Assuming that the storage of sensor nodes is limited and the MDC may not visit sub-networks frequently which results in buffer overflow in sensor nodes. But the buffer space of sensor node is not considered in this work, while scheduling the MDC visit to each sub-network.

K. Ramanan and E. Baburaj [13] have outlined different critical issues in wireless sensor network. An extensive study of different issues associated with existing data gathering algorithms is done and here two key issues are focused. The issues focused on are network lifetime and saving energy of them. Since wireless sensor networks have great scope in the research field, to solve many open issues still researches are going on. Wireless sensor networks are at the time of this writing not yet ready for practical deployment because some of the underlying hardware problems with respect to the energy supply and miniaturization were not solved completely. The problems cannot be resolved in the near future also. In a Wireless sensor networks, more data can be collected by the sink(s) by prolonging the network lifetime. Hence the sink collects more data. The efficient usage of energy is crucial for the networks lifetime.

Mario Di Francesco et al [14] have extensively characterized data collection in Wireless Sensor Networks with Mobile Elements (WSN-MEs). WSNs with MEs are defined. A comprehensive taxonomy of their architectures is provided based on the role of the MEs. An overview of the data collection process is presented and the corresponding issues and challenges are identified. An extensive survey of the related literature is provided based on these issues. The underlying approaches and solutions are compared with the existing works with hints to open problems and future research directions. The data collection process is discussed in depth and its main challenges are highlighted. The analysis of each topic by a comparative survey of the approaches available in the literature is done.

Ramesh Rajagopalan and Pramod K. Varshney [15] have presented a comprehensive survey of data aggregation algorithms in wireless sensor networks. Most of the works focus on the optimization of important performance measures such as network lifetime, data latency, data

accuracy and energy consumption. The three main focus areas of data aggregation algorithms are efficient organization, routing and data aggregation tree construction. The main features, the advantages and disadvantages of each data aggregation algorithm are described and also the special features of data aggregation such as security and source coding. They also highlighted the trade-offs between energy efficiency, data accuracy and latency. The development of an efficient routing mechanism for data aggregation is focused in most of the existing work. Even though the works on data aggregation technique looks promising, they have scope for future research. There is still much more to explore in the context of data aggregation combining the aspects of security, data latency and system lifetime. The relation between energy efficiency and system lifetime and its systematic study can be an avenue of future research.

Authors have also done survey by dividing the Data Gathering technique as Static and Mobile based on mobility of the nodes. The Data Gathering techniques are analyzed in terms of Energy Conservation, Reliability and Network lifetime [1].

4 ALGORITHM FOR SENSING INTELLIGENT DATA AND DATA GATHERING

The main objective of the scheme is sensing Intelligent data by sensor nodes and continuous data gathering by the Base station sent by individual sensor nodes [16]. Here authors have considered Temperature as the intelligent data to analyze the redundancy aspect by plotting the graphs using the statistics obtained with this experiment. The main aim of the experiment is to deploy / create a small distributed cluster of Temperature and Light sensing Wireless sensor devices. The devices are deployed in a random fashion. All the source sensors i.e. Node 1, Node 2, Node 3, Node 4, Node 5 and Node 6 are equipped with the light and temperature sensors.

4.1 Experimental Setup

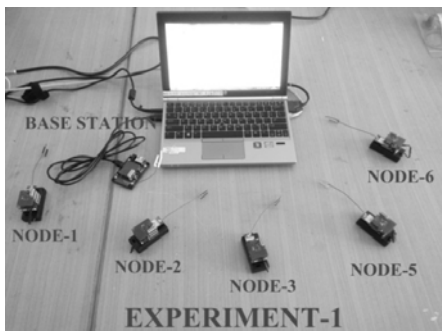


Fig4.1 Photograph of Experimental setup

As shown in Fig 4.1 to implement Data gathering technique at the Base station authors have used iSense Modular Wireless Sensor Hardware and Software System of

Coalesenses product whose moto is to bring the gap between virtuality and reality [12]. Advantages of iSense are:

1. Modular approach in both hardware and software
2. Tools and plug ins required to setup the development environment are free and open source
3. Supports Over The Air Programming (OTAP) of the Sensor Device.
4. Customizable firmware
5. Based on open source GCC based C++ Compiler, this making programming of the modules easy.
6. Supports HTTP and Constrained Application Protocol (CoAP) servers.
7. Supports 2 networking stacks with both IPv4 and IPv6 addressing

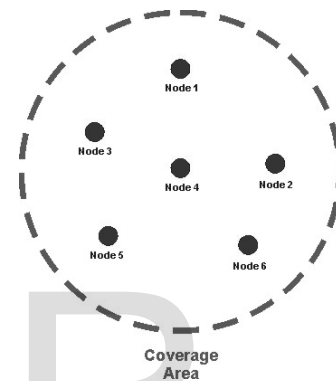


Fig 4.2. Distributed Sensor Nodes

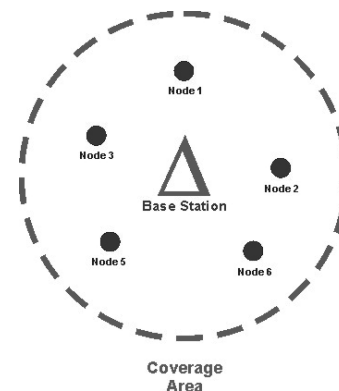


Fig4.3 Base Station Receiving Sensed Data (Temperature)

First all nodes are connected to the iSense modules one by one and programmed to sense Temperature and Luminance after every one minute as shown in Fig4.2. After taking reading all nodes are disconnected from the iSense module and made it battery operated. They are programmed to wirelessly send the temperature and light value sensed to the Base Station / Cluster Head node for an interval of every 1 minute as shown in Fig4.3.

The base station is programmed to receive all the data which is being sent by the source nodes. The source nodes are connected to the system and then flashed with the program to send the data. Similarly the base station is also connected to the system to enable it to receive the data.

4.2 Initialization Algorithm

```

1. Initialization with default values
    Task_set_light_Threshold=1
    Task_read_sensor=2
2. Algorithm for Booting of sensors
    a. Create Environmental instance
    if
        { allocation of environmental module=Successful}
        if
            { Light sensors = Enabled,
Configure sensors with luminance.
Add a task to be called after 1 second of Booting.
        }
        Set application as data handler,
        If
            {
                Luminance -> beyond %
            }
        if
            { Temperature sensor = Enabled,
Configure the sensor with Temperature
threshold=350C
                & hysteresis value=300C
            }
        Set application as data handler,
        if
            { Temperature threshold -> exceeded ||
Temperature falls back
                below hysteresis value
            }
    }

```

4.3 Algorithm to enable Environmental Sensor module

```

Add task to be called in s minute for predicting
sensor readings.
if
    { any of above condition fails= Error report
    }

```

4.4 Algorithm of application steps

```

1. if
    { 1. sensor data received -> set a task to wake
up in one minute
        2. read sensor data & report output
    }

```

4.5 Algorithm to present output

```

1. if
    { light condition changed -> output Luminance
    }

```

```

2. if
    { Temperature threshold exceed -> output
Temperature
    }

```

5 ANALYSIS

Actually the sequence of the intelligent data received from the sensors at the destination depends upon the time delay. It means if all the devices flashed at simultaneously and they initiated at the same time then all the device try to send at same time. In this case according to CSMA algorithm whichever sensor node get access for the channel that device will send data to the destination first and followed by the next. The above condition is very rare because usually it is not possible to start all the devices simultaneously, there will be some minute delay between the device initialization (power on). So in this case it is not sure that the destination will get the intelligent data sequentially because of channel condition (disturbances, obstacles) between the sensor node and the Base station.

6 RESULTS OF PROPOSED INTELLIGENT DATA GATHERING TECHNIQUE

TABLE 1.
Intelligent Data (Temperature and Luminance) Received by Base Station after every minute.

Node No.	Temperature in ⁰ C	Luminance	Time (Hours. Minutes)
6	27 ⁰ C	83 lux	17.00
2	27 ⁰ C	79 lux	17.02
1	27 ⁰ C	71 lux	17.02
5	28 ⁰ C	60 lux	17.02
6	27 ⁰ C	85 lux	17.02
6	27 ⁰ C	86 lux	17.04
2	27 ⁰ C	73 lux	17.05
1	27 ⁰ C	69 lux	17.05
5	28 ⁰ C	62 lux	17.05
6	27 ⁰ C	31 lux	17.05
2	27 ⁰ C	53 lux	17.07-
5	27 ⁰ C	62 lux	17.08
3	28 ⁰ C	62 lux	17.08
2	27 ⁰ C	60 lux	17.09
1	28 ⁰ C	58 lux	17.09
5	28 ⁰ C	61 lux	17.09
6	27 ⁰ C	76 lux	17.09

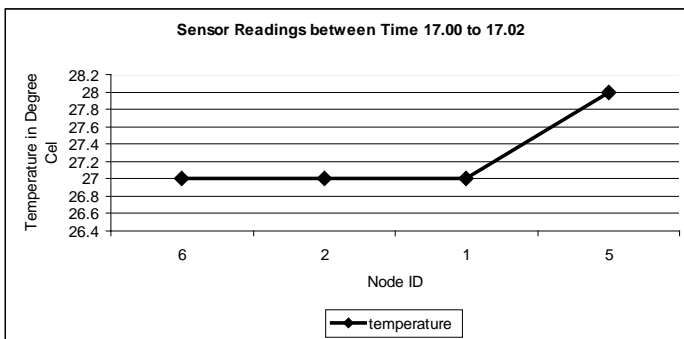


Fig.6.1 Redundant data at Node 1, 2 and 6

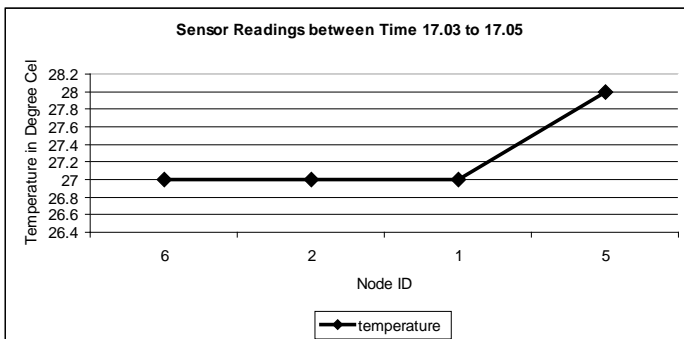


Fig.6.2 Redundant data at Node 1, 2 and 6

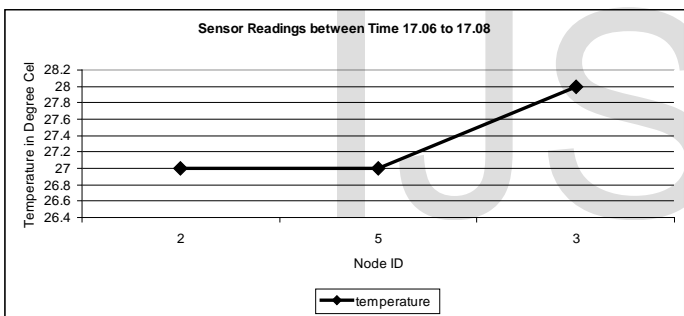


Fig.6. 3 Redundant data at Node 2 and 5

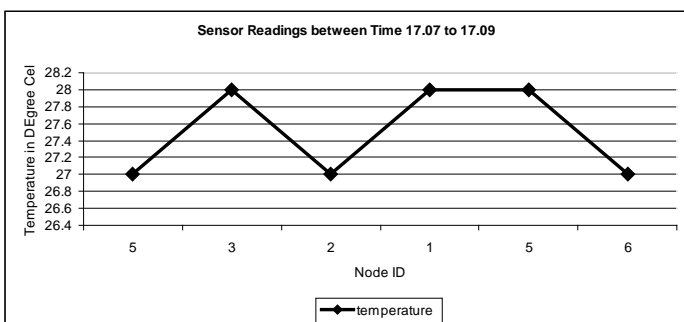


Fig.6. 4 Redundant data at Node 1, 3, 5, and 2, 6

The statistics were collected over a period of 10 minutes. Fig (6.1to 6.4) shows the data (Temperature) received at the base station for every 2 minutes. From the recorded statistics we can derive that in an interval of 2 minutes the temperature sensed by the sensors are almost same and few sensors are actually sending the same information to the base station .The same pattern continues in rest of the experiment

time as well. This behavior of the sensors sending same data to the base station will lead to an undesirable situation in which there would be data redundancy, energy loss and even congestion. To depict the sensed data over a period of 10 minutes we have plotted graphs for time interval of 2 minutes.

7 CONCLUSION

Hardware implementation of Intelligent data gathering Algorithm using sensor nodes and Base station with JN5148microcontroller is implemented. The result proves:

1. Base station will receive data from every device for each round but the sequence at the destination may vary.
2. When sensor nodes sense same data and send it to Base station, at the base station redundant data will be there which lead to more energy consumption and congestion in the channel.

Authors conclude with the fact that Algorithm is effective and implementation with the hardware assures that this scheme is simple technology to visualize in reality intelligent data gathering at the Base station.

8 FUTURE WORK

Future work will focus on implementation of the clustered architecture using same hardware equipments where Redundant data received at the Base station will be removed. Future work also includes tacking with incurred congestion to improve the life time of Wireless Sensor Network.

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