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Multi hop Cluster Network based WSN

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***Abstract*— In this project, a Multihop Cluster network based WSN and its formation algorithm is proposed. The proposed network structure is shown to be the most efficient in terms of data collection time. The proposed network structure can greatly reduce the data collection time while keeping the total communication distance and the network lifetime at acceptable values. The delay time for each of the sensor node is determined. As a future enhancement, we can improve the system to reduce the delay on packet transmission between the source and the destination by adding more number of sensor nodes and thereby predicting the delay time and increasing the network lifetime.**

***Index Terms*— Multi hop Cluster network, WSN, Network lifetime**

I. Introduction

Sensors are hardware devices that produce a measurable response to a change in a physical condition like temperature or pressure. Sensors measure physical data of the parameter to be monitored. The continual analog signal produced by the sensors is digitized by an analog-to-digital converter and sent to controllers for further processing.

A sensor node should be small in size, consume extremely low energy, operate in high volumetric densities, be autonomous and operate unattended, and be adaptive to the environment. As wireless sensor nodes are typically very small electronic devices, they can only be equipped with a limited power source of less than 0.5-2 ampere per hour and 1.2 to 3.7 volts.

Sensors are classified into three categories such as passive, omni-directional sensors; passive, narrow-beam sensors; and active sensors. Passive sensors sense the data without actually manipulating the environment by active probing. They are self powered that is, energy is needed only to amplify their analog signal. Active sensors actively probe the environment, for example, a sonar or radar sensor, and they require continuous energy from a power source. Narrow-beam sensors have a well-defined notion of direction of measurement, similar to a camera. Omni-directional sensors have no notion of direction involved in their measurements.

The main characteristics of a WSN include

- Power consumption constrains for nodes using batteries or energy harvesting
- Ability to cope with node failures
- Mobility of nodes
- Dynamic network topology
- Communication failures
- Heterogeneity of nodes
- Scalability to large scale of deployment
- Ability to withstand harsh environmental conditions
- Ease of use
- Unattended operation
- Power consumption

Sensor nodes can be imagined as small computers, extremely basic in terms of their interfaces and their components. They usually consist of a processing unit with limited computational power and limited memory, sensors or MEMS (including specific conditioning circuitry), a communication device (usually radio transceivers or alternatively optical), and a power source usually in the form of a battery. Other possible inclusions are energy harvesting modules, secondary ASICs and possibly secondary communication devices.

The base stations are one or more distinguished components of the WSN with much more computational, energy and communication resources. They act as a gateway between sensor nodes and the end user as they typically forward data from the WSN on to a server. Other special components in routing based networks are routers, designed to compute, calculate and distribute the routing tables. Many techniques are used to connect to the outside world including mobile phone networks, satellite phones, radio modems, long-range Wi-Fi links etc.

The transition from large to small scale sensor nodes has several advantages. Small sensor nodes are easy to manufacture with much lower cost than large scale sensors. With a mass volume of such low cost and tiny sensor nodes, they can be deployed very closely to the target phenomena or sensing fields at an extremely high density. Therefore, the shorter sensing range and lower sensing accuracy of each individual node are compensated for by the shorter sensing distance and large number of sensors around the target objects, which generates a high signal to noise ratio (SNR).Since computing and communication devices can be integrated with sensors, large-sample in-network and intelligent information fusion becomes feasible. The intelligence of sensor nodes and the availability of multiple onboard sensors also enhance the flexibility of the entire system. Sensor networks can be used to monitor environmental changes. An example could be water pollution detection in a lake that is located near a factory that uses chemical substances. Sensor nodes could be randomly deployed in unknown and hostile areas and relay the exact origin of a pollutant to a centralized authority to take appropriate measures to limit the spreading of pollution. Other examples include forest fire detection, air pollution and rainfall observation in agriculture. Military uses sensor networks for battlefield surveillance; sensors could monitor vehicular traffic, track the position of the enemy or even safeguard the equipment of the side deploying sensors.

Sensors can also be used in large buildings or factories monitoring climate changes. Thermostats and temperature sensor nodes are deployed all over the building's area. In addition, sensors could be used to monitor vibration that could damage the structure of a building. Sensors can be used in biomedical applications to improve the quality of the provided care. Sensors are implanted in the human body to monitor medical problems like cancer and help patients maintain their health. Wireless sensor networks are also used to control the temperature and humidity levels inside commercial greenhouses. When the temperature and humidity drops below specific levels, the greenhouse manager must be notified via e-mail or cell phone text message, or host systems can trigger misting systems, open vents, turn on fans, or control a wide variety of system responses.

The lifecycle costs for wireless communications are less than for wire-based communication is often cited as a leading commercial driver behind WSNs. While the cost comparison is a major factor, especially in retrofit applications or harsh environments, it would be limiting to reduce the benefits of WSNs to cost effective connectivity. The ability to sense, communicate and collaborate in real time, combined with the proliferation of capable devices turns context information into a pervasive commodity. This provides significant added value to a variety of applications, such as industrial business processes, as they can access a real-time and finely defined operational picture.

The increased timeliness and granularity of available context information enables more intelligent applications and services to be deployed, making use of high or low level context to support the respective layers of decision making. Overall, by providing a real time interconnection between the physical and digital worlds, WSNs allow step changes in efficiency and effectiveness, as well as enabling new added value services across many business sectors.

II. EXISTING SYSTEM

In [1],the joint work of mobile robots and wireless sensor networks is done for environmental monitoring through a system in which robotic data mules collect measurements gathered by sensing nodes. Environmental monitoring is one in which scientist collects environmental data. The sensing device is called motes and the mobile robots are called mules. The motes are distributed on the environment. Because the motes are physically small, battery-operated, the concept of using mobile robot is introduced. The mules move towards the motes and collects data from them. The actual data-download process uses the standard NACK-based Automatic Repeat reQuest (ARQ) protocol.

Advantages of this paper are the energy of the sensor nodes is increased and hence the life time of the network is increased and the data thus collected will be reliable. The disadvantage is determining the trajectory movement of mules is difficult.

[2] focuses on data aggregation scheduling problem to minimize delay. Data aggregation is critical to the network performance in WSNs and the aggregation scheduling is a feasible way of improving the quality. In this paper, we study the problem of distributed aggregation scheduling in WSNs and propose a distributed scheduling method with an upper bound on delay of 16 R + $\triangle$ -14 time slots, Where, R is the network radius and is the maximum node degree in the communication graph of the original network. Our TDMA schedule uses a bottom-up approach: The schedule nodes level by level starting from the lowest level. Our Improved data Aggregation Scheduling (IAS) algorithm consists of two phases: 1) aggregation tree construction and 2) aggregation scheduling. As our algorithm is aggregation-tree-based, in the first phase, we construct an aggregate distributed method of constructing a CDS (connected dominating set).

Our simulation results shows that our theoretical results shows that our algorithms perform better in practice. We prove that the overall lower bound of delay for data aggregation under any interference model is max{log n , R}, where n is the network size The advantages are the delay is minimized and data reliability is achieved. The disadvantage is the centralised algorithm does not works properly in changing large networks.

In [3], we focus on the joint effect of clustering and data correlation on the performance of wireless sensor networks and we propose a novel cluster-based data collection scheme for sensor networks with direct sink access (CDC-DSA) and provide an analytical framework to evaluate its performance in terms of energy consumption, latency, and robustness. In this scheme, cluster heads use a low-overhead and simple medium access control (MAC) conceptually similar to ALOHA to contend for the reach back channel to the data sink. The packet arrival is not modeled by a continuous random process, and the data is collected periodically by transient analysis. By using random geometry tools, we study the optimal average cluster size and energy savings, under the proposed MAC, vary according to the level of data correlation in the network. A simple MAC protocol is used to minimize latency.. The steps involved in the date collection process are Cluster Formation, Intra cluster Communication and random access for the reach back channel. Markov chain analysis is used to study the packet reception by the data sink.

Advantages of direct communication between sensors and CHs are it adds minimal complexity to the network architecture and the cost and delay of cluster formation will be negligible compared to those for actual data communication. The disadvantage is perfect aggregation is not possible.

[4] deals with the data collection strategies in lifetime-constrained wireless sensor networks. Our objective is to maximize the accuracy of data collected by the base station over the network lifetime.We formulate the lifetime-constrained data collection problem by means of an offline algorithm called dynamic programming which is used to compute the optimal data update strategy. The basic strategy is applied directly to individual data collection where the application monitors the reading of an individual sensor node.

In [5], we develop and analyze low-energy adaptive clustering hierarchy (LEACH).LEACH includes a new, distributed cluster formation technique that enables self-organization of large numbers of nodes, algorithms for adapting clusters and rotating cluster head positions to evenly distribute the energy load among all the nodes. LEACH an application-specific protocol employs the following techniques to achieve the design goals stated: 1) randomized, adaptive, self-configuring cluster formation; 2) localized control for data transfers; 3) low-energy media access control (MAC); and 4) application-specific data processing, such as data aggregation or compression. The operation of LEACH is divided into rounds. Each round begins with a set-up phase when the clusters are organized, followed by a steady-state phase when data are transferred from the nodes to the cluster head and on to the BS. The steps involved are Cluster Head Selection Algorithms, Cluster Formation Algorithm, This algorithm uses TDMA scheduling. Steady-State Phase, LEACH-C: BS Cluster Formation.

Results from our experiments show that LEACH provides the high performance needed under the tight constraints of the wireless channel. The advantage of this paper is it improves system lifetime by an order of magnitude compared with general-purpose multihop approaches. The disadvantage is cluster set-up overhead occurs.

The experimental evaluation is done using a wide range of real data traces for both individual and aggregate data collections. The advantage of this paper is that the proposed adaptive strategies significantly improve the accuracy of data collected by the base station over the network lifetime. The disadvantage is some energy is wasted while sending data updates.

III. PROPOSED SYSTEM

A wireless sensor node is built up of three major units they are

1. Microcontroller unit (MCU)
2. Transceiver unit (TCR)
3. Sensor board (SB)

The energy consumed by a wireless sensor node can be expressed as

$$E_i\_SN = E_i\_MCU + E_i\_TCR + E_i\_SB$$

Where E_i_MCU indicates the energy consumed by the MCU, E_i_TCR indicates the energy consumed by the TCR, and E_i_SB indicates the energy consumed by the SB and E_i_TCR can be further expressed as

$$E_i\_TCR = E_i\_TCR\_RX + E_i\_TCR\_TX\ (d_i)$$

Where E_i_TCR_RX = energy consumed in receiving mode and E_i_TCR_TX (d_i) =energy consumed in receiving mode.

The total energy is given as

$$ETOT\ (N) = E_i\_MCU + E_i\_TCR\_RX + E_i\_TCR\_TX\ (d_i) + E_i\_SB$$

Where, ETOT (N) = C1+ summation of all E_i_TCR_TX (d_i) here C1 is a constant and E_i_TCR_TX (d_i) is a function of d_i which depends on the network structure. The path loss exponent is equal to 2E_i_TCR_TX (d_i) can be expressed as

$$E_i\_TCR\_TX\ (d_i) = Ei\_TCR\_EC + Ei\_TCR\_PA(d_i)2$$

Where Ei_TCR_EC is the energy consumed by TCR's electronic circuitry, while Ei_TCR_PA denotes the energy consumed by power amplifier of the TCR. Taking as constants it is written as

ETOT (N)= C1+C2+C3(d_i)2 ,where C2 and C3 are constants.

The top-down approach is a kind of centralized control algorithm. In this approach, the execution takes place at the base station. The base station will instruct the sensor nodes to establish the essential data links and form the appropriate network structure. The Cluster head is determined by using the following steps.

Step 1: A fully connected network of N node (N>=4).These N nodes form a set H's=1, b=N/2

Step 2: Select b nodes from set H's to form set Hs+1 such that the total edge weight within set Hs+1 is maximized .The rest in H's form H's+1.Cut all connections among nodes in set Hs+1.Set b=b/2 and s=s+1.

Step 3: Repeat steps 2 until b<2. Set r=2.

Step 4: Nodes with degree N-r form set L. Nodes with degree greater than N-r form set U. Reduce connections among nodes between set L and U until each node in set L is only connected to a single node in set U. Set r=rx2.

Step 5: Repeat step 4 until r=N. As a result the cluster head is elected and the packet transmission takes place.

IV. CONCLUSION

In this project, a Multihop Cluster network based WSN and its formation algorithm is proposed. The proposed network structure is shown to be the most efficient in terms of data collection time. The proposed network structure can greatly reduce the data collection time while keeping the total communication distance and the network lifetime at acceptable values. The delay time for each of the sensor node is determined. As a future enhancement, we can improve the system to reduce the delay on packet transmission between the source and the destination by adding more number of sensor nodes and thereby predicting the delay time and increasing the network lifetime.

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