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Advancement of the Greenhouse with the Usage of a Wireless Sensor Network with Optimised Routing

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***Abstract*-**Due to the growing demand for crop output, quality, and the usage of high-quality greenhouses, modern greenhouses are becoming larger and more complex in their monitoring and control systems. The rise in greenhouse size has increased the necessity for real-time monitoring of certain parameters. This has added complexity to their management and maintenance. The purpose of this paper is to describe a wireless sensor network-based system for monitoring and controlling greenhouses. Because tiny nodes are utilised in WSN, they are spatially scattered, battery-powered, and energy-limited; as a result, nodes may die, resulting in communication failure. Thus, to address this shortcoming, we propose a routing protocol that balances resource usage across all sensor nodes, thereby extending the sensor node's lifetime. As a result, a potential greenhouse capable of measuring a variety of factors has been created.

***Keywords*-** Greenhouse, routing protocol, and wireless sensor network

I. INTRODUCTION

With the rapid growth of crops, measuring environmental parameters has become more difficult, resulting in a variety of conflicts related to time and environmental elements such as temperature, humidity, soil moisture, and so on.

A WSN is made up of a large number of smart sensors that communicate through radio in sensor fields to build a multihop network. They collect and process data from the sensing region before transmitting it to the data base station. WSNs can be utilised in a variety of applications, including environmental monitoring, smart homes, commercial, and military applications. The greenhouse agricultural industry is accelerating its growth in response to the growing demand for fresh vegetables in large and medium cities. It is a type of location in which it is possible to alter the environment in which plants grow, to produce optimal conditions for plant growth, and to isolate plants from environmental changes and the influence of the weather. On the basis of maximising the use of natural resources, greenhouse monitoring systems optimise plant growth by adjusting greenhouse environment variables such as temperature, humidity, illumination intensity, and soil moisture, with the goal of increasing crop yield, improving crop quality, regulating growth cycle, and maximising economic benefit. Greenhouse monitoring is a complex system; the various parameters in the greenhouse require automatic monitoring, data processing, real-time control, and on-line optimization.

Our system monitors a network of sensors, each of which detects changes in the greenhouse's characteristics on a periodic basis. This data is sent to the sink node. The sink node is connected directly to the management centre. The managing centre enables users to monitor and control greenhouse parameters.

Fig 1- Sensor nodes deployment

Sensor nodes are built on the widely used Arduino platform. Arduino is an open source electronics prototyping platform featuring a programmable hardware and software environment. On nRF24L01 radio modules, we are designing a network protocol. We have incorporated characteristics of network protocols, particularly clustering protocols, such as low energy adaptive clustering hierarchy (Leach) and improved leach.

The following sections comprise the remainder of this work. In Section II, we explain the system's architecture and node hardware design. In Section III, we describe the design of the layer 2 and 3 operations of the WSN protocol. Section IV contains the research questions and experiments. Finally, in Section V, we detail the work.

II. SYSTEM DEVELOPMENT

We constructed a network of smart objects based on the Arduino platform for this experimental project.

(a) Network of Clusters:

The proposed one hop architecture is depicted in Figure 2.

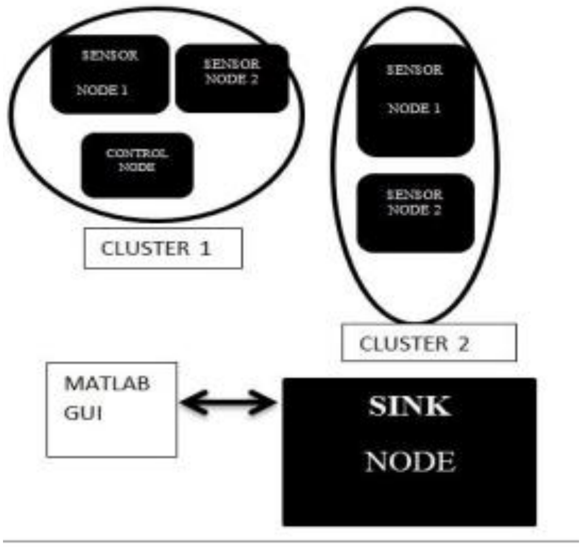

Figure 2 greenhouse cluster network

Three groups of sensors are used in the sensor network: one for each cluster and one for the sink node. Each group operates on a dedicated radio frequency channel. The sensors monitor any changes in the greenhouse's properties. The sensor will be strategically placed on the floor and will sense frequently in order to determine the parameters.

1. Sensor node- A sensor node measures the distance to the sensor on a periodic basis and compares it to the previous measurement. If the result changes, an advertisement message (ADV) is sent to the cluster leader (CH).

2. The Cluster Head (CH) monitors the greenhouse while also waiting for ADV messages from other sensor nodes. It consolidates the data and sends it to the sink node.

3. Sink node- This fixed node listens continuously on specified channels in order to relay packets from the cluster head to the management station.

(b) Architecture of Nodes:

We utilise the Arduino framework, but with numerous hardware enhancements, such as more energy-efficient surface mount device (SMD) components and additional analogue and digital I/O pins. The Atmel ATmega328P microcontroller features a 32Kb inbuilt flash memory with read/write capability, a 1Kb EEPROM, and a 2Kb SRAM. We employ a dedicated nRF24L01 low-power radio module operating in the ISM band at 24.5 GHz. The radio employs FSK modulation and operates on 125RF channels at data rates of 250kb/s, 1 or 2 Mb/s. We're going to use a DHT11 sensor, which is a very basic, extremely inexpensive digital temperature and humidity sensor. It measures the ambient air using a capacitive humidity sensor and a thermistor and outputs a digital signal on the data pin (no analogue input pins needed). It is quite simple to operate, however data collection takes careful timing. The volumetric water content of soil is determined using a soil moisture sensor. A LDR sensor is a variable resistor that is controlled by light. A photoresistor's resistance lowers as the incident light intensity increases; in other words, it shows photoconductivity. External batteries and a USB-powered sink node are used. A motor to power the fan in the event that the greenhouse's temperature rises too high. Battery voltage decreases when the battery's energy capacity decreases.

III. DESIGN OF THE WSN PROTOCOL

We developed and evaluated a wireless communication protocol that incorporates some of the characteristics of clustering hierarchical protocols such as LEACH and optimised LEACH. FIGURE 3 illustrates LEACH (Low Energy Adaptive Clustering Hierarchy), an energy-aware strategy for WSNs. In LEACH, the randomly selected Cluster Head (CH) receives data from cluster members and adds its own, and then sends it directly to the sink, which uses a significant amount of energy on the sensor node.

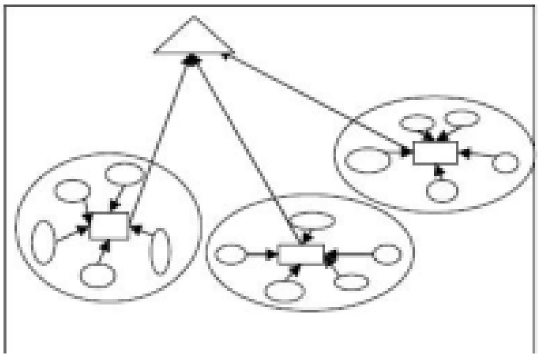

Figure 3 Prototype LEACH

The optimised LEACH technique is explored in detail, with the goal of lowering the node's death rate and possibly increasing the network's lifetime as a result of the lower death rate. This technique utilises multiple rounds to deliver data to the sink. After each round of data transmission to the sink, check the cluster head's leftover energy. If the energy of the cluster head is less than the maximum or threshold energy, the cluster head becomes the more energetic node in the cluster. Our implementation is based on LEACH clustering, in which clusters are formed with a cluster head and member nodes. After each round, the residual energy is checked, and the node with a value greater than the threshold becomes the cluster head. Once the data has been transmitted to the cluster head, the node enters sleep mode. As a result, this protocol keeps the number of transmissions to a minimum, conserving energy and preventing the node from dying. When a sensor detects changes in parameters, it transmits the information to the sink node.

The sensor will not have new data to report frequently, reducing the quantity of transmissions and extending the system's lifetime.

(i) Operation of the second layer:
We implemented a collision avoidance technique in which any node wishing to broadcast must first listen to the channel. If the node is available, it transfers the packet and awaits an acknowledgement. If the node is occupied, it waits for a back-off period before listening to the channel again. The packet is discarded after a number of fruitless attempts.

(ii) Operation of the System:
The system's operation is divided into three parts, as illustrated in Figure 3: CH selection, sensing, and communication.
(a) Phase of Cluster Head Selection:
- The CH transmits a message titled "Energy Request."
- The SNs monitor their energy consumption and provide this information to the CH via an Energy Reply message.
- The CH compiles all responses and does a comparison of energy levels. The new CH is chosen from the node with the highest energy level.
- CH notifies all SNs of the new CH ID.
- Simultaneously, the SNs update the CH ID.

(b) Phase of Sensation:
The node detects when the value of a parameter changes. If there is one, the node enters the Communication Phase; otherwise, it enters the Sleep Phase. Due to the synchronisation of the SNs during CH selection, they would all awaken at the same moment.

(c) Phase of communication:
The node notifies the CH of the revised parking lot status via an ADV message. Meanwhile, the CH collects all SNs' ADV packets. The CH transmits to the sink an aggregated data packet (DATA) containing all gathered status changes.

IV. EXPERIMENTAL RESEARCH

Our objective is to provide a low-energy implementation of a smart parking application. Several of the study questions in this initiative include the following:
Our objective is to provide a low-energy implementation of a smart parking application. Several of the study questions in this initiative include the following:
- Is the Arduino platform an appropriate platform for this particular WSN application?
- How can we reduce energy usage per node while extending the life of the network?
- How do we optimise the algorithm for selecting CHs?
- How trustworthy is this system?

To assess the protocol's performance, we present two distinct versions on the same real case. The sink is positioned in conjunction with the monitoring centre between two clusters comprised of five nodes and a control node.
- The entire network has been partitioned into two clusters, each with five SNs.
- The network is composed of ten SNs that are all members of the same cluster.

V. RESULTS

The monitoring center's graphical user interface is seen in Figure 4. The GUI depicted in Figure 5 shows the various readings of the greenhouse's parameters as well as the node type after each loop. The results demonstrate that the clustering method is adapted through the use of optimised routing, which reduces the node's energy consumption and increases the node's lifetime.

Fig 4- GUI showing monitoring center

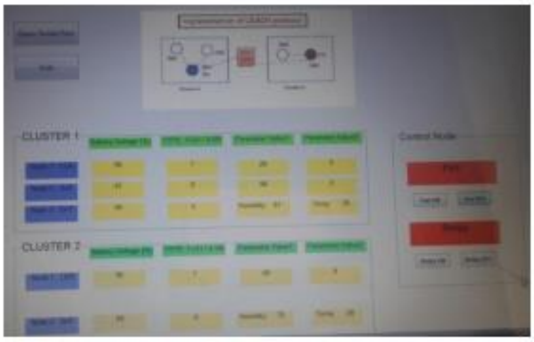
Fig 5- GUI of monitoring center showing the battery voltage and type of node as CH

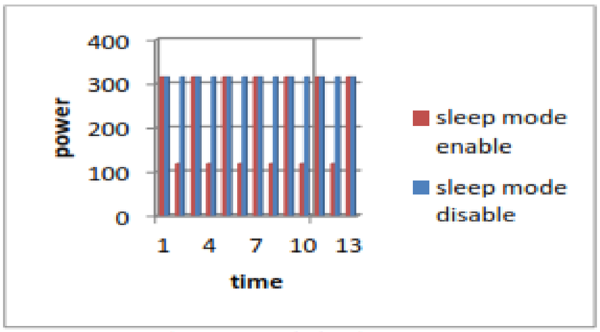

Fig 6- Bar graph showing power

VI. CONCLUSION

We provided a feasible implementation of a protocol for clustering WSNs. Our protocol is hierarchical; all nodes are clustered together under a single CH. We designed a CH selection process that is energy-aware, similar to the LEACH protocol. Arduino development boards and nRF24L01+ low-power RF modules were used to create the system. Additionally, by implementing a routing protocol, we are able to conserve the node's energy, extending the node's lifetime.

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