An Energy Efficient Monitoring System for Precision Agriculture in Wireless Sensor Networks

Surbhi Saraswat, Abhishek Tripathi, Hari Prabhat Gupta and Tanima Dutta

***Abstract*— A Wireless Sensor Network (WSN) consists of several communication and sensing units for monitoring the environment and communication the monitored information to the sink node. The future WSNs find their applications in many areas such as agriculture monitoring, farming, fishery, etc. The main aim of such WSNs are to improve the processing speed and reduce the network cost. Such WSNs are usually consider the low cost sensors and actuator for monitoring the given region and 24x7 basis for uninterrupted operation. The energy consumption of such system is high and also occupy huge storage space to store the captured data. In this paper, we propose an Energy Efficient monitoring system for precision agriculture using WSNs. The prototype is designed to optimize the energy requirement for monitoring the given region. We use three possible regular deployment patters in this paper.**

***Keywords*— Agriculture, Sensor, Wireless Sensor Network.**

I. Introduction

A Wireless Sensor Network (WSN) consists of several communication and sensing units for monitoring the environment and communication the monitored information to the sink node. The future WSNs find their applications in many areas such as agriculture monitoring, farming, fishery, and traffic monitoring [1]–[3]. In any application of the WSN, the monitoring of the given region and connectivity between the sensor nodes are the important matrices for measuring the quality of the system. A WSN is suitable for monitoring the FoI only if each event is monitored by at least one sensor and all the sensor nodes are connected with each others [4]–[6].

A WSN for monitoring of the precision agriculture consists of low cost sensor nodes. Such sensor nodes have sensing unit, communication unit, processing unit, and power unit. The sensing unit uses the sense the environment. For example, the proximity sensor uses for identifying the moving objects (farmer, animal, birds) in the agriculture field. The communication unit relay the sensory data to the sink or base station. Fig. 1 illustrates a scenario where a moving vehicle works as a sink node in the network. The base station generates the alarm or responsible for taking the final decision. The processing unit doing logical work. Finally, the power unit uses for supplying the power to the sensor nodes.

Energy efficiency is one of the key intrinsic property of any agriculture monitoring system [7]–[10]. It impacts more in the case of large-scale applications and difficult access applications, where the energy sources of the system are difficult or even not possible to maintain. For example, it is very difficult to enter in the agriculture field when the crops are too dense. The other scenario is when the sensors are deployed inside the crop land. Such scenarios motivate us to work on an energy-efficient system for precision agriculture. We develop an energy efficient monitoring system for precision agriculture to detect and identify the objects moving inside the crop land.

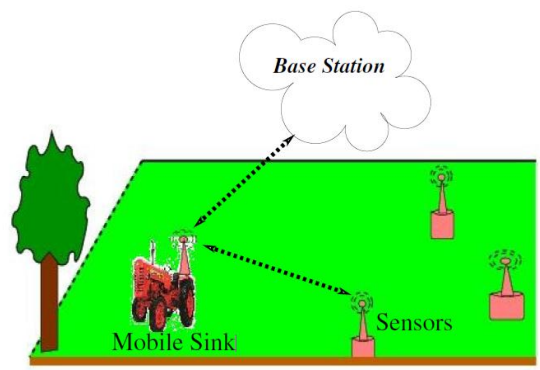

Fig. 1: An energy-efficient monitoring system for precision agriculture using mobile sink in WSNs.

The rest of the paper is organized as follows: In the next section, we explain the motivation and contribution of our work. Section III illustrates the proposed system model in this paper. We present the results in Section IV. Finally, the paper is concluded in Section V.

II. MOTIVATION AND MAJOR CONTRIBUTION

This work is motivated by the ubiquitous behavior of the sensor nodes in the agriculture field, i.e., the sensor nodes are not visible but working for sensing the environment. Such sensor nodes have limited battery which cannot be replaced or recharge.

In this work, an energy efficient wireless sensor network system is proposed and implemented on real test-bed for the monitoring applications in precision agriculture. A prototype is developed as a proof of concept for solving the high energy consumption problem. The performance evaluations have been carried out with short-range wireless communication technologies, which are highly relevant for sensor networking. Fig. 2 shows the setup of the proposed system using sensor

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modes.

The system is designed to cover sensor nodes, wireless communication in WSNs, transmission protocol, and capabilities for remote data access, management, and maintenance. The prototype uses proximity sensors for monitoring the region. The system architecture is oriented to meet the requirements for surveillance in general, and an instance of the prototype for monitoring the laboratory access by the visitors and behaviour is presented.

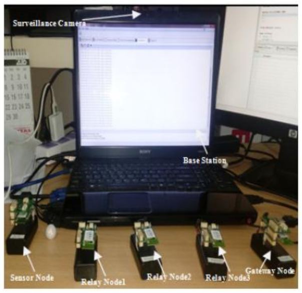


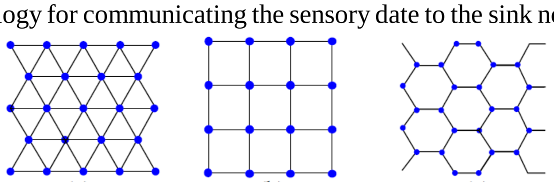
Fig. 2: Prototype of an Energy-Efficient Monitoring System for Precision Agriculture using Wireless Sensor Networks.

III. THE SYSTEM MODEL

The experiment test-bed consists of proximity sensors and relay nodes. The proximity sensors are used for tracking the moving objects in the agriculture field. The relay nodes are used for communicating the sensory data to the base sink node. The sensor gateway is used for interfacing WSN with the computing console; Sensor Application Software; Middleware components for distributing the sensory data to sensor applications; and Surveillance Camera.

We used triangle, hexagon, and square deployment patters that we have proposed in [11]. Such deployment requires least number of sensor nodes for the designed level of monitoring of agriculture region. Fig. 3 illustrates the deployment patters of our work. The work in [11] solved the following problem:

What is the regular node deployment pattern that uses the minimum number of sensor nodes for monitoring the region in a connected WSN. The proposed work illustrate that the sensor node requirement depends on the sensing range and communication range of the sensor nodes. We use zigbee technology for communicating the sensory date to the sink node.



(a) (b) (c)

Fig. 3: Illustration of the deployment of the sensor nodes in the system.

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In this system, the WSN triggers the attached monitoring device to switch from sleep mode to the active mode and generate the alarm. Firstly, the sensor nodes detect moving objects that feature a temperature different from the environment. After sensing, the proximity sensor sends the information to the nearest relay node to forward the information to the base station. The base station comprising the gateway which receives the information travelling from relay node. The multi-hopping provides degree of freedom for large distribution. The gateway passes this information to console station. In this case a laptop is configured as console station with pre-installed software to support the WSNs. The console station performs triggering of the devices to switch from sleep mode to the active mode and generate the alarm.

IV. PROTOTYPE RESULTS

In this section, we illustrate the experimental results. We calculate the power consumption and network delay in the system.

A. Power Consumption

We estimate the power consumption as the total energy consumed of all the deployed sensor nodes in a given experiment time period. In our previous work [11], we illustrated that the hexagon pattern consumes maximum number of sensor nodes in the network and therefore consumes maximum power. We plot the results with respect to the hexagon deployment.

Parts (a), (b), and (c) of Fig. 4 illustrates the impact of the sensing and communication ranges of the sensor nodes on the power consumption of the network. It shows that the power consumption is increased when we used hexagon pattern. It also shows that the large size agriculture region consumes almost equal power consumption.

B. Delay

We estimate the network delay as the generated sensory value to the staring time of the alarm system. Since, hexagon consists maximum number of sensor nodes and therefore has longest relay path from source sensor to destination. Parts (a), (b), and (c) of Fig. 5 illustrates the impact of the sensing and communication ranges of the sensor nodes on the delay of the network. Similar as previous result, the network delay is increased when we used hexagon pattern. The network delay is also increased because of the size of the network.

V. FUTURE WORK AND CONCLUSION

In this work, we developed an energy-efficient system for precision agriculture using WSNs. The results illustrated that the energy consumption of the network is depends on the deployment pattern of the sensor nodes. It also illustrated that the delay of the network is more when we used more number of sensor nodes. In this work, we assumed that the network does not consider any obstacle in the agriculture region. In future, we work on removing such assumption of the network. Next, we assume that all sensor nodes are working and does not consider the fault in network. However, it is also not true. In future, we will propose a fault-tolerant network for monitoring an agriculture region

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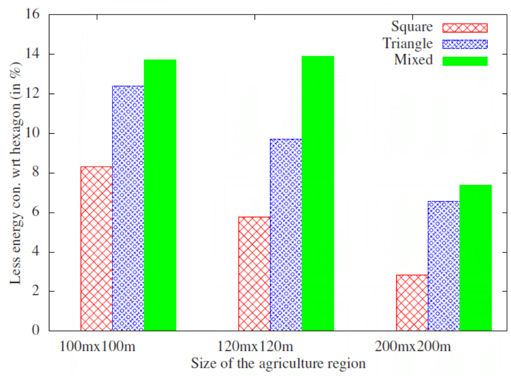
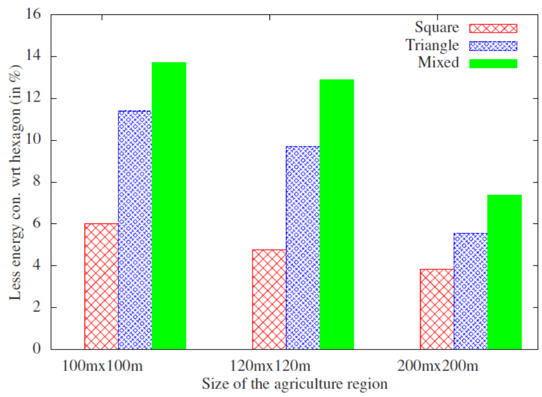


(a) Illustration of energy consumption with respect to the hexagon when sensing range equals to the communication range.



(b) Illustration of energy consumption with respect to the hexagon when sensing range greater than to the communication range.

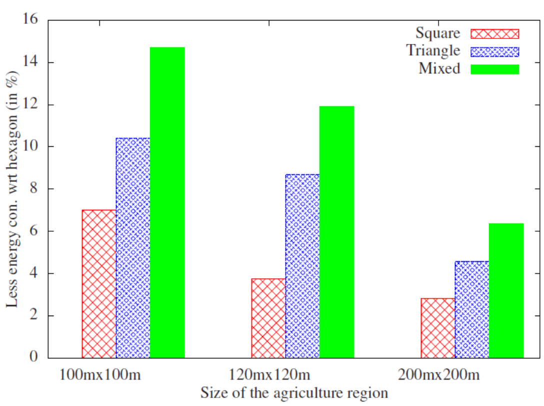
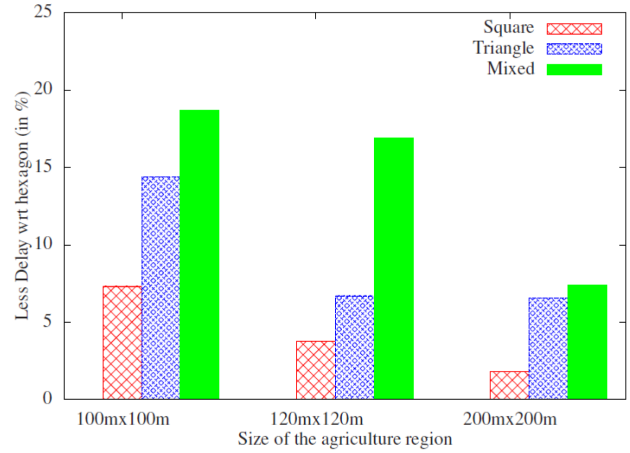
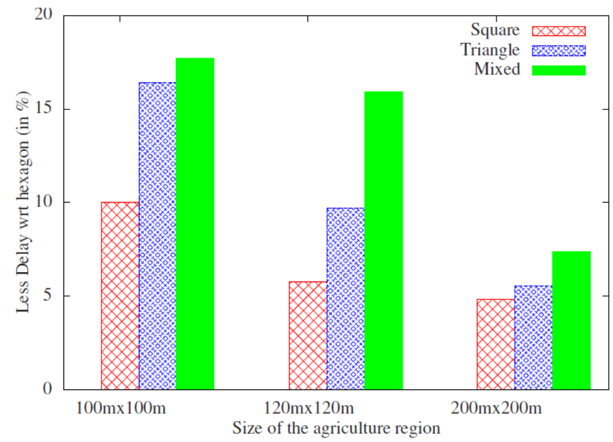


Illustration of energy consumption with respect to the hexagon when sensing range less than to the communication range.

Fig. 4: Illustration of impact of sensing and communication ranges of the sensor nodes on the power consumption of the network.



(a) Illustration of network delay with respect to the hexagon when sensing range equals to the communication range.



(b) Illustration of network delay with respect to the hexagon when sensing range greater than to the communication range.

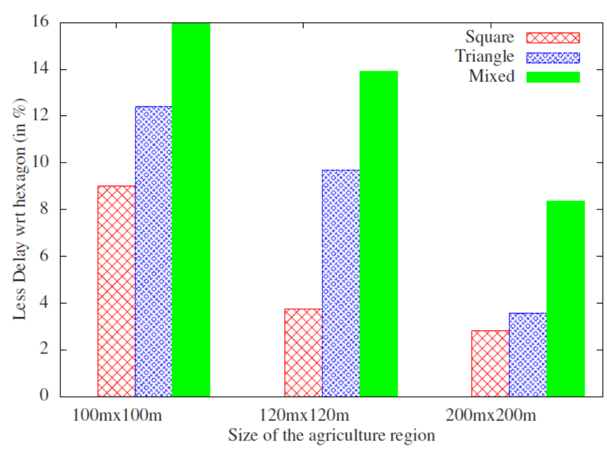


Illustration of network delay with respect to the hexagon when sensing range less than to the communication range.

Fig. 5: Illustration of impact of sensing and communication ranges of the sensor nodes on the network delay.

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