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Exploring Dynamics of Deployment Region For WSN Deployment

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***Abstract*— By deploying wireless sensor network (WSN) in large tea gardens, overall productive capacity of tea plants can be increased. Since tea gardens are extended over an area of hundred of hectares, there may be variation within a single estate. This paper proposes to explore and analyze the dynamics of tea plantation area and utilize the information while deploying sensor nodes. Entire area can be divided into regions on the basis of frequency of changes in parameters or also called as dynamics of the region. Depending on the rate of change of measured parameters, separate regions are proposed to have different number of sensor nodes. Since parameters of different regions are varying at dissimilar rates, so transmission interval cannot be same for all the defined regions. Data is transmitted from nodes of separate regions at different rates. Thus the work proposes to optimize number of sensor nodes and transmission interval to save energy in a WSN deployment for tea gardens. The proposed method can save up to 37% of energy.**

Keywords- Camellia assamica, WSN, number of nodes, transmission interval, energy consumption

I. INTRODUCTION

WSN is an emerging technology which supports IoT (Internet of Things). Sensors are considered to be eyes and ears of IoT technology. Networks of sensors sense the data and after processing send it to a remote station using transceiver. Data received at remote station is used for making decisions or building decision support systems. In agriculture, crops or plants are grown over a large area. Data collection from these large fields is necessary to make important decisions but it is a tedious task. WSN can help in data collection from these large agricultural fields.

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Over the years, many researchers have widely studied the application of WSN in the field of agriculture. While few tried to focus a particular crop or a particular disease related to a crop, others focused on general scenarios like irrigation. While rice, tomato etc. are the crops for which application and utility of WSN or IoT is extensively studied, Tea is one of the least worked upon crops in the field of IoT. Out of it, most of the available literature is from Tea boards in collaboration with other government institutions like C-DAC. Although use of electronics for tasting and grading of Tea has substantial research available but application of WSN in tea garden areas does not have much significant work. Upon searching with different keywords on IEEE digital library, authors found less than 10 relevant articles for application of WSN in tea plantations.

Tea is not only a widely consumed beverage in India but also an important export item. So it contributes a significant sum in economic growth of India. According to the 63rd annual report of Tea Board of India, in year 2016-17 a total of 227.63 million Kg of tea was exported out of India at value of Rs. 4632.5 crores [1]. According to the chapter 5 of same report, the fund allocation to Tea Research Institutions for R & D was Rs. 9 crore for year 2016-17. Two major varieties of tea plant are *Camellia sinensis* (Chinese Variety) and *Camellia assamica* (Indian Variety). Rest of the paper is organized as follow. Section 3 presents the problem and methodology. In section 4, results are discussed. Section 5 concludes the paper.

II. RELATED WORK

Sun et al. [2, 3] implemented a set up of 25 nodes in Tea Research Institution, Guangdong Academy of Agricultural Sciences. Out of 25, 10 nodes were deployed for soil moisture content, 1 for sensing of temperature and humidity, 13 data relay nodes and 1 for connection to server room. Nodes acquire data every second and send it to base station. Quality of Service (QoS) was analyzed for different network scales. ATmega128L was used for processing and CC2520 was used as transceiver. Nodes were deployed randomly and in a diamond-shaped network. Packet Loss Rato (PLR) was less for diamond-shaped deployment.

Saikia et al. [4] proposed the use of sensor networks during fermentation and drying of Tea leaves. After plucking of Tea leaves, it has to go through a process of withering, rolling, cutting, fermentation and drying. Duration, temperature and relative humidity of fermentation process decides the quality of tea. A total of 6 sensor nodes were deployed. These sensors were calibrated according to the environment before deployment.

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Wang et al. [5] proposed to plant the tea in WSN monitored greenhouse to make it sprout early. Hong et al. [6] proposed a real time system based on Z-BEE WSN to prevent frosting on tea leaves. Two sensor nodes were deployed, one at 6m height from ground and other at the height of plant's canopy. Along with two sensors, one data gathering device SZ06-2K-9-S was used. SZ02-ZBEE was used at data processing and transport layer. Difference in the temperature captured by two sensors was used to make decision for switching on the fan to prevent frosting. Dasgupta et al. [7] used water-level and temperature sensor in collaboration with National Instruments' LabVIEW to check water accumulation in roots of tea plants.

Baruah et al. [8] used sensors and camera to monitor the tea plantation area. Two WSN nodes were placed at distance of 10 m from each other and both the nodes send the data to a gateway placed 50m away. Gateway was connected to server PC using Ethernet cable. Data is sent to gateway every 15 minutes. Gupta et al. [9] proposed a setup for larger geographical area and used integration of WSN and GIS (Geographic Information System). 13 field stations were setup over the area of 205 hectares. The paper focused on building a spatial map of information using interpolation. Inverse Distance Weighted (IDW) was used as interpolation algorithm to predict the value of soil pH, soil moisture and soil temperature at unsampled locations of large field. Thus the use of WSN in tea gardens can help in improving overall productivity.

III. PROBLEM AND PROPOSED SOLUTION

Since *Camellia assamica* is mostly grown on slopes of mountains in large areas stretched over hundreds of hectares, so there are huge variations across the field. Soil moisture level at the end of slope is always different from the tip of the slope. Areas in upper mountains have more frequent variations because of intermittent of cloud and sunshine. Shady areas are less prone to climatic changes than open areas. Also parts of tea estates touching Meleng River and Western Ghats have more frequently changing environment than areas far from river banks. Other than these, micro-climatic zones are also present in a tea plantation area. Most of the present literature assumes these large areas to be uniform.

Authors propose to consider the dynamics of field of *Camellia assamica* to increase network lifetime. As stated in the literature [10], most of the energy consumption in the setup of a WSN is consumed by transceiver or radio. As shown in figure 1, radio consumes maximum energy in a wireless network. So

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optimizing a transceiver can help in reducing overall energy consumption of network and hence prolonging the network lifetime.

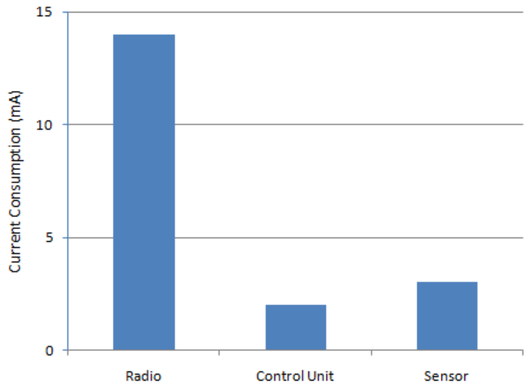

Fig. 1. Current Consumption in a WSN Node [10]

The field should first be tested and analyzed for its dynamics and variations over time (temporal) and space (spatial) using a pilot experiment. Field can be divided into separate regions considering the rate of change of measured parameters. Areas having similar kind of dynamics should fall under one region. In the next step, number of sensors nodes required for one region should be estimated. Region more dynamic in nature or having high rate of change of parameters requires more number of nodes while region with less temporal variations need less number of nodes. Sampaio and Motoyama presented ways of estimating number of sensor nodes based on two concepts: number of available addresses and traffic queuing [11]. Along with estimating number of nodes, authors propose to change the frequency of data transmission according to the region. In region with high rate of change of parameters, data should be frequently transmitted to base station. However, there may be regions in which parameters does not have significant variation even over the duration of hours. Such regions require less transmission rate.

IV. Results and Discussion

The proposed work was compared with two setups [8, 9] implemented by Tea association of India in collaboration with C-DAC, West Bengal at Tocklai Experimental Station, Jorhat, Assam.

In the first setup [8], two WSN nodes were placed at distance of 10 m from each other and transmission interval is 15 minutes. Since in a tea plantation, parameters don't change much over a distance of 10m, so assuming one node to send data every 15 minutes while other node sends data on hourly basis. CC2520

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mote of Zigbee is used as transceiver. Considering modeling of current for Zigbee/CC2520 mote [12], earlier setup consumes 0.207507 Joule of energy over the time of one day. However proposed setup consumes 0.129688 Joule of energy/day. Hence the proposed setup saves almost 37.5% of energy/day. The operating voltage of nodes is 12V. For comparison, data sent was assumed to be one byte. The percentage of energy saved will vary with number of bytes sent and duration of experiment.

In the second setup [9], 13 field stations were setup over the area of 205 hectares. Authors propose to divide the area into two regions representing separate dynamics. Region-1 is assumed to have more frequent variations than Region-2. Authors propose to operate 8 nodes on region-1 at transmission or sampling interval of 15 minutes while other 5 nodes operate in region-2 at transmission interval of one hour. Operating voltage of nodes is 12V. Earlier setup which assumes uniform field area consumes 1.3 Joule/day while proposed setup with two separate regions consumes 0.95 Joule/day. Hence the proposed scenario saves 26.17% of energy/ day. Data sent was assumed to be one byte. CC2520 mote of Zigbee is used as transceiver. Further, following the same concept, area can be divided into more than two regions and the least dynamic region can operate with one sensor node also. Thus it can save more energy and network will operate for longer duration.

V. CONCLUSION

The proposed work optimizes the number of sensor nodes and rate of data transmission to reduce energy consumption and prolong network lifetime of WSN in a tea garden area. Authors suggest not assuming environment of large plantation areas to be uniform. Exploring the dynamic nature of parameters both spatially and temporally, can help in saving a precious resource of WSN i.e. energy. In future work, packet length can also be optimized to prolong lifetime of nodes.

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