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A Review of Efficient Information Delivery and Clustering for Drip Irrigation Management using WSN

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Abstract

In this paper a concise outline for improving throughput and average end to end delay of information gathered from the agriculture field for precision agriculture, using a distributed clustering mechanism has been outlined. This algorithm offers a throughput of 180 bits/seconds. Besides delivery of water level information packets/signals to base station, it also computes a threshold as well as calculates the values based on transmission range. This overall computational mechanism helps us to build a robust mechanism for delivery of information to the base station, thus reducing the packet loss. A wireless sensor network is a system consisting of sensor nodes, which incorporates a radio frequency (RF) transceiver, sensor, microcontroller and a power source. Recent advances in wireless sensor networking technology have led to the expansion of low cost, low power, multifunctional sensor nodes. Sensor nodes facilitate environment sensing together with data processing, are able to network with other sensor systems and exchange data with external users. Sensor networks are used for a variety of applications including wireless data acquisition, environmental monitoring, irrigation management, safety management and in many other areas. In this paper, a review of incorporating a distributed clustering algorithm for an agricultural application has been elaborated.

Keywords: Wireless sensor network, sensor node, distributed clustering, water level monitoring, drip irrigation, precision agriculture.

1. INTRODUCTION

A normal wireless sensor network (WSN) protocol consists of layers like application layer, transport layer, network layer, data link layer, physical layer, power management plane, mobility management plane and the task management plane. Currently two standard technologies available for wireless sensor networks are Zigbee, and Bluetooth both operates in Industrial Scientific and Medical (ISM) band of 2.4 GHz, which provides license free operation for scientific research and study purpose. In general, increase in frequency increases bandwidth which allows high speed data transmission. In-order to decrease the power requirement distance between sensor nodes has to be reduced as possible [13-16]. Multi-hop communication over the ISM will be promising technique in WSN, since it consumes less power than traditional single-hop communication. A sensor is intelligent to convert physical or chemical readings gathered from the environment into signals that can be calculated by a system. A multi-sensor node is intelligent to sense several magnitude values in the same device. In a multi-sensor, the input variables may be temperature, fire, motion detection sensors, infrared radiation, humidity and smoke. A wireless sensor network could be a functional architecture for the deployment of the sensors used for fire detection and verification.

The most imperative factors for the quality and yield of plant growth are temperature, humidity, light and the level of nutrition content of the soil in-addition with the carbon dioxide in the surrounding atmosphere. Constant monitoring of these ecological variables gives information to the cultivator to better understand, how each aspect affects growth and how to achieve maximal crop productiveness. The best possible greenhouse climate modification can facilitate us to advance productivity and to get remarkable energy saving, predominantly during the winter in northern countries. In the past age band, greenhouses it was enough to have one cabled dimension point in the middle to offer the information to the greenhouse automation system. The arrangement itself was typically simple without opportunities to supervise locally heating, light, ventilation or some other actions which were affecting the greenhouse interior climate. The archetypal size of the greenhouse itself is much larger than it was before, and the greenhouse facilities afford several options to make local adjustments to light, ventilation and other greenhouse support systems. However, added measurement data is also needed to put up this kind of automation system to labor properly. Increased number of measurement points should not dramatically augment the automation system cost. It should also be probable to easily alter the location of the measurement points according to the particular needs, which depend on the definite plant, on the possible changes in the external weather or greenhouse arrangement and on the plant placement in the greenhouse. Wireless sensor network can form a helpful part of the automation system architecture in contemporary greenhouses constructively. Wireless communication is used to transmit the measurements and to establish communicate between the centralized control and the actuators located to the different parts of the greenhouse. In highly developed WSN systems, some parts of the control system has to be implemented on the field in a distributed so that local control loops can be created. WSN is fast, cheap and easy compared to cabled network systems.

Moreover, it is easy to relocate the measurement points when needed by immediately moving sensor nodes from one location to another within a communication range of the coordinator gadget. If the greenhouse vegetation is high and dense, the small and light weight nodes can be hanged up with the branches. WSN is easy to maintain, relatively inexpensive and trouble-free. The only other expense occur only when the sensor nodes run out of batteries (figure 1) and the batteries have to be charged or replaced. Lifespan of the battery can be increased to several years if a proficient power saving algorithm is applied. In this work, the very first steps towards the wireless greenhouse automation system by building a wireless measuring arrangement for that purpose is taken and by testing its feasibility and reliability with a straightforward setup [2, 3].

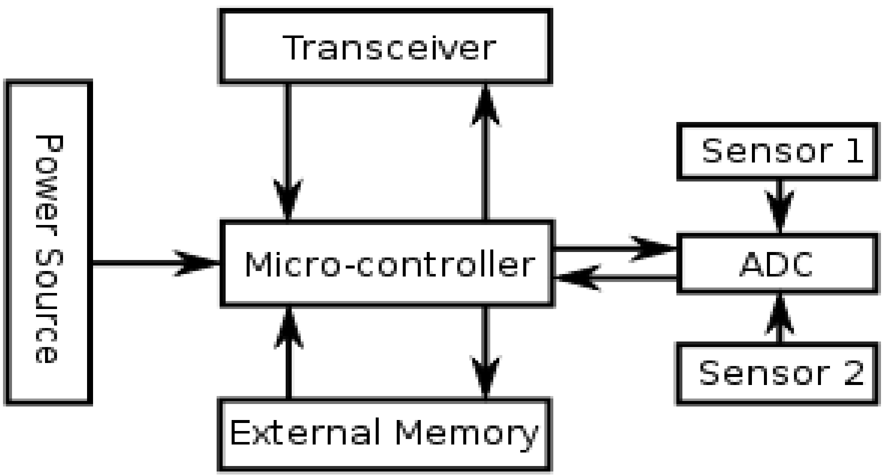


Figure 1: Various blocks of a wireless sensor node

These greenhouse parameters are generally essential in the case of precision agriculture [4, 5]. In this paper, a mechanism for cluster formation for drip irrigation system for precision agriculture has been elaborated. Keeping aside these greenhouse parameters which are essential for cultivation, methodology for cluster formation in drip irrigation system shall be discussed. A distributed clustering mechanism has been employed for cluster formation [7, 8]. Also, few parameters that is necessary for wireless sensor node deployment, for agricultural application has been discussed in the subsequent sections.

2. PLANTATION MANAGEMENT USING WSN

For developing an efficient system for agricultural system management, the foremost inputs to the system will be the availability of accurate data's (figure 2) like soil properties, agronomic, physicochemical parameters, atmospheric data, etc., Data collection can be made flexible on a day-to-day basis or even hourly basis based on the need. Normal laboratory analysis of above mentioned parameters and manual decision-making take a long time even with the most sophisticated analytical techniques. Most of the samples have to be brought from the field to laboratories to analyze most of the time. By the time the results are available and decisions are taken, the conditions of the farm may change which results in inappropriate decision. Quick and quality decision-making at the farm level will enhance agricultural productivity and quality manifold which further needs accurate and real time properties of the field.

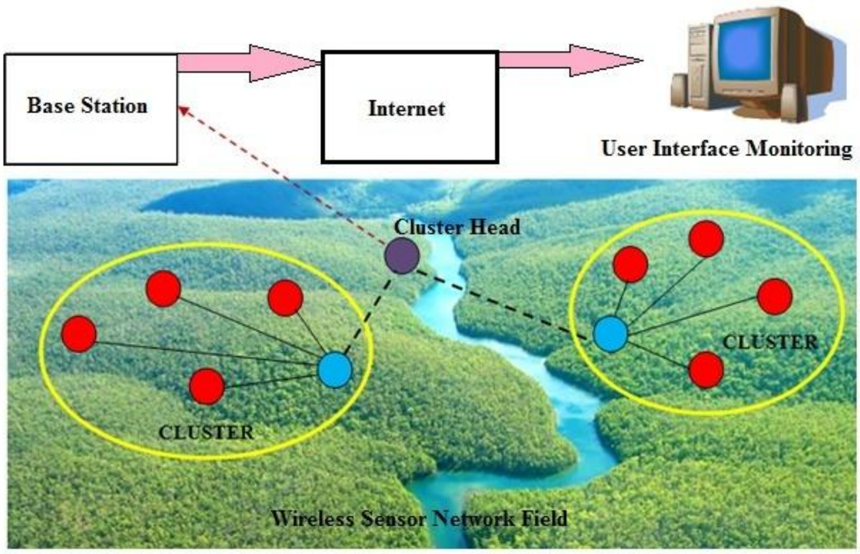


Figure 2: WSN in Precision agriculture

Computer-aided decision-making process can handle and analyze several input parameters at the same time which involves large databases. Monitoring of physical and environmental parameters including soil moisture, soil temperature, nutrition content of the soil, leaf temperature, relative humidity, air temperature, rainfall, vapor pressure and availability of sun light is done through a wireless sensor network. WSN is comprised of distributed sensors to monitor physical, chemical and environmental conditions. WSN integrates sensors, wireless and processing tools whoch are capable of sensing different physical parameters without any loss in sensed data accuracy. The parameters are processed and wirelessly transmitted to a centralized data storage system through a gateway from where they may be remotely accessed and analyzed by the user [17]. The system architecture of a WSN-based system consists of different sensors interfaced to electronic hardware with a suit of data processing tools. The electronic hardware is also equipped with wireless communication modules which allows sensed data to be modulated and transmitted in accordance to a selected protocol. These hardware nodes are called motes in WSN. Each of these motes are interfaced with some set of wireless sensors depending on the applications interest. The sensors may be programmed to sense in a continuous or discrete manner. The needed parameters for precision agriculture have been enumerated in the next section.

3. WSN IN PRECISION AGRICULTURE

WSN technology can broadly be applied into three areas of agriculture: a) Fertilizer control, b) Irrigation management and c) Pest management. The sensors are interfaced with the mote to sense parameters like temperature, relative humidity, solar radiation, rainfall, wind speed and direction, soil moisture and temperature, leaf wetness and soil pH. The following parameters should essentially be accounted before deploying sensor nodes in a wireless sensor field.

A. The Greenhouse Environment

A contemporary greenhouse can consist of copious parts which contain their own confined climate variable settings. As a result, a quantity of measurement points is also needed. This group of environment is demanding both for the sensor node electronics and for the short-range IEEE 802.15.4 wireless network, in which communication choice is greatly longer in open environments [9, 10].

B. Sensors

Speedy response time, squat power consumption and tolerance beside moisture climate, relative humidity and temperature sensor forms an idyllic preference and explanation for the greenhouse environment. Communication among sensor nodes can be carried out by IIC interface. Luminosity can be measured by light sensor, which converts light intensity to equivalent voltage. Unstable output signal is handled by low-pass filter to acquire exact luminosity values. CO_2 measuring takes longer time than other measurements and CO_2 sensor voltage supply have to be within little volts. The carbon dioxide assessment can be read from the ensuing output voltage. Operational amplifier raises the voltage level of weak signal from the sensor.

C. Greenhouses

A greenhouse is a pattern covering the ground frequently used for growth and progress of plants that will revisit the owner's risk, time and capital. This exhibit is mounted with the purpose of caring crop and allowing a better environment to its advancement. This defend is enough to guarantee a higher quality in production in some cases. However, when the chief idea is to achieve a superior control on the horticulture development, it is necessary to examine and control the variables that influence the progress of a culture. The chief role of a greenhouse is to offer a more compassionate environment than outside. Unlike what happens in customary agriculture, where crop conditions and yield depend on natural resources such as climate, soil and others, a greenhouse ought to promise production independent of climatic factors. It is noteworthy to view that even though a greenhouse protects crop from peripheral factors such as winds, water excess and warmth it may root plentiful problems such as fungus and extreme humidity [1].

D. Temperature

Temperature is one of the main key factors to be monitored since it is unswervingly related to the development and progress of the plants. For all plant varieties, there is a temperature variety considered as a best range and to most plants this range is comparatively varying between 10ºC and 30ºC. Among these parameters of temperature: intense temperatures, maximum temperature, minimum temperature, day and night temperatures, difference between day and night temperatures are to be cautiously considered.

E. Water and Humidity

An additional significant factor in greenhouses is water. The absorption of water by plants is associated with the radiation. The deficient in or low level of water affects growth and photosynthesis of these plants. Besides air, the ground humidity also regulates the development of plants. The air humidity is interconnected with the transpiration, while the ground humidity is linked to water absorption and the photosynthesis. An atmosphere with tremendous humidity decreases plants transpiration, thereby reducing growth and may endorse the proliferation of fungus. On the other hand, crouch humidity level environments might cause dehydration [6].

F. Radiation

Radiation is an elementary element in greenhouse production and sunlight is the key starting place of radiation. It is an imperative component for photosynthesis and carbon fixing. Momentous radiation features are intensity and duration. The radiation intensity is linked to plant development and the duration is explicitly associated with its metabolism.

G. CO_2 Concentration

CO_2 is an indispensable nutrient for the plant development, allowing the adaptation of carbon. The carbon retaining process occurs through the photosynthesis when plants take away CO_2 from the atmosphere. During photosynthesis, the plant use carbon and radiation to produce carbohydrate, whose purpose is to permit the plant development. Therefore, an enriched air environment should add to plant growth, but it is also vital to note that an intense carbon level may turn the environment poisonous.

4. THE DRIP IRRIGATION AUTOMATION SYSTEM

Conventional irrigation methods like overhead sprinklers and flood-type feeding systems usually lead to wetness in and around the lower portion of the leaves and stems of the plants. The entire soil surface becomes saturated and often stays wet even after the irrigation is completed. Such condition induces infections in leaf mold with fungus growth. Flood-type methods consume a large volume of water, but the area between crops remains dry and receives moisture only by the incidental rainfall. The drip irrigation technique slowly applies some small amount of water to the plant's root zone. Water is supplied frequently, or on daily basis to maintain favorable soil moisture condition and prevents moisture-stress in the plant with proper use of water resources. WSN based drip irrigation system is a real time feedback control system which continuously monitors and controls all the activities of the drip irrigation system.

A typical drip irrigation system consist of delivery systems, filters, pressure regulators, valve or gauges, chemical injectors, measuring sensors/instruments and controllers. WSN framework installed in the field could gather various physical and chemical parameters related to irrigation and plant health. These includes various temperature parameters like ambient temperature, ambient humidity, soil temperature, drip water temperature, soil moisture, soil pH, water pressure, flow rate, amount of water, energy calculation, chemical concentration and water level. The data is sent to the central server wirelessly through the motes and gateways [11, 12]. Based on the data received, the central server generates necessary control signals, which are routed to the respective controllers through control buses which enables implementation of closed-loop automation for the drip irrigation system. The main function of the system is to enable switching on and off of the motors and gauges remotely. The system also ensures that all the devices are checked for fault and only then the motor is started.

5. ALGORITHM FOR DRIP IRRIGATION SYSTEM

In this paper, a mesh topology in which sensor nodes are placed in the farm area have been properly reviewed and adopted [17]. Sensors in this topology are mobile where as the base station is stationary and it collects the data from sensor nodes and process them. Efficient clustering of sensors in the wireless sensor field is considered as the basic operation in this research work. This work elaborates how to forward the sensed data to the base station effectively. For this purpose the farm area consisting of deployed WSN nodes has been formed initially. Now set the position of sensor and sink nodes in the farm and the monitoring station location. Set the transmission range for each node. Now for each node, calculate distance from: node to node, node to sink and node to forwarding node. Also calculate: Angle a and predict min angle for next route based on fuzzy time series, if the current angle a is available as predicted, continue with path [find possible node (x, y)] or else hold packet for limited time. If connections (i, j) = 1 i.e., there is a link based on transmission range, send the packet information i.e., water level information and some other essential details about field of interest. The packet reaches to the sink node and gets stored there. Else connections (i, j) = infinity, end the structure. Therefore values of sensor nodes are stored in sink nodes. These sink node sends the stored values to monitoring station. On the basis of water level information, the switch is made on/off.

6. RESULTS AND DISCUSSIONS

Here we obtain information of water level by using wireless sensor nodes. On the x-axis, we plot the number of readings of one sensor whereas on the y-axis we plot the magnitude of water level (figure 3). Here we have taken the ten water level readings of one sensor and the corresponding magnitude of water level readings. The next step is to deliver the obtained water level information to the forwarding node and then to the sink node (base station). This process is known as Packet Delivery. In the percentage form it is known as Packet Delivery Ratio (PDR) as expressed by equation 1.

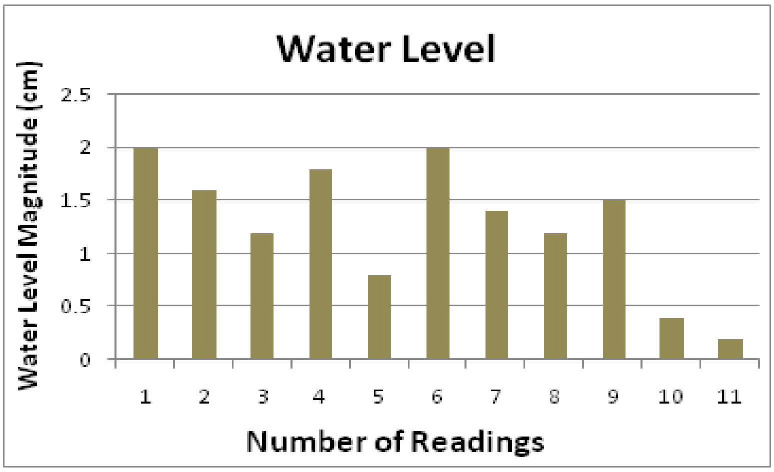


Figure 3: Water Level Information

$$PDR = \frac{\Sigma\ Number\ of\ packets\ received}{\Sigma\ Number\ of\ packets\ sent} \times 100 \qquad (1)$$

The greater value of packet delivery ratio means the better performance of the protocol. The PDR is inversely proportional to Packet Lost Ratio (PLR) as expressed in equation 2. Packet lost ratio is the total number of packets dropped during the transmission.

$$PLR = \frac{\sum Number\ of\ packets\ lost}{\sum\left(Number\ of\ packets\ lost + Number\ of\ packets\ received\ successfully\right)} \times 100$$

... (2)

7. SIMULATION RESULTS

By using fuzzy time series algorithm, we get the initial throughput of 46 bits/sec, which is represented by blue line (figure 4). It is known as Fuzzy THR. When Nuppy algorithm is employed, we get the throughput between 48 bits/sec. This is referred to as Nuppy THR, represented by red lines. In this comparison, with 200 sensor nodes employed for throughput calculation, we can clearly see that, the throughput of fuzzy time series increases with increase in the number of wireless sensor nodes.

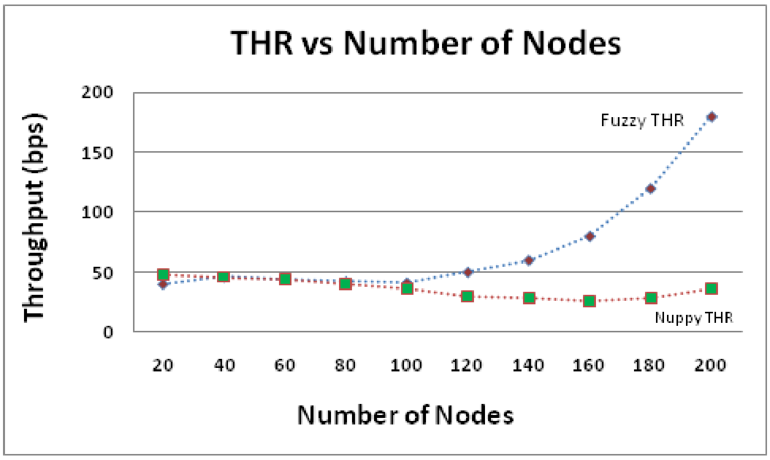
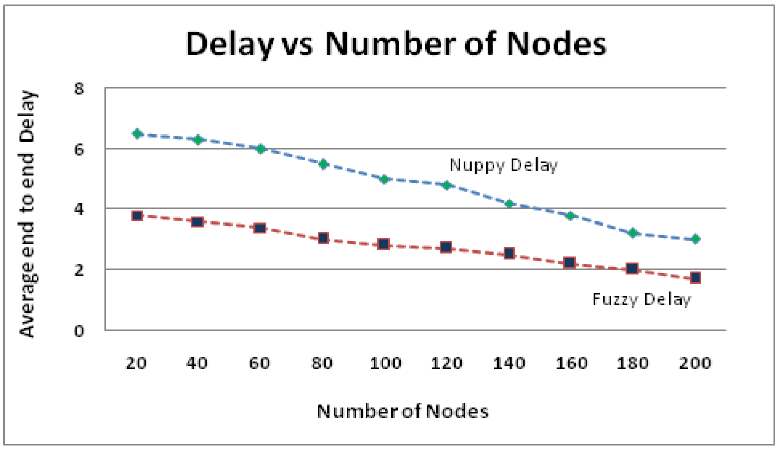


Figure 4: Throughput versus number of nodes

Figure 5, shows the Nuppy delay being given by blue line, whereas fuzzy delay is represented by red line. In case of nuppy delay, the average end to end delay is found to be between 6.5 msec to 3 msec. In Fuzzy algorithm, the average end to end delay is found to occur between 3.8 msec to 1.8 msec. Hence by the employment of fuzzy time series algorithm, better average end to end delay could be attained which could be understood from the results. Hence, in improved Fuzzy based algorithm, reliable water level information could be attained in comparison with the Nuppy algorithm.



8. CONCLUSION AND FUTURE WORK

Conventional Flood-type methods consume large volume of water, but the area between crop rows remains dry and receives moisture only from the incidental rainfall, whereas the drip irrigation technique slowly applies a small amount of water to the plant's root zone. Therefore by using the fuzzy based algorithm in wireless sensor drip irrigation technique, the wastage of water can be controlled. Also by using wireless sensor network, laborers are not essentially needed. In this paper, water level information is achieved by the usage of 200 wireless sensor nodes. The comparison between the two clustering mechanisms, clearly gives an idea to employ fuzzy time series algorithm, when throughput is mandatory for a drip irrigation system. When the number of sensor nodes is increased, there is a large amount of power consumption by sensors to deliver the water/packet information to the monitoring station. Thus it is mandatory to minimize the power consumption by using some power control techniques. In future, an energy efficient protocol will be employed in the same mechanism, to maximize the network lifetime.

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