Real Time Environmental Monitoring in Palm Oil Plantation Using Wireless Sensor Network

Reza Firsandaya Malik
Computer Engineering Department
Faculty of Computer Science, Sriwijaya University
South Sumatera, Indonesia
Email: rezafm@ilkom.unsri.ac.id

Muhammad Hafiz, Achmad Nopransyah, Muhammad Reyhan Zalbina and Tri Wanda Septian
Computer Engineering Department
Faculty of Computer Science, Sriwijaya University
South Sumatera, Indonesia

***Abstract*—The production of the palm oil accounted for 10.15% of total palm oil production in Indonesia. Farmland monitoring system is designed to determine the condition of temperature and soil moisture on oil palm plantation. In this study, we design and build a Wireless Sensor Network (WSN) with fitted temperature and moisture sensors for monitoring soil quality. The process of temperature and moisture data communication from sensor nodes to the sink using a routing protocol that named Power-Efficient Gathering in Sensor Information Systems (PEGASIS). The routing process in the PEGASIS is the nodes will form a chain by selecting a leader node as a gateway. The development of WSN is composed of 3 nodes and 1 sink with three different scenarios. The first scenario is placed moisture sensors on three nodes (single sensor), the second is placed the temperature sensors on three nodes (single sensor) and the third is placed moisture sensor on two node and one node equiped by temperature sensor (multi sensor). The evaluation of WSN communication using the PEGASIS routing protocol compared to the direct transmission using delay, packet loss and energy have done. The results obtained are the difference between the lifetime sensor nodes between direct transmission and the pegasis is 7 minutes time difference. For the average delay of PEGASIS and direct transmission is 31.23 and 30.92 ms respectively. All transmission in both scheme have packet loss 0%. Conclusion, the WSN has successfully implemented with longer life time energy using PEGASIS than direct transmission methods.**

Keywords*—Wireless Sensor Network, Pegasis, Direct Transmission, Palm Plantation, Real-Time Monitoring

Introduction

The modern age of wireless sensor network (WSN) forms of a large number of energy-saving equipment that is connected to each other by a wireless network. The WSN difference with the usual set of sensors is the ability to form a network that supports cooperation, collaboration and coordination between the sensors. The application includes a wide range of fields, ranging from environmental monitoring, forecasting natural disasters and their mitigation, protection of the country and even to entertainment and household needs.

Basically, WSN is different from other computer network such as the Internet, and therefore requires a paradigm WSN and the adoption of a different design. WSN often used for special purposes, which should be included in the calculation and design applications. For example habits of media transfer and the factors that influence it. For battery-operated sensor, one of the most important parameters is the conservation of battery power, because the battery replacement is difficult or even impossible in the particular application. Therefore, the design of sensor networks must be optimized to extend the life of the network.

Development detector plantation soil quality with WSN technology already done by other researchers with a different object domain, such as water quality [1] and quality of agricultural land [2,3]. There are several drawbacks that limited sensors detect a number of conditions on the ground separately as soil temperature, soil pH, and soil moisture, the communication between the point of WSN, and monitoring system. By utilizing several advantages WSN, which is easy operation, small size, and requires very low power, it can integrate sensors with wireless devices.

In this research, the integrating a soil temperature, soil pH, and soil moisture sensors by connecting to the WSN using PEGASIS routing protocol is presented.

Wireless Sensor Network

Principle of WSN

WSN consists of many individual embedded systems that have the ability to interact with their surroundings through a variety of sensors, process locally and communicating information about such information with their neighbors. Point sensor typically consists of three components: the Wireless Module, Sensor Board and Board Programming, and can consist of individual or mounted in a special system.

PEGASIS Routing Protocol

The PEGASIS routing protocol is the routing protocol that every node can receive and transmit data to a close neighbor and vice versa, then took over the rotating position as leader-node for transmitting data to the sink or BS (Base Station). Such an approach is to distribute the energy load evenly between sensor nodes in the network [4].

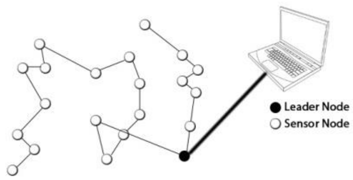


Figure 1. PEGASIS [3]

PEGASIS forming a chain between the sensor nodes so that each node will receive and transmit data to nearby neighbors. Data collected moves from node to node, synergy, and finally designated node sends data to the sink. Node - the node that is in turn transmits the data to the sink so that the average energy - average spent by each node per round is reduced. Therefore, PEGASIS has two main objectives. First, increase the lifetime of each node by using collaborative techniques and as a result the lifetime of these nodes will increase. Second, only allow local coordination between adjacent nodes so that the communication bandwidth consumed is reduced [4]. The PEGASIS avoid the formation of clusters, and only uses one node in the chain of communication to transmit data to the sink rather than using multiple nodes. In determining the nearest node in PEGASIS, each node uses the power of the signal to measure distance to all neighboring nodes and then adjust the strength of the signal so that only one node can be heard. PEGASIS in the communication chain consisting of nodes that are closest to one another and form a service or a communications line to sink.

Enviromental Factors of Palm Oil [5]

Original oil palm plant is a plant that grows wild in the forests and scrub the area but then cultivated. As a crop, oil palm requires good environmental conditions to be able to grow optimally. Climatic conditions and soil is a major factor of growth of oil palm in addition to other factors such as the nature and treatment of genetically technical culture. Oil palm can grow well in tropical areas with a range 15ºLU - 15ºLS. Altitude related to air temperature, humidity, and solar radiation. Plants grow perfect at altitude 0-400 m above sea level (asl), optimal humidity 80-90%, and solar radiation 5-7 hours / day. Average rainfall - annual average that allows for the growth of palm oil is 1250 - 3000 mm are evenly throughout the year, rainfall is optimal range 1750 - 2500 mm with a maximum number of dry months 3 months. The growth of oil palm plantations require temperatures between 22 º - 33ºC. Oil palm requires sunlight intensity is high enough to perform photosynthesis. Wind speed of about 5-6 km / h is very good to help pollinate palm. The wind is too strong causes plants to be tilted even collapsed [6]. Characteristics of the soil used include rock on the ground, effective soil depth, soil texture, soil drainage conditions, and the level of soil acidity (pH). Good land for oil palm plantations is clay dusty, dusty clay loam, clayey loam and sandy clay loam. Effective depth of good soil is if deeper than 100 cm. Acidity (pH) soil is optimal at pH 5-6 and pH 3.5-4 on peatlands. Soil chemical properties such as acidity (pH) can be addressed through dolomite fertilizer, agricultural lime (kaptan) and phosphate (rock phosphate). Physical and biological properties of the soil can be improved by the use of organic materials [6].

RESEARCH METHODOLOGY

System design is done in this research through several phases of designing hardware and software.

The First Phase: The Hardware Design

In this phase, WSN hardware design using 3 microcontroller Arduino Uno Rev3 with each additional Xbee unit, XBee Shield, a temperature sensor (LM35), and moisture sensors (humidity sensor) as the node (according to conditions); 1 unit XBee and XBee adapters, as sinks and 3 pieces of pots containing soil with different moisture levels (dry, moist, wet) as an object of experimentation. The whole hardware are integrated to form a node. Each node is given power by a battery of 9 volts to operate. In general, the design of the system hardware shown in Figure 2.

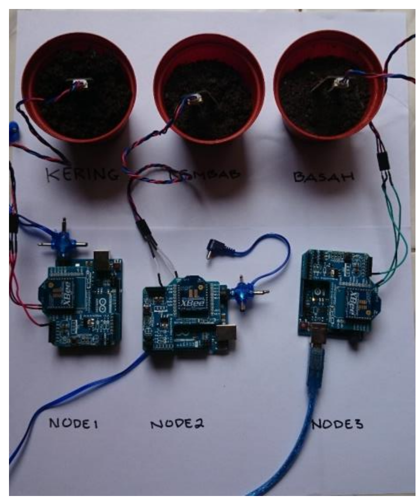


Figure 2. Plantation Soil Quality Measurement Using WSN

The Second Phase: The Software Design

At this phase, the implementation PEGASIS on WSN routing algorithms using Arduino and XBee. At this algorithm the basic idea is to extend the life (lifetime) network, where this lifetime refers to the lifetime of the batteries used in each - each sensor node. The system works is that the sensor nodes only need to communicate with their nearest neighbors (a close neighbor) and in turns communicates directly with the sink. The communication chain formed on PEGASIS algorithm consists of nodes that are closest to each other and form a path (communication line) directly to the sink.

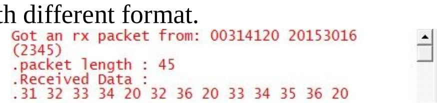
The Third Phase: The Integration

After the integration, the data communications testing. Testing parameters to be measured is a precision sensor data (soil temperature, soil pH, and soil moisture), and end-to-end delay. Scenario trial for 3 (three) nodes and 1 (one) sink is as follows:

1. Single Sensor: Install only one sensor at the node. The WSN nodes to ensure communication between the sink goes well with each same sensor that soil moisture sensor.
2. Multi Sensor: Installing different sensors on the number of nodes in WSN is if there are three nodes and one sink the two 2 different nodes installed node with the next node.

Results and Discussions

In Figure 3 is the result of a routing communication of PEGASIS in the first duty cycle. From the log data can be analyzed that the log data received are included each node addresses and temperature datas. In the data received, it can be described "1234 26 3456 26". Data 1234 is the DL (Destination Address Low) of Node 1 and 26 is a temperature data (°C). For 3456 the data are from the DL Node 3, and 26 is also the temperature data (°C) from the test results. The data format of the received data comprises node address, accompanied by temperature data. For the moisture sensor data, it shown same log data with different format.



```
Got an rx packet from: 00314120 20153016
(2345)
.packet length : 45
.Received Data :
.31 32 33 34 20 32 36 20 33 34 35 36 20
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Figure 3. Data Sensor Log

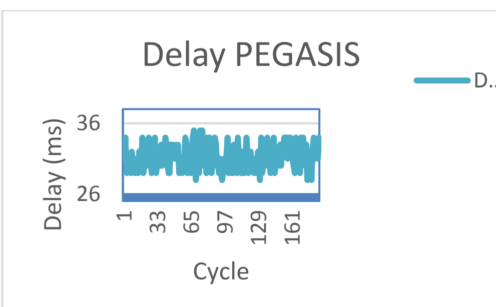

Figure 4. PEGASIS Delay for 3 Nodes Using Moisture Sensors

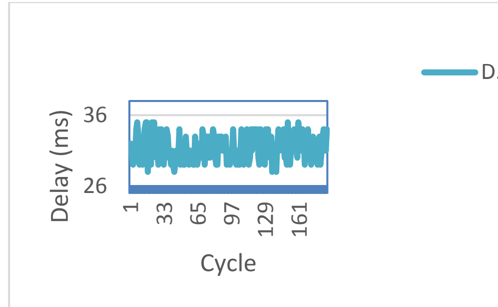

Figure 5. PEGASIS Delay for 3 Nodes Using Temperature Sensors

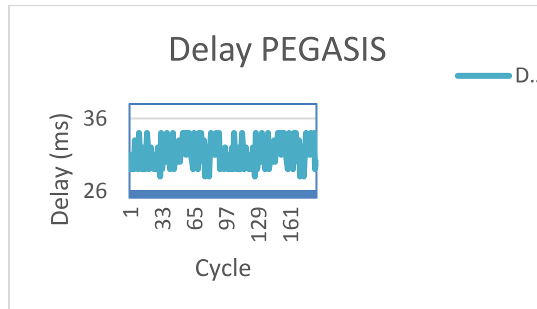

Figure 6. PEGASIS Delay for 2 Nodes Using Moisture Sensors and 1 Node Using Temperature Sensor.

From Figure 4-6, the delay average results from three scenarion in PEGASIS consecutive are 31.17; 31.34 and 31.19 ms. It is shown that WSN sink and nodes able to transmit sensor's datas.

CONCLUSIONS

The design of WSN are used to detect soil quality can communicate properly between the sink and nodes. The nodes can deliver soil moisture and temperature. In communication data testing results showed that the delay average for three scenarios condition are 31.23 ms. Future works, This research will need more nodes to validate the network performance.

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