International Journal of Engineering & Technology, 7 (4.44) (2018) 147-151

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Log Data Structure for Illegal Logging Tracking System

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Abstract

Forest is a natural ecosystem that plays an important role in human life. Unfortunately, due to the exploitation of the forest wealth, the forest ecosystem becomes increasingly diminished. One of the most significant forest damages caused by illegal logging. In some cases, sometimes the information about log harvest that obtained from the logging area always has a discrepancy. To reduce the cunning which is done by the perpetrators, however, a system that can track and monitor the log position from a remote area is needed. This system using APC220 as a WSN using Star topology, embed with RFID reader and Arduino Uno. By designing a log data structure, the tracking and monitoring log is possible to build. This system was testing by three scenarios. The log data structure can be interpreted 100% by the system. According to the resulting test, it can be concluded that this system can track down the position of the log, and inform the forest patrol officer the predictable place where the log is missing.

Keywords: *Log tracking; monitoring and tracking, illegal logging, WSN, APC 220.*

1. Introduction

Forest is an ecosystem unit in the form of a stretch of the land, containing biological natural resources dominated by trees in the natural environment, which cannot be separated from one another [1]. Forests provide many benefits for human survival. One of the benefits is timber. Forests are the biggest timber-producing land for humans. Timber that comes from the forest can be used as a variety of commodities by humans, such as paper, furniture, fence, or roof truss, and etc. Indonesian Government regulation number six of the year 2007 concerning forest management and preparation of forest management plant as well as forest utilization in article 110 paragraph one, which contains applications for business licenses and permits for expansion of the primary forest products in Indonesia [2]. However, with the existence of government regulations, it still cannot prevent illegal logging.

Illegal logging is the biggest issue of the causes of forest destruction and degradation. Illegal logging is an activity that occurs by logging without permission or logging but not in the industrial forests [3]. Many adverse factors can affect by illegal logging. From an economic standpoint, the government loses until billions of dollars. On the legal and political side, there are violations of the regulations and codes of ethics. On the environmental side, there is ecological damage that will bring negative impacts to humans such as landslides, floods and a reduction in oxygen production [4].

One effort to reduce illegal logging is by tracking and monitoring technology [5]. The timber that has been harvested in the forest will be transported into a large field called log yard or timber yard, where the timber will be distributed to other parties. [6].

The process of delivering timber from the forest to third parties is done through several stages. It is Pre-harvest processes stages and post-harvest processes stages. The pre-harvest process is the process of cutting trees and delivering the log to the log yard storage on the edge of the forest. While the post-harvest process is the stage to deliver the log from the log yard storage to a factory or third party. The process of delivering timber can be seen in fig.1.

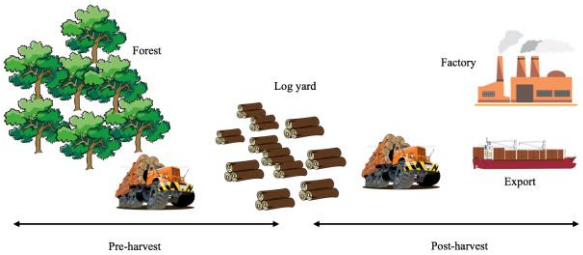


Fig. 1: The Process of Delivering Log

In this paper, monitoring and tracking logs will be carried out on the pre-harvest conditions in the forest industries in Bojonegoro area of Central Java. Pre-harvest in industrial forests in the Bojonegoro region through several stages. The first stage is the stage where trees the authorities log trees. The second stage the log will be transported to the log yard by using a log transport car on the specified path inside the forest. The delivering log will passed several log checking stations that prepared along the path from the log area to the log yard. At each point in the checking station, there will be checked by the officer, whether the log is suitable with the documents that sent by the logging area officers or not.

To be able to track and monitor the position of each log that is delivering from logging area, at each checking station point will be installed an RFID reader to detect the presence of logs and the APC 220 to deliver the finding information to the base station (central data). If there is a log that is not detected by the RFID reader, it will be checked manually by the forest officer patrol whether the log with the undetected id is not in the log transport car.

Tracking and monitoring systems in the Pre-harvest process will be implemented using communication module APC 220, Arduino Uno, RTC and RFID Long Range HW-VX 6346K which is inte-

grated with Wireless Sensor Network (WSN) technology. This research focuses on log tracking and making a monitoring interface so that the system can monitor the log.
This paper will be described in detail in five chapters. Chapter one describes the background of the research. Chapter two explains an overview of related research fields. Chapter three illustrates the proposed system. Chapter four describes and analyzes the result of the testing system, and the last chapter describes the conclusions and future research that might probably enhanced in the future.

2. Overview of Related Research

Wireless Sensor Network (WSN) is one of the technologies that is widely used to tackle illegal logging [7]. WSN applications classified into two categories. Tracking and Monitoring. Monitoring can be done in indoors area or outdoor area, such as monitoring the process of moving logs from the logging area to the logging yard. Meanwhile, the tracking application is a tracking of the objects, such as animals, human and vehicle. In the case of illegal logging, objects that can be tracked are the log.
Aboussaid et.al, design a trees RFID tracking system, she used RFID passive tag and handheld readers to identify the log. She uses 3G as a communication between the tag reader and the server [8]. Hema et.al, using a vibration sensor as a sensing mote and Zigbee as a protocol [9]. Both of the research is not using tracking, for research that conducted by Aboussaid, it takes the role of forest patrol officers to actively checking every cutting log. While the research carried out by Hema et.al, is limited since it is only focusing on tree detection in the area that connected to the WSN Network.
Similar with Hema, Kasim et.al, also made a monitoring for the agriculture system using WSN. The differences only in the type of the sensor that has been used to the system [10] [11]. Hodoñ et.al, using WSN to monitor the use of electric power as a smart power metering [12]. He is also doing testing to maximize the performance energy in WSN [13]. While Kocharoen et.al, designed the WSN to detect the sounds of a chainsaw in the forest, using the sound sensor [14]. All the WSN functions and categories used by the research above included in the monitoring process, none of them focusing on the tracking process.
Alexandru et.al, combines a simulation framework which is made to tackle illegal logging. By combining WSN Technology with gossip sleep protocol, sensing mote that uses in his research is a chainsaw sound sensor. His research also using drone and airplane to do patrol around the forest [15]. Unfortunately, this research does not explixitly track the logs since the research is only focusing on the WSN method.
According to the overview of the related research, however, there is still no system that can monitor the logs in real time, automatically and supervised. This research aims to track and monitor the log in the pre-harvest process from area logging until it is delivering to the log yard storage. This part of the system will be placed at each tracking station along the route, so each log can be tracked down until the log yard storage. Each tree in the forest is planted with RFID since the RFID still plays a valuable tool to store data about the identity of the trees [16][17]. Each RFID numbered with the identification of the tree. Monitoring is done using the configuration of the APC 220 and the RFID Reader HW-VX 6364K. In this proposed system, log-code is also designed for tracking the logs so the logs can be detected, identified, tracked, and monitored remotely as a real-time system by forest patrol officers. The entire system will be processed using Arduino ATMega328P.

3. Proposed System

After the overview of similar research, the next step is to explain the proposed system that will be presented in this paper. As previously described, this research uses a long-range RFID reader to identify the tree id that was cut down. The RFID card used by the system is active RFID. The communication module that will be used as WSN is APC 220 which is a semi-duplex low power communication module that has high MCU and high speeds RF. The microcontroller Arduino Uno ATmega328P is embedded to the system together with the Real Time Clock (RTC) module as a low-power serial real-time clock.
The use of WSN topology applied to this system is a star topology as shown in fig.2. APC 220 A and B used as a transmitter, and APC 220C functions as a receiver. The transmitter will send data in the form of string code to the receiver. In the receiver side, the string code will be parsing. The parsing data then sent to the computer for monitoring.

Fig. 2: Wireless Sensor Network Topology Using APC220

All components are finally designed as shown in fig.3. In the logging area, RFID will be embedded in each tree, and the RFID reader will be stored in each location tracking station. The whole system is associated with the star topology to the base station.

Fig. 3: Illegal Logging Tracking Proposed System

In the forest, there are indeed many road routes to the forest exit. But, the log trip route to be traversed is always the same, every time the logging process occurs for one logging document. Therefore, in this research, a design interface was created for the exit of one route to the log storage area in the outer region of the forest. Fig.4 shows the image of Pre-harvest mapping checking station. Logging area means the area of the logging trees. Non-logging area means the areas where logging is not allowed. Tracking station 1 and tracking station 2 is the place where the log is being to check by the system. Log yard is the area where the logging trees are placed in the storage to be delivered into the third party. All this mapping is mapped for the Pre-harvest process.

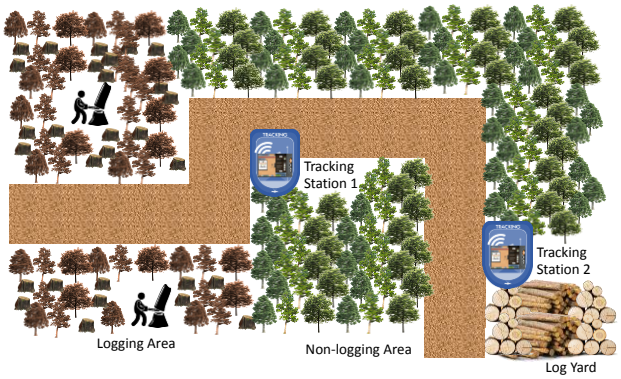


Fig. 4: Pre-Harvest Mapping Checking Station

After designing and mapping, the next step is mapping the data structure in order to determine the identity of log timber. This code will be used for tracking the logs from one place to another place. In figure 5 it can be described that the data structure is encoding consists of a 13-bit string. The first-bit string addresses the code from the start bit of a data; the next two bits are the code to identify the tracking station, the next three bits are identified tree code, the next six bits are identifying the code of time which is consisting of hours, minutes, and seconds. The last bit states the information of end bit. For example, if the detected code is a01201225035#, it means report from tracking station_01, detected id_tree = 201, at 22:50:35.

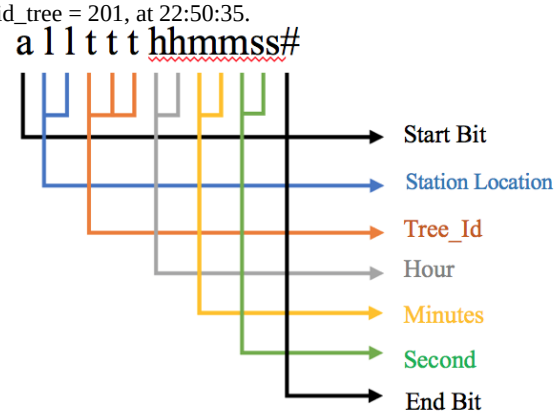


Fig. 5: Log Data Structure for Tracking System

Fig.6 shows the prototype of the APC 220 as a transmitter and receiver. In the transmitter section, the data code is sent from the detection of RFID. Whereas on the receiver the data code that comes from the transmitter, will be parsed and translated.

The monitoring design at the base station can be seen in fig.7. there is a mapping of the delivering path of the log. The road is described from the logging area to the log yard in the pre-harvest process. Three interface boxes provide information to the officer regarding the log detected for each checkpoint station tracking

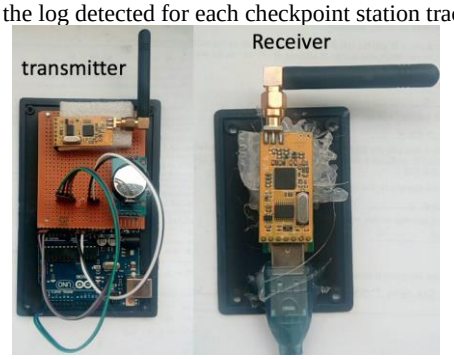


Fig. 6: Transmitter and Receiver Prototype

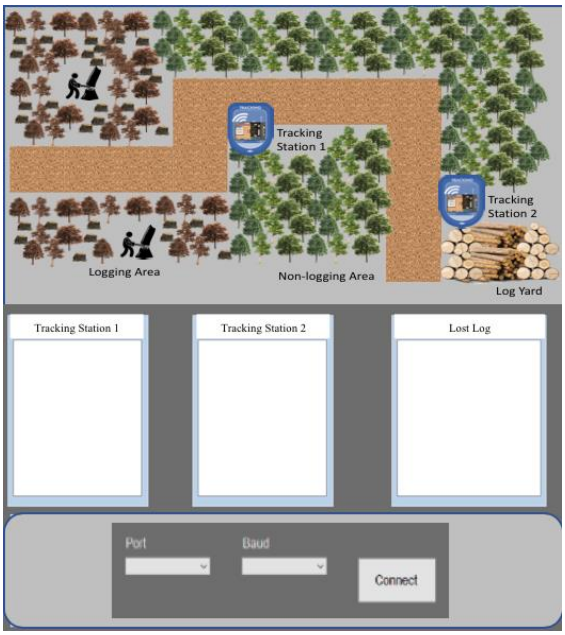


Fig. 7: Interface Monitoring System Log Tracking

The system works can be seen in the flowchart in fig.8 below. The system starts when the log in the logging area is ready to be sent to the storage area in the log yard. APC 220 installed in the logging area will send data from the RFID reader which is installed in each log. The data then sent to the APC base station to be stored and used as data for comparison in each area of the tracking station that will pass through by the log.

After the log truck arrives in tracking station 1, the RFID reader which is located on the tracking station 1 will read the RFID tagged in each log. Every data captured will be communicated with the data at the base station by comparing the data captured with the data that was sent from the logging area. If the data compared is the same, then the data will be displayed in the monitoring interface. Whereas if there is a log that is not found, the data will be entered into the monitoring interface for the lost log category.

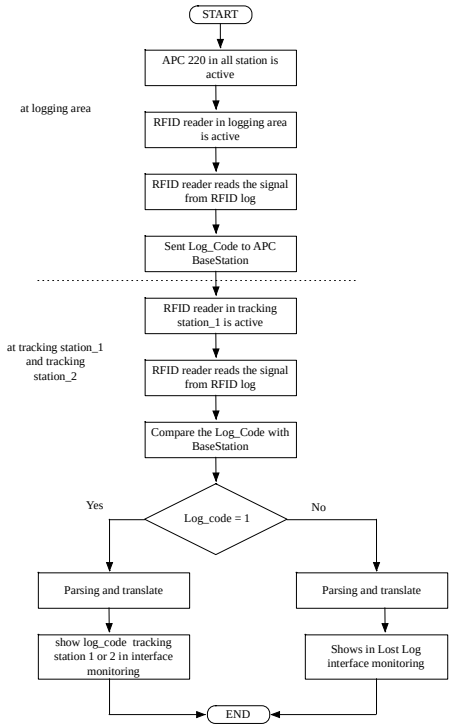


Fig.8: Flowchart of The Proposed System

4. Testing System

The system will be tested using three scenarios. The first scenario is to test communication between APC 220 with different frequencies and different node IDs. The second scenario tests the data parsing on the monitoring interface that found in the tracking station. The third scenario tests the overall tracking log system in the pre-harvest process.

4.1. Testing Communication between APC220

The first scenario aims to see the communication that occurs between APC 220 that is connected in the topology that has been designed. Testing is done using RF-Truly Magical, an application used to configure APC 220. By setting the parameters in RF-Truly Magical, the RF Frequency is set at 400 Hz – 422 Hz and the node ID is set to the same or different id number. Test results can be seen in table 1.

Table 1: Result Testing Between APC220

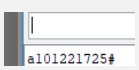
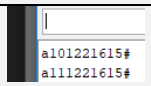
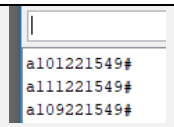
Setting APC220	Status	Status
RF Frequency = 422 MHz RF RX/TX Rate = 9600 RF Power = 9 NET ID 12345 Node ID 101 Series Rate 9600	Frequency and node ID are equal	Sent
RF Frequency = 400 MHz RF RX/TX Rate = 9600 RF Power = 9 NET ID 10000 Node ID 101 Series Rate 9600	Frequency and node ID are different	Failed
RF Frequency = 422 MHz RF RX/TX Rate = 9600 RF Power = 9 NET ID 10000 Node ID 101 Series Rate 9600	Frequency is equal but different node ID	Sent

Based on the table above, it can be seen that the frequency must be set in the same value (hertz) so that the APC nodes can communicate with each other. The different Node ID does not affect the communication process as long as APC works on the same frequency. But to overcome the redundancies of node IDs, it would be better if each node ID was uniquely identified. Every communication between APC with different frequency will be failed.

4.2. Testing Data Parsing

This scenario is done in order to see the data sent by the transmitter whether it can be appropriately translated in the monitoring interface. The test begins with an experiment sending data starting from detection data for one tree up to three data tree which is detected simultaneously by the system. Test results can be seen in table 2.

Table 2: Result Testing Between APC220

Detection Data Code	Data Serial Monitor	Interface Display Monitoring
a101221725#		Sent
a101221615# a111221615#		Sent
a101221549# a111221549# a109221549#		Sent

In table 2, it can be concluded that data that has been successfully parsed can be appropriately translated into the monitoring interface. The existence of several logs that must be detected does not affect the test result. All logs that pass through the tracking station can be read, sent, and received by the monitoring interface

4.3. Testing Log Tracking System in Interface Monitoring

The third scenario is a test scenario that is done to see whether the tracking log system can work properly or not. Testing will be carried out on the monitoring interface. The test results can be seen in fig.9 below. In the figure, the log truck transport has arrived at the station tracking as checkpoint station_1.
RFID reader reads RFID signal which is embedded in a tree and sends the structure data to the monitoring interface system at the base station. There are three logs sent and RFID detected as many as three pieces of logs. It can be seen in fig.9 inside boxes tracking station 1.

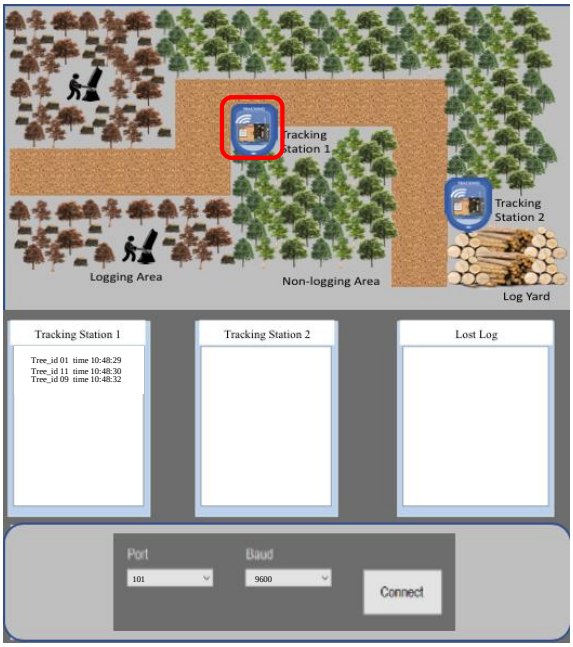


Fig.9: Interface Monitoring System Log at Tracking Station 1

The truck log continued to move on to the tracking station_2. In the middle of the road, RFID with tree_id 11 is released. When the truck log has arrived at the tracking station_2, the RFID reader will read the signal RFID from the remaining log on the log truck. The reader will send the data into the base station, compare with the data in the base station and display the captured id on the monitor interface tracking station_2. Since there is a lost log found in this station, the box of missing log will display the id lost log. The display showed in fig.10.

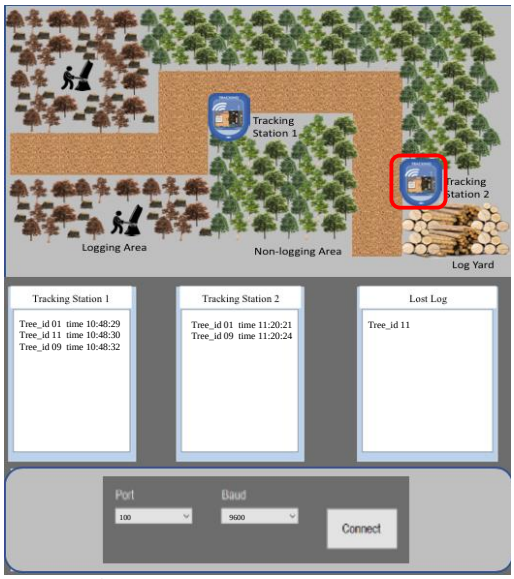


Fig.10: Interface Monitoring System Log at Tracking Station 2

In the picture, the lost log is reporting as a missing log. The missing log that showed in fig.10 is a log with tree_id = 11. Thus, based on that experiment, the tracking logs from the logging area into the log yard can be adequately monitored by the system. When the truck log can reach its destination, the log yard area, the display monitoring can be seen as in fig.11.

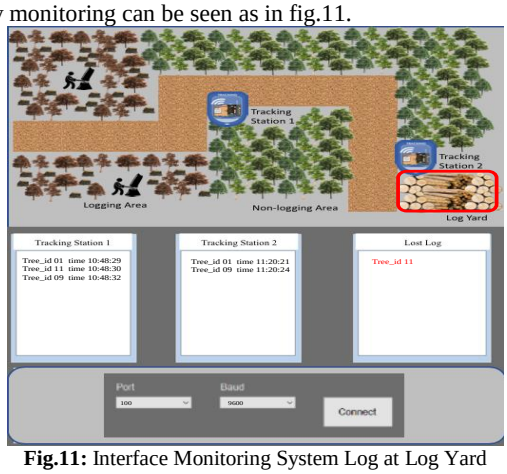


Fig.11: Interface Monitoring System Log at Log Yard

The truck log has arrived at the log yard area and can be reported to the warehouse log head officer that there is a missing log during the trip between tracking station_1 and tracking station_2.

The tests were carried out repeatedly and obtained 100% of the system can interpret the data structure and inform the log if there was a missing log properly to the forest patrol officers.

5. Conclusion and Future Research

This paper proposed tracking system to tackle illegal logging. According to the previous research, there is still no system that can be tracked and monitoring mobility of a single log in real time and automatically. This system using APC 220 as a WSN head node combine with RFID tag and reader HW-VX 6346K can provide good collaboration to inform the occurrence of missing log. The use of RFID still plays a valuable tool to store the information of the log. Since the price is also cheap and ease to identify by the readers. Log can be tracked down, and predictable were the logs were missing. According to the information that provided by the system, the forest patrol officers can act immediately to the location where the log was missing. This monitoring and tracking system can be enhanced until the post-harvest process.

For the future research, this monitoring and tracking system can be enhanced until post-harvest process and send to the consumer. So that, the consumer can satisfy and makes sure that their furniture comes from the certified wood. Besides, the system can also be developed by using GPS and other communication modules. Application Program Interface can be built, and the API routine can be used for various Internet of Things applications to monitor forests from a remote area.

Acknowledgement

We would like to thank to PPM of Telkom University for the financial support to publish and doing this research in the scheme of Penelitian Dana Terapan. We also would like to thanks to School of Applied Science, Telkom University, which provides a testing ground for the implementation.

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