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# Application Cosmic Lora Ray for the Development of Peatland Forest Fire Prevention System in Indonesia

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**Abstract***:* Peat forest fires are commonly observed in Riau Province, Indonesia, especially in the dry season. These occurrences are often caused by the bad disposal of cigarette butts or the uncontrolled burning of specific garden areas. Hence, this study aims to develop an air-monitoring technology capable of transmitting data from several sensor nodes, to predict the state of normality in specific forest areas. The data of air temperature, humidity, and smoke density were obtained and transferred from the transmitting point (client) to the receiving (server) nodes. The server was a single system containing solar panels, a charging system, Li-Ion batteries, temperature and Smoke sensor, 20x4 server-side character LCD, and a Cosmic LoRa Ray-based microcontroller. The temperature and smoke sensors realistically recorded the air temperature and humidity, and the smoke density, respectively. The data of these two systems were also transferred to the microcontroller for processing before transmission to the server, and the results obtained were then displayed in a 20x4 character LCD.

***Keywords:*** *client, cosmic Lora Ray, peat forest fires, sensor nodes, server*

## 1. Introduction

Indonesia has the largest tropical peat area in the world, which is between 13.5-26.5 million ha with an average of 20 million ha. Approximately 50% of the world's tropical peat, which is around 40 million ha is found within the country, where the danger of peatland fires is one of the most nationally encountered disasters. This is due to the detrimental impact of the disaster on national and regional communities. In the last 5 years (2014-2018), several data showed the yearly occurrences of peat fires, with the highest devastations observed in 2015 and 2018, at 2,611,411.44 and 510,564.21 ha, respectively. The three important elements that contribute to the eruption of peatland fires are (1) fuel, as in peat organic material, (2) oxygen, and (3) complete combustion materials, such as fuel, oxygen, and heat energy, which are often known as the fire triangle. According to the theory of this triangle, fires commonly occurred due to 3 factors, namely fuel, heat, and oxygen. In combustible peat lands, the level of fuel availability is influenced by the moisture conditions of the soil, which is generally affected by peat water level. Moreover, the TMA (Water Level) theoretically affects the moisture content, indicating that the distance of the water level from the peat surface tends to increase the flow components. This is found at a depth of 30 and 80 cm TMA, with no occurrence, observed at 50 cm. These are influenced by the unstable condition of the peat location [1].

The peat lands in Riau Province have a fairly high level of fire hazard, as observed from several occurrences every dry season. At the beginning of 2019, approximately 1,263.83 of 2,700 ha were mostly devastated in Bengkalis Regency, based on the daily report on smoke disaster emergency alerts. Almost every sub-district in this area was hit by fires throughout this period, with the worst occurrence recorded on Rupat Island, Bengkalis, Indonesia. Therefore, this study aims to develop a system capable of monitoring the conditions of fire-prone areas, to prevent peat forest disasters. In this case, a system was created regarding the capability to detect changes in temperature, humidity, and air quality concentrations. This is equipped with a single power source from solar panels, packaged in a mini form (sensor node), and capable of transmitting data to the server through the integrated LoRa modul.

## 2. Literature Review

Several leading scientists have analyzed the use of wireless sensor networks in remote monitoring systems. According to Khamukhin and Bertoldo [2], the spectral analysis of forest fire noise was assessed for early detection, using wireless sensor networks. This determined the types of forest fires by analyzing the power spectrum in the noise frequency range between 250-450 Hz. In this condition, 9 spectrums of the disasters were subsequently obtained.

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Yang et al. [3] also described the early detection of forest fire through unmanned aerial vehicle platforms. In this report, a detection system was created by flying a drone to visualize the affected areas, as well as compress and transmit the images to the ground station, which forwarded the data to the processing center. This center then decompressed the data and alerted the software for smoke and flame detections. Furthermore, Eridani et al. [4] evaluated a LoRa network monitoring system, using a smart gateway (Raspberry Pi 3b+) in a simple LoRa protocol (SLP). The module used in this analysis was a Dragino LoRa, which operated at 868 MHz with Spreading Factor 7 and Arduino Uno. This system was only developed to access the Local Area Network, with the results showing that the smart gateway handled the LoRa communication and monitoring information systems. In this condition, the transmission speed of delivery was 489 bit/s, with a 26% packet loss at a distance of 1 m.

Based on Yuliandoko and Rohman [5], a flooding detection system was described regarding water monitoring and ZigBee mesh protocol. In this report, the disaster data were observed by the sensors and transmitted through the ZigBee system. The results also proved that the best mesh network had a max distance of 75 M between nodes. Opipah et al. [6] subsequently evaluated the prototype design of a LoRA-based smart home system, to monitor room temperature and control electronic devices. In this analysis, the utilized communication module was the 915-MHz LoRa Dragino 915 MHz module, which was used between the LoRa client and server. The designed LoRA-based prototype was then used to realistically monitor room temperature and control electronic devices through a communication signal range between LoRa client and server, at a maximum range of 183 and 63 m in a semi-opened and closed area, respectively [7]. According to Gehani et al. [7], the LoRa Band 915-MHz Application was explained for Agro-Informatics. Using LoRa device modules, sensors were designed to detect and measure soluble toxins in the agricultural soils from industrial water sources. These systems were buried with cameras capable of detecting and classifying the pathogens affecting plants. Sensor measurement samples and camera images were also obtained and transmitted to the LoRa central concentrator (gate) above ground. These LoRa devices were buried at varying depths, although both ground and air had similar transmitted signal strength. Additionally, subsequent experiments were carried out to measure the RSSI (received signal strength indicator) and SNR (signal to noise ratio) under different LoRa dispersion factors, coding levels, and soil depth. The results also showed that the depth of the LoRa burial transceiver should not exceed 50 cm for agro-informatics applications [7]–[10]. The present monitoring system for peatland fires is still manually operated through assessment towers and carried out by the Provincial BPBD employees deployed to each district in Riau Province, Indonesia. Most of these systems are ineffective for several reasons, as follows:

1. Inadequate daily assessment, although only during working hours.
2. Monitoring distance is limited to specific forest areas due to limited viewing points.
3. The distance of the monitoring tower is located on the side of the forest and far from housing.

This study aims to develop an optimal realistic monitoring system, using a wireless sensor network. It also aims to design and implement the system in a real environment, subsequently emphasizing the problem of technical constraints.

## 3. Design System

When developing a forest fire monitoring system, the consideration of all applicable parameters is very important. These parameters include solar panel power, communication and buck converter modules, ambient temperature, environmental humidity, air quality (smoke), Li-Ion battery, and microcontroller. They are also important due to the definition of basic systematic characteristics [4]–[7]. For detecting peat land fires in Riau Province, the development of an all-parameter monitoring system was originally designed as a block diagram. Self- powered sensor node system with battery source recharged via solar panels [11]. The data transmission system for the forest fire detector also contains 2 node sensors, namely, the transmitter (client) and receiver (server). Furthermore, the delivery system having wireless communication uses a LoRa module integrated into Cosmic Ray, with an Arduino Pro Mini-based microcontroller. In this condition, the client contains a solar panel, buck converter module, Li-Ion battery, temperature and humidity sensors, smoke detector, and Cosmic LoRa Ray. Although the server is similar to the client, an additional character LCD is still observed as a data display. The structure of this system is shown in Fig. 1.

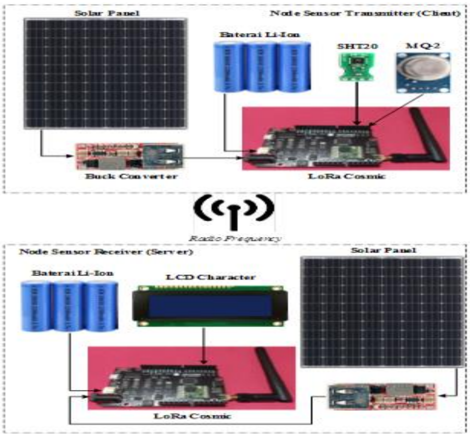

**Fig 1.** Structure scheme of data transmission system based node sensor

Based on this system, the main task of Cosmic LoRa Ray is to process sensor data, control the wireless network, and transfer data from the client to the server. At the server, the value measured by the sensor is often displayed on the character LCD. This is because the server stores hourly, daily, weekly, monthly, and yearly value report measured by the sensors. Using the LoRa Cosmic Ray wireless network, the forest fire monitoring system is divided into two parts, namely a data collection and receiving unit for air conditions or transmitter and receiver node sensors. In the transmitter node sensor, the following blocks are observed, which is further illustrated in Fig. 2.

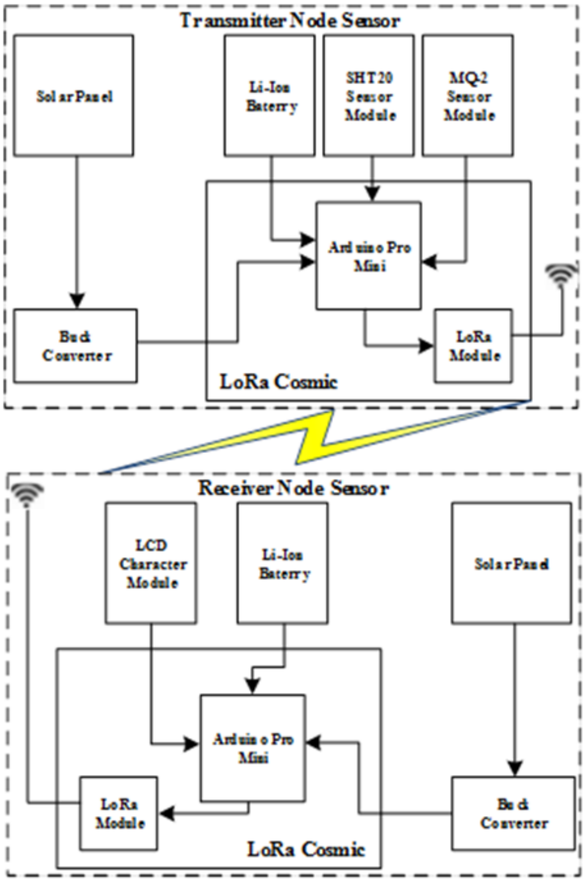

**Fig 2.** Block diagram of data transmission system based node sensor

At the transmitter node sensor, the power source originates from the solar panel, at a capacity, maximum voltage, and current of 10 WP, 18 V, and 0.56 A [12]. In this condition, the voltage generated is forwarded to the buck converter, which is capable of obtaining the inputs and outputs of 6-20 and 5 V, respectively, with a maximum current of 3 A [13]. This leads to the direct connection of the converter to the utilized microcontroller (LoRa Cosmic Ray), which emphasizes the Arduino Pro Mini system integrating the 915-Mhz LoRa module [14]. Moreover, the configurations used between the module and Pro mini-systems include the RESET, DIO, NSS, MOSI, MISO, and SCK pin LoRa to pin 9, 2, 10, 11, 12, and 13Arduino, respectively [15]. The LoRa Cosmic Ray module also has a built-in Li-Ion charger circuit, for the connection to a Li-Ion battery. In this analysis, the 3 batteries used are arranged in parallel and produce a current and voltage capacity of 3,900 mA and 3.7 V, respectively [16]. The SHT20 sensor module also features a communication protocol inter-integrated circuit (I2C), with the utilized connection configurations including pin VCC, GND, SDA, and SCL to pin 3.3 V, GND, SDA, and SCL Arduino, respectively [17], [18]. Additionally, the MQ-2 sensor module (smoke sensor) has an analogue signal output with the following configurations, namely VCC, GND, and AO pin MQ-2 to VCC, GND, and AO pin Arduino, respectively [19].

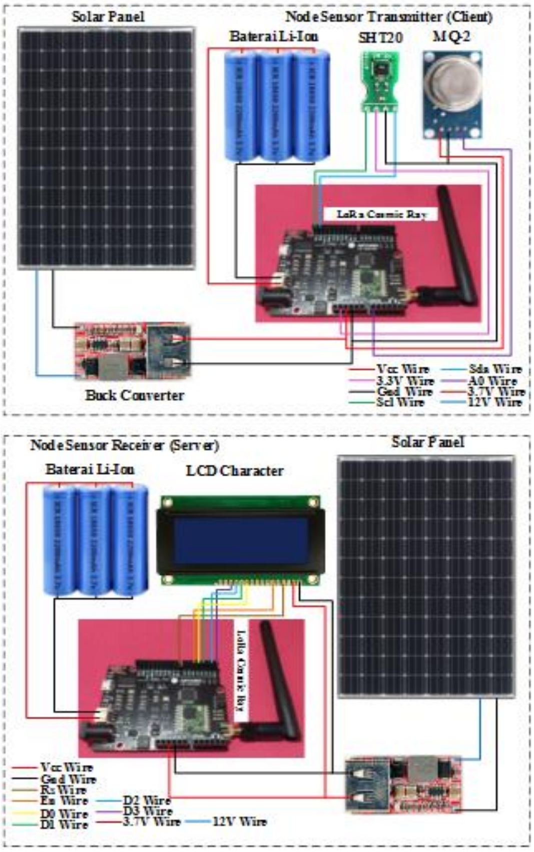

**Fig 3.** Wiring diagram for all system

Based on the receiver node sensor, the power source originates from the solar panel with a similar capacity as observed in the transmitter. The voltage generated is also transmitted to the buck converter and directly connected to the utilized microcontroller (LoRa Cosmic Ray). In this condition, the utilized battery is found in 3 pieces and arranged in parallel. The character LCD is also used to display the data obtained from the transmitter node sensor, with the pin configuration containing the following 6 data, namely (1) pin Rs LCD to pin 8 Arduino, (2) pin enable LCD to pin 5Arduino, (3) pin D0 LCD to pin 4 Arduino, (4) pin D1 LCD to pin 3Arduino, (5) pin D2 LCD to pin 1 Arduino, and (6) pin D3 LCD to pin 0 Arduino.

Subsequently, 2 pins were found to supply the character LCD, namely, VCC and GND to pins VCC and GND Arduino [20].

The forest fire monitoring system contained two parts, namely air condition data collection and reception models, which were observed as distributors. This is because the two systems were observed at a specific distance from each other and communicated to the sensor data. Therefore, the software was separately created for each system in the Arduino IDE environment, with the systematic algorithms shown in Fig. 4 and 5 below:

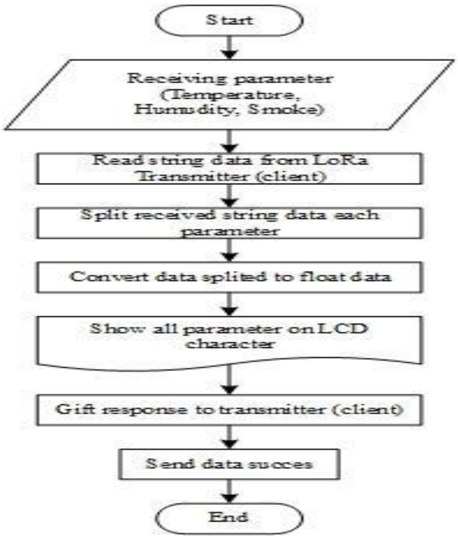

**Fig. 4.** Software algorithm for receiver node sensor (server)

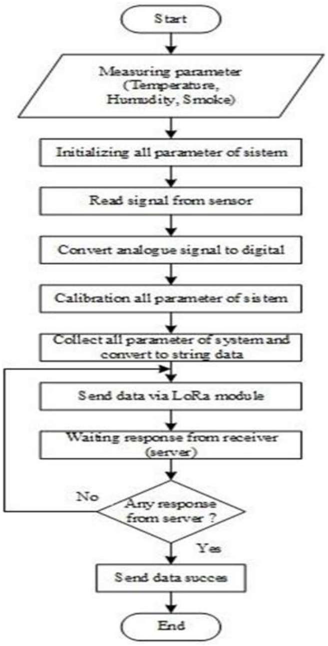

**Fig 5.** Software algorithm for transmitter node sensor (client)

According to Fig. 5, the operating system of the client began from the recording of all parameters, including temperature, humidity, and smoke from each sensor. These recordings had an analogue signal output, which needed to be digitally converted before occurring on the microcontroller. The sensor data in this analysis entering the microcontroller was calibrated to match the correct readings and obtained in a 1-string packet. After these activities, the results obtained were transmitted to the receiver node sensor, using the LoRa module. In this condition, the transmitter node sensor awaited feedback from the receiver, which indicated the successful delivery of a transmission to the server. Based on Fig. 4, the operation of the receiver node sensor system began with the retrieval of all parameters, including temperature, humidity, and smoke from the transmitter. The retrieved data were observed in a 1-string packet and divided into 3 parts. These were then displayed on the character LCD, with the server providing feedback to the client.

## 4. Results and Discussion

The analysis of the transmitter node sensor was carried out through several stages before the transmission of data to the server. This involved the readings of the air-based smoke concentrations and the temperature and humidity data using the SHT20 sensor. In this condition, the data obtained were calibrated by the microcontroller in international units, before being transmitted to the servers. The analytical results of the transmitter node sensor in Fig. 6.

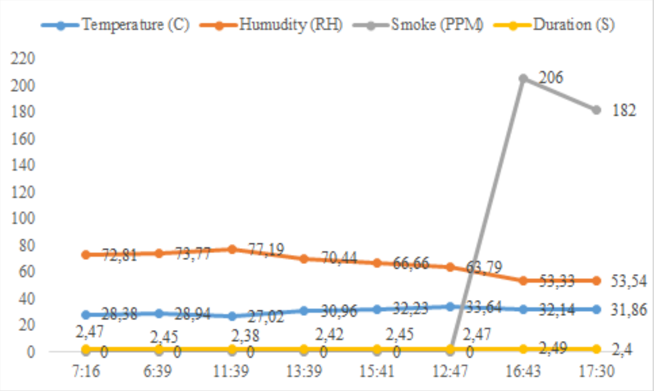

**Fig 6.** Testing of Transmitter Node Sensor (Client)

According to Fig 6, the fastest and longest duration for each delivery were 2.38 and 2.49 s, respectively. For the receiver node sensor (server), data was obtained from the client in a 1-string delivery package, which contained temperature, humidity, and smoke readings. These data were separated (parsed data) for display on the character LCD, with the server subsequently providing feedback to the transmitter as confirmation for successful information delivery. The analytical results of the receiver node sensor were shown in Fig. 7.

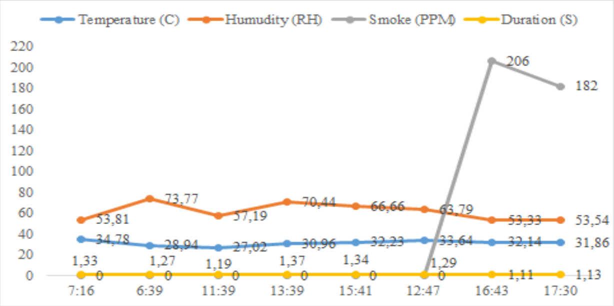

**Fig 7**. Testing of Receiver Node Sensor (Server)

Based on Fig 7, the fastest and longest duration for each data receipt before the provision of feedback to the client were 1.11 and 1.34 s, respectively. Based on Tables 1 and 2, the data transmitted to the server also did not experience losses. The next test emphasized the electricity consumption required by the transmitter and receiver node sensors (client and server), where 3 parameters were subsequently observed, namely voltage, current, and power. Fig. 8, 9, and 10 show the voltage, current, and power consumptions, respectively. Each test was also conducted through a sample and data lag time of 10 and 0.5 s, respectively.

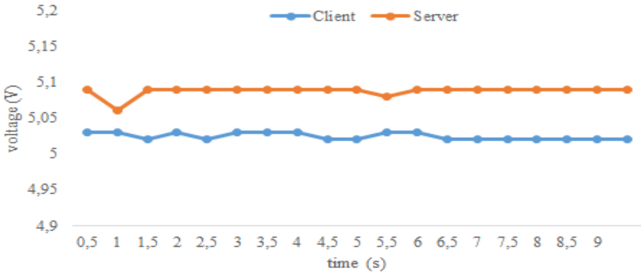

**Fig 8.** Comparison of voltage consumption between the client and server

According to Fig. 8, the lowest voltage drop at the server was observed at 1 s and 5.06 V, with relative stability found at 5.09 V. Meanwhile the voltage was relatively varied at the transmitter, between 5.02-5.03 V.

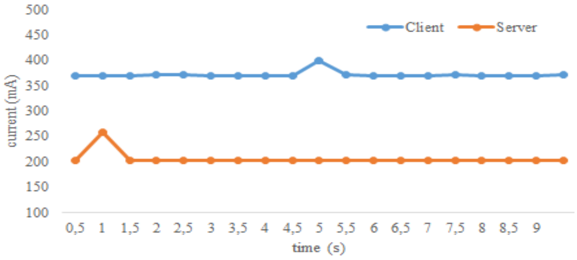

**Fig 9.** Comparison of current consumption between client and server

Fig. 9 shows the highest current consumption at the transmitter was observed at 5 s and 398.6 mA, which continuously fluctuated during subsequent analysis. However, the consumption was lower at the server and more relatively stable at 202 mA.

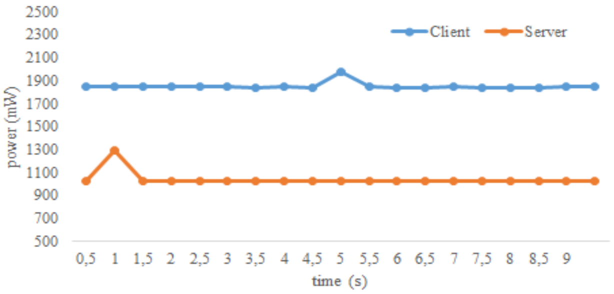

**Fig 10.** Comparison of power consumption between client and server

Based on Fig. 10, the highest power consumption at the transmitter node sensor (client) was found at 5 s and 1,980 mW, which continuously fluctuated during subsequent tests. Meanwhile, the power current consumption of the receiver node sensor (server) was lower and more relatively stable at 1,026 mW.

## 5. Conclusion

The test results on the sending side (client) require a sending time of 2.38 and 2.49 seconds and on the receiving side (server) the delay in receiving data is between 1.11 and 1.34 seconds. While for testing the comparison of power consumption on the sending side (client), a maximum power of 1980 mW is obtained at the 5th second and on the receiving side (server) the maximum power is 1298 in the 2nd second and is relatively stable at 1026 mW.

### Author contributions

**Jefri Lianda:** Conceptualization, Methodology, Software, Writing-Original draft, **Hikmatul Amri:** Data curation, Writing-Original draft preparation, Software, Validation, and **Aripriharta:** Visualization, Investigation, Writing-Reviewing and Editing.

### Conflicts of interest

The authors declare no conflicts of interest.

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