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Performance Analysis of Data Transmission Device In Wireless Sensor Network

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Abstract — *One of which study of wireless sensor networks is the quality of data transmission. The quality of data transmission on a wireless transmission system is greatly influenced by the characteristics of the data transmission method. Apart from that the sensor network topology will affect the mechanism of data transmission both data transmission between sensor points (sensor nodes) and sending data from sensor points to the central point (gateway node). So that the selection of sensor system devices and the ability to live (life time) is an interesting study for further investigation. Apart from that, the sensor placement scenario also affects the quality of data transmission.*

This research implements several sensor network scenarios on two methods of data transmission i.e. standard Radio Frequency (RF24) and WiFi (ESP8266). The quality of data transmission will be measured based on the time delay (delay transmission) and the use of power (power consumption) on each sensor device that is connected in a sensor network. The results of the implementation that have been carried out are the assembly and programming of Gateway devices and sensor nodes each of 1 (one) and 4 (four) pieces. Next install the devices into a temperature sensor network. The network will be created using a mesh topology (tree and star). The results of testing the device show that the device has been able to work well to measure and send data from the node to the gateway.

The results of power and time delay measurements from several pre-designed network scenarios show a large decrease in power at the gateway device compared to the sensor node. Meanwhile the transmission delay is greatly influenced by the data sending algorithm.

Keywords — *transmissions delay time, power usage, wireless sensor network.*

I. INTRODUCTION

With major developments in embedded systems and wireless communication technology, wireless sensor networks (WSN) have gained worldwide attention and have grown rapidly in the past decade. Wireless sensor networks are large scale networks with low cost, small size, low power and limited processing sensor nodes that are used in various types of environments. As a basic part of WSNs, the sensor node consists of several components: a microcontroller, transceiver, sensor, and power supply[1]. By combining these different components into a mini device, this sensor node becomes multi-functional and has been applied to various application scenarios: sports monitoring[2], environmental and ecological monitoring [3], vehicle monitoring [4]. Therefore very diverse scenarios require special requirements on WSN designs, which differentiate them from conventional networks. In general, WSNs are easy to achieve large scalability with various data transmission densities.

Meanwhile, specific sensor network protocols and algorithms with self-organizing capabilities are usually designed and implemented at sensor nodes. Overall sensor networks have low maintenance requirements and are tolerant of communication failures and topological changes that can be caused by sensor node function, sensor node mobility or node power loss. In addition, sensor nodes can also be used in harsh environments with self-managed networks to perform tasks assigned in an unmanned manner. However, further applications and limited potential cannot guarantee high performance in some scenarios especially for real-time applications. Short range of communication can cause energy waste and network inefficiency, because multi-hop communication is always needed to transport data between source nodes and sink node. Severe energy constraints also lead to worse observations: an increase in data processing capability using a powerful processor is not expected, because the energy will be drained very quickly and make the network useless in the given task. Limited energy also means that it is impossible to also maintain multi-hop communication operations for a long time.

Meanwhile, sensor nodes are expected to be widely used in many remote area applications, where frequent replacing or recharging batteries is uncomfortable. Therefore, energy-efficient sensor networks are needed to do work in such conditions. Taking energy consumption as the main consideration, while not reducing the performance of other networks, it is therefore desirable as a priority strategy in the design of wireless sensor networks today. It should be done due to the weaknesses of WSN such as limited process capabilities and low sensor node data. Meanwhile, Maulana et al have conducted testing on a sensor network consisting of three sensors[5]. Therefore an applicative research is needed to find out the performance of data transmission in several sensor network scenarios which are more comprehensive and involve many sensor nodes. The results of these tests will be compared with radio network standards [6] as information in sensor network planning.

Radio transmission methods on wireless sensor networks that use several transmission standards have different characteristics. The data transmission characteristics of each transmission method will affect the quality of data transmission. Therefore it is necessary to examine how the influence of the characteristics of the data transmission method affects the quality of data transmission and power usage in wireless sensor networks. This experiment was done by configuring scenario for temperature sensor network.

II. LITERATURE REVIEW

Vasilakos et al offer a power evaluation method on wireless sensor networks named Energy Management Systems for Wireless Sensor Networks (EMrise) [7]. The evaluation method consists of three parts, namely: simulation method, measurement and calibration methods and optimization algorithm. Meanwhile [8] uses the protocol in routing (routing protocol) to see the power efficiency of the sensor network. The simulation can improve the quality of data transmission and reduce power consumption on sensor devices. The same thing was done by [9] in order to maximize the use of sensor device power. Cui et al. used the test bed method in assessing the performance of sensor networks using different radio technologies (multi-radio) [10]. The development of this wireless sensor network will support implementation in other fields such as health and the environment.

A. Wireless Sensor Networks

Wireless Sensor Network is a sensor network topology consisting of several sensors both as a data producer (data originator) and a data supplier (data router)[11]. A group of sensors forms a sensor network and is connected to a wider communication network.

Data collected from sensor networks can also be collected or stored in a database. Database can be in the form of storage media or using a database network (cloud database)[12]. Utilization of a database on the internet network will provide easy access so it does not depend on distance and time. The characteristics of radio transmission standards are explained in the following table I.

TABLE I RADIO MODULE SPECIFICATIONS

No	Parameter	nRF24[13]	ESP8266[14]
1	Frequency of work	2.4 GHz	2.4 GHz
2	Data Transfer Speed	250 Kbps, 1 Mbps, 2 Mbps 11 Mbps	250 Kbps, 1 Mbps, 2 Mbps 11 Mbps
3	Current consumption	9 mA (Tx) 12 mA (Rx)	120 mA (Tx) 50 mA (Rx)
4	Output Power	- 6 dBm	- 10 dBm

B. Sensor Node

The development of wireless sensor network technology has been increasingly rapid at this time. Wireless sensor networks are basically a combination of sensor technology and communication technology. Sensor network technology was developed as a basis for a monitoring system. The monitoring system is divided into three main parts, namely: the server (master) device, the sensor and actuator device and the communication device.

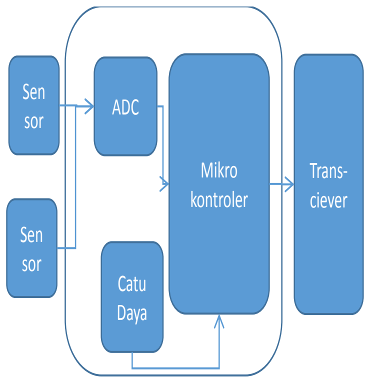

Fig.1 Node Sensor Configuration

The server device has the duty to control the entire process of monitoring and controlling the system. While the sensor and actuator devices are tasked with providing input data and output data for server devices. The communication device sent data between the server / master device and the sensor and actuator device. This basic concept applies generally in sensor network systems [15] as in Fig.1 which is wiring connection between the microcontroller and the transmitter. The microcontroller component functions as the main controller and sensor data processing [16]. While the transmitter component used to send data between sensors from different locations. The use of these components has become a norm in the implementation of sensor networks because of their reliability and ease.

III. RESEARCH METHOD

This research is a qualitative experimental study. Research activities can be described as follows:

a. Determination of the sensor network scenario model through literature study, in this case seeing the development of the latest sensor network scenario model through journal search. Search results are written in the introduction and theoretical basis of this research report.

b. Design and develop of sensor system devices in wireless sensor networks.

c. Implementation of sensor networks with various topological scenarios in a particular environment, in this case using the telecommunications laboratory room. The data transmission scenario is shown in

Fig.2. Star scenarios (data) data from each sensor node is sent directly to the gateway (master), while the Tree scenario (tree) data from sensor nodes is sent through other sensors as intermediaries. This scenario will be used when measuring and testing sensor networks to obtain data on the temperature sensor network performance.

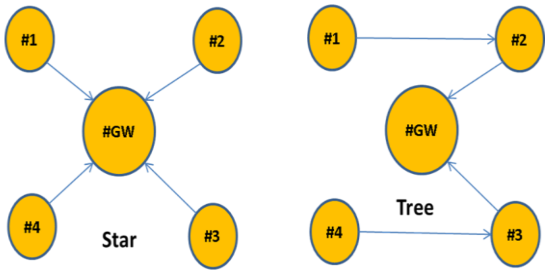

Fig.2 Sensor Network Scenarios

d. The algorithm used in general is presented in Fig.3 and Fig.4. Sensor data obtained from each sensor node will be sent to the server or gateway after time synchronization. It is intended that the delivery time and reception time can be recorded. Every data received is then stored and then analysed as measurement data. The algorithm is written in a program that is implemented on each device.

e. Field data measurement is done by calculating the delivery time and power usage on the sensor device from several test points. This activity will be carried out after all the devices are ready and the network scenario is implemented

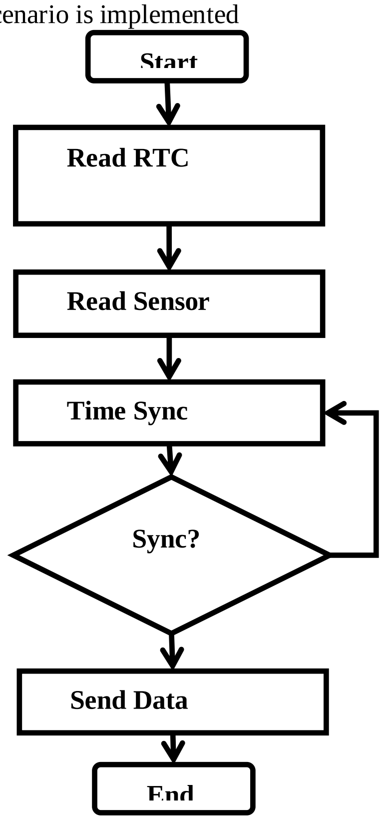

Fig.3 Main Program of Data Transmitted

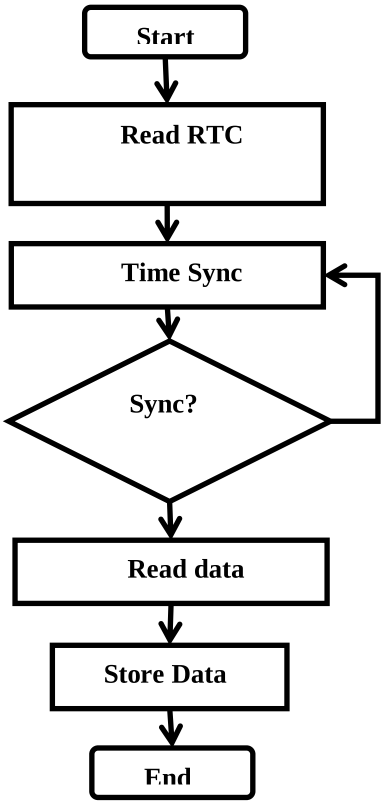

Fig.4 Main Program of Data Received

f. Statistical data regression is used to determine the level of power usage in several network scenarios. Statistical data testing will be performed after all data from the field measurements are complete and complete.

g. Statistical test results will be compared with the data transmission standard of each radio module specification.

h. Finally drawing conclusions from the results of research.

IV. RESEARCH RESULT AND DISCUSSCION

. The results of the temperature sensor network testing can be seen in Fig. 5. Each shows output data that was successfully measured and the results of power measurement and transmission delay on the temperature sensor network that has been tested.

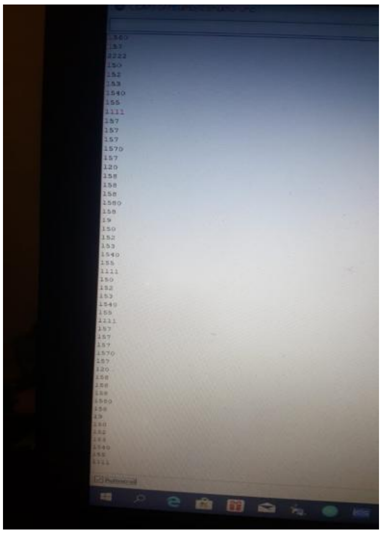

Fig.5 Output Data from Serial Monitor

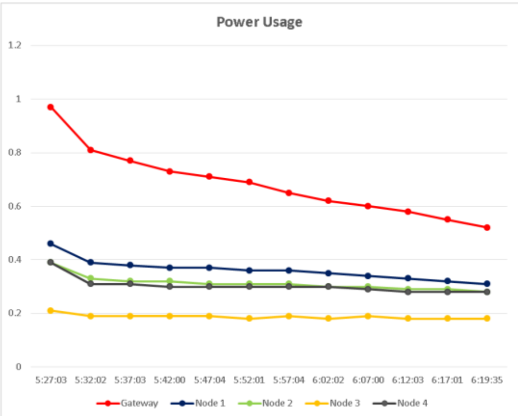

Fig.6 Power Output of Each Devices[17]

Based on Fig. 6, the results of this study indicate that power usage is on the gateway is higher than the power usage at the sensor node because the gateway is working harder than other sensor nodes to receive and store data delivery results.

At the gateway the power usage has a decrease interval of 0.06mA in 15 minutes early because the voltage on the battery is still high, while the sensor node has an interval decrease of 0.01mA / 5 minutes is constant until the end.

With a 9V alkaline battery the gateway is able to receive data from the sensor node ± 65 minutes until the last power used to receive data is 0.3mA. There is a difference from the results of power usage on nodes 1,2,3, and 4 because the INA219 sensor has a resolution measurement of 0.8mA so that measurements for the Arduino system power use are small becomes less precise.

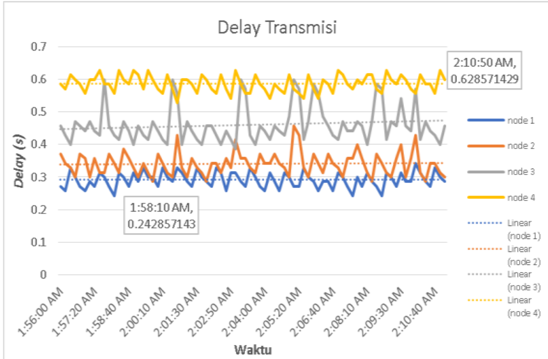

Fig.7 Delay Transmission on the Network [17]

Based on the results of the study in Fig. 7, it shows that testing is done to test the timeliness of sending data between each node. Test result shows that the time on the RTC sometimes varies for each node. By therefore a calibration is performed to obtain the same time for each node. It also shows that the system can send data in a manner simultaneous. In the sensor node section, the system is set at 1 second time intervals for each node for each data transmission. Delivery at each sensor node has a delay in receiving data (delay) the fastest is 0.242 seconds and the slowest is 0.628 seconds with a large data of 70 bytes.

Delay due to a lot of data that has a clash / collision so that the data is lost or overlap. The sensor node sends data for 2 hours, then the node. The gateway will receive and store data to obtain valid data. Data then it will be calculated and the average delay that occurs at node 1 is 0.292 seconds, node 2 is 0.341 seconds, node 3 is 0.457 seconds and node 4 is 0.587 seconds by sampling data on time intervals taken every 10 seconds 15 minutes of initial data.

IV. CONCLUSIONS

The results of the study can be concluded as follows:

The gateway device functions as a center for monitoring data on the results of temperature measurements, so that power usage is greatest. It can be understood that there are more devices connected in the system than sensor node devices.

Measurement of the average delay produces a value commensurate with the speed of transmission, however, because the process of sending data is done simultaneously causing an error sending data. This resulted in an increase in transmission delay.

Further research is needed to find out the performance of wireless sensor networks with different data sending algorithms and other network scenarios.

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