Prototype Development Of Distance Detection System Based On The Internet Of Things Using Esp 8266 Wifi Nodemcu Module

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Abstract. In the previous article about detecting train arrivals [4], we discussed the data transmission process which is the weakness of the system. This article discusses how to overcome these shortcomings. Distance detection systems need to be added to devices that are more powerful and faster in transmitting data. The prototype is built based on the development of the previous prototype. The initial product is a distance detector that has a motion sensor and a data transmission module in the form of Lora 400 MHz and a GSM module. Product development includes the addition of the NodeMCU WIFI module to existing devices. System development aims to: (1) Develop a distance detection system equipped with a WIFI module; and (2) Increase the data transmission speed of the distance detection system equipped with the WIFI NodeMCU module. The implementation method uses research and development techniques [3]. System development takes 6 months, with the stages of completion being system requirements analysis, hardware, and software design, system prototyping, and tool testing. Checklist data and delivery time are used as test data. Furthermore, the data is analyzed quantitatively to determine the achievement of results according to predetermined indicators. The device is equipped with a GPS module, a Lora-R02 receiver and transmitter module, and a Nodemcu ESP8266 module as a replacement for the 900A SIM module which transmits data faster. When the device is being tested, all the sensors of the tool work well at range of 125 meters (previously less than 100 meters). While the Lora module can react when the object has reached a distance of 300 meters. Data transmission previously using GSM modules took 10-13 seconds. After using the WIFI module, data transmission only takes 1-3 seconds.

Keywords: prototype, distance detection, wifi module

1. Background

Previously, the author has built a tool that detects the arrival distance of an object. The device is equipped with SIM900A and Lora 400mHz modules. These devices have difficulty communicating due to network constraints and obstruction of radio waves by buildings or objects that absorb radio waves. So that the data transmission signal cannot be sent quickly. If the data is not sent quickly, then the tool cannot function as it originally intended, which is to detect the arrival of an object quickly.

Various efforts need to be made, such as strengthening the signal and replacing the SIM module with the latest module that supports 4G technology. Another way to amplify the sending signal is to convert the GSM signal into a WIFI signal. Therefore, an additional module is needed in the form of a WIFI NODEMCU module which is expected to speed up signal transmission to the receiver.
In the next section, it will be discussed whether the performance of the NodeMCU module can speed up signal transmission so that the purpose of making the tool can be achieved.

2. Literature Review
The 900A SIM module is a GSM module that runs on a 2/3G network. This module is no longer suitable for use in Indonesia, which is already using the 4G network and is even starting to explore 5G networks. However, the presence of cellular signals in the Indonesian Region is still not evenly distributed.

Internet for Everything (English: Internet of Things, or IoT) is a concept that aims to expand the benefits of continuously connected internet connectivity. As for capabilities such as data sharing, remote control, and so on, including objects in the real world. [1]

Basically, the Internet of Things refers to objects that can be uniquely identified as virtual representations in an Internet-based structure. How the Internet of Things works is by utilizing a programming argument where each argument command produces an interaction between machines that are connected automatically without human intervention and at any distance.

Arduino is an open-source single-board microcontroller, derived from the Wiring platform, designed to facilitate the use of electronics in various fields. It is also an open hardware list aimed at anyone who wants to create interactive electronic prototypes based on flexible and easy-to-use hardware and software. The hardware has an Atmel AVR processor, and the software has its own programming language [2].

For flexibility, programs are loaded via the bootloader although there is an option to bypass the bootloader and use the downloader to program the microcontroller directly through the ISP port. One of the Arduino modules is Arduino GSM. Arduino GSM module allows devices to be controlled via cellular signal.

2.1 Modul NodeMCU ESP8266
This module is a development derivative module of the ESP8266 family of IoT (Internet of Things) platform modules, type ESP-12 [1]. The ESP8266 module can be learned from the previous article. Functionally, this module is almost similar to the Arduino module platform, but what makes it different is that it is devoted to "Connected to the Internet".

For now, there are 3 versions of the NodeMCU [1] module, including:

2.1.1 NodeMCU 0.9
This version (v0.9) is the first version to have 4 MB flash memory as its (System on Chip) SoC and the ESP8266 used is the ESP-12. The weakness of this version is in terms of the size of the wide board module, so if you want to make a prototype using this version of the module on the breadboard, the pins are used up only for this module.

2.1.2 NodeMCU 1.0
This version is a development of version 0.9. And in version 1.0, the ESP8266 used is the ESP-12E type which is considered more stable than the ESP-12. In addition, the size of the module board is reduced so that it is compatible with making project prototypes on the breadboard. And there are dedicated pins for SPI (Serial Peripheral Interface) and PWM (Pulse Width Modulation) communication which are not available in version 0.9.

2.1.3 NodeMCU 1.0 (unofficial board).
It is said to be an unofficial board because this module product was produced unofficially with the approval of the NodeMCU Official Developer.

In general, the NODEMCU based on the ESP8266 microprocessor has a very low current consumption of between 15 A and 400 mA which can be further reduced with deep sleep mode enabled to 0.5 A. The current consumption is then a factor of 70000 higher in deep sleep mode for Arduino Uno with 35 mA.
3. Development Method

The device is developed using the research and development method [3]. The tool development stage consists of: evaluating the previous device, integrating the tool with the WIFI NodeMCU module, software adjustment, testing data transmission, and completing the device. The test results will be compared with tools that previously used the 900A SIM Module.

Based on the evaluation of the previous device, there are delays in data transmission. Next, the suggestion is to use a supplement module that can accelerate data transmission. Using WIFI NodeMCU, the system is expected to improve the ability of the early warning system by increasing the ability to transmit the data. This system aims to be able to detect the arrival of objects at a certain distance from the receiver, then turn on the siren and the lights. Detection data is broadcast from the moving object continuously while it is running.

Prototyping this system requires several components: (i) Arduino devices in both devices, both receivers at the intersection point and in moving objects, (ii) Nodemcu wifi ESP8266 for internet communication between two devices via cellular signals, (iii) prototype system power supply devices, (iv) LCD and alarm, (v) Siren, and (vi) Lora Radio Module.

![Figure 1. Transmitter and Receiver prototype design](image)

As shown in Figure 1, all the modules will be assembled into a single unit. The finished tool will be connected to the computer. The computer will set the initial position of the coordinates to be determined by the GPS module. The computer program will arrange that when the object moves, the coordinates of the object are immediately sent from the transmitter to the receiver via the internet. Internet connection is established through a 4G-signal WIFI transmitter which will be captured by the NodeMCU. The process of sending data and sending time will be recorded by the computer. The delivery data will be used as evaluation material whether the tool is functionally an early detection of the arrival of objects or not.

The test includes black-box testing, which is testing the function of the arrival detection system of an object. Observations were made to perform functional tests on the prototype. The instrument used is a system functional test checklist. The instrument used in the validation is also a checklist or validation format. The data obtained were analysed descriptively.

4. Result and Discussion

The workings of the tool are: (i) The tool is first connected to WIFI, (ii) On one side of the tool, the motion sensor detects movement, (iii) Once an object is detected, the transmitter equipment will send data to the receiver, (iv) The Receiver will accept the signal, (vi) the device will turn on warning siren.

The test begins by determining the starting point of departure where the latitude is -7.744106, and the longitude is 110.373986. The object then moves. When crossing the reference point, the receiver device will ring a buzzer for a few seconds, then the indicator light will change from red to green when the simulated transmitter enters the specified distance. The reference distance is set at a radius of 125 meters from the receiver.
The distance ($S$) between transmitter and receiver is calculated using the following formula:

$$S = ACOS(COS(RAD(90 - L_1))COS(RAD(90 - L_2)) + SIN(RAD(90 - L_1))SIN(RAD(90 - L_2))$$

(1)

The test results are shown in Table 1. Observations show that in the functional test, the WIFI module, GPS module, 433MHz Lora module, LED, and Buzzer function as desired. At a distance of 307.4501867 meters, the WIFI module will transmit telemetry data to the receiver. In range 98.21 meters, the LED turning from red to green, indicating that position of the transmitter has reach 100 meters range. Then the Buzzer will beep for a few seconds.

Table 1. Some of the results of the tool test

| Time       | GPS Status | Coordinate of Transmitter | Coordinate of Receiver | Distance in meter | Status of IOT | Status of LED | Status of Buzzer |
|------------|------------|----------------------------|------------------------|-------------------|---------------|---------------|------------------|
| 05:33:14   | Lock       | -7.744106, 110,373986     | -7.746076, 110,372028  | 307.4501867       | Success       | Failed        | off              |
| 05:33:16   | Lock       | -7.744111, 110,373963     | -7.746076, 110,372028  | 305.3587329       | Success       | Failed        | off              |
| 05:33:16   | Lock       | -7.744111, 110,373963     | -7.746076, 110,372028  | 305.3587329       | Success       | Success       | off              |
| 05:35:09   | Lock       | -7.749209, 110,372344     | -7.746076, 110,372028  | 102.6004502       | Success       | Success       | off              |
| 05:35:10   | Lock       | -7.745245, 110,372233     | -7.746076, 110,372028  | 98.21151786       | Success       | Success       | on               |

In establishing a connection to the internet, the WIFI module maintains a stable and reliable speed when initiating IP addresses and data transmission protocols. This causes the process of sending data to be faster, both from the side of the receiving device and from the side of the sending device. The GSM module has difficulty initiating a bond to the internet due to poor signal problems so that the communication protocol and sending address are somewhat disrupted. The comparison of data transmission speed can be seen in Table 2.

Table 2. Comparison of Sensor Data Delivery Between GSM Module (GSM) and WIFI NodeMCU Module (MCU)

| Module | Time       | Initiation Time | Transmitting Time | Receiving Time | Total Time |
|--------|------------|-----------------|-------------------|---------------|------------|
| GSM    | 05:33:14   | 3 seconds       | 5 seconds         | 2 seconds     | 10 seconds |
| MCU    | 05:33:14   | 1 seconds       | 1 seconds         | 0.5 seconds   | 2.5 seconds|
| GSM    | 05:35:09   | 4 seconds       | 5 seconds         | 2.5 seconds   | 11.5 seconds|
| MCU    | 05:35:09   | 1 seconds       | 1 seconds         | 0.5 seconds   | 2.5 seconds|
| GSM    | 05:39:24   | 3 seconds       | 3 seconds         | 2 seconds     | 8 seconds  |
| MCU    | 05:39:24   | 1 seconds       | 1 seconds         | 0.5 seconds   | 2.5 seconds|
| GSM    | 05:51:10   | 4 seconds       | 6 seconds         | 2 seconds     | 12 seconds |
| MCU    | 05:51:10   | 1 seconds       | 1 seconds         | 0.5 seconds   | 2.5 seconds|
5. Summary

According to the results and discussion, it can be concluded that: (1) All devices work completely well, (2) Data is sent by WIFI module 3-4 times faster than sending using GSM Module, (3) Receiver receives a signal when Transmitter reaches distance less than 300 meters. The receiver then will activate the led, buzzer, and siren when the object reaches a range of 100 meters, and (4) the device of the distance detection system is successfully developed with some shortcomings.

References

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