The Application of Internet of Things System for Water Quality Monitoring

Tito Yuwono, Luqman Hakim, Irfan Ardi, Umar

***Abstract*—Currently, Internet becomes something very close to us. Internet is a media that connects machines, equipments, softwares and things. This system is called Internet of Things (IoT). Now, The applications of IoT are in the many areas, such as environment, transportation, supply chain management, etc. By IoT Technology, human will get the information easily. Also, IoT is given to alert or to alarm for reminding or important information. This paper will discuss the application of IoT in the environment area, specifically water quality monitoring. The first phase of this research is the pH monitoring. By knowing the pH of the water, we can determine whether the fluid is contaminated or not. pH content in the water will also determine the health of aquatic life. To build the IoT system for water quality monitoring, we use several components, such as pH sensor, microcontroller, RF modem, and servers. We use a BTA and Xbee PROas pH sensor and RF modem. From the testing, we conclude that the system works properly. The range of transmission with 2 repeaters for LOS outdoor is 3000m, while NLOS outdoor is 2050m.**

***Index Terms*—Internet of Things, Water, Quality, pH, monitoring.**

I. Introduction

Internet of Things (IoT) is a new form of communication between people with things and the things with things [1]. The main strength of IoT is high impact on the lives of people. IoT term has appeared a few years ago and then become advanced Wireless Technology [1]. IoT is the integration of the physical world with the virtual world via the internet [1]. IoT is a system connecting between physical objects and virtual objects, things, and devices through internet. The main objective of IoT is any time, any place, and any-one [2]. This makes things and people are very close.

The applications of IoT are in many areas. They are logistic and supply chain management, transportation, health care, and environment and disaster mitigation [1]. The application can be found in supply chain management area, supermarket chain management [3], logistic IoT Unified Information System [4], and Logistic Geographical Information Detection [5], and a Logistic Mobile Application [6]. In the transportation area, the IoT application includes road condition monitoring and alert system [7], license plate identification [8], remote performance monitoring system and simulation testing [9], and Transport vehicle monitoring system [10]. In the environment field, the applications of IoT are health monitoring and risk evaluation of earthen sites [11], smart heat and electricity management transportation. Similar research has been carried out by many researchers. The technology used for water quality monitoring is ZigBee techology[12-16].

The aim of this paper is to discuss the development and the deployment of the IoT in environment area, specially for water quality monitoring. The first step of this research, we start to develop IoT application for pH monitoring. Water is a vital necessity for life. The existence of fresh water is limited. This is caused by increasing population, urbanization and climate change. Before consumption, the water must be guaranteed without pollutants. By using the IoT, the information of water quality is known quickly by people or Person in Charge. By knowing the pH of the water, we can determine whether the fluid is contaminated or not. PH content in the water will determine the health of aquatic life.

The organization of the paper is as follows. Section 1 describes the introduction of IoT and it's application, Section 2 describes the design of circuit of the IoT system, Section 3 presents the result of research and discussion, and Section 4 gives conclusion of this paper.

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II. Circuit Desain of IoT System

A. Hardware Design

There are two main parts in this IoT design, hardware and software. Fig. 1 shows the block diagram of this system. The components of hardware include sensors, microcontrollers, data loggers, RF modems, and servers. The sensors used to measure the pH is BTA. Source voltage for this sensor is 5 volts DC. The output of BTA sensors is in the analog form. So it is necessary to convert from analog signal to digital signal. In this study, we use the internal ADC of microcontroller AT Mega 32. Fig. 2 and Fig. 3 show the BTA sensor (pHSensor) and the microcontroller AT Mega 32.

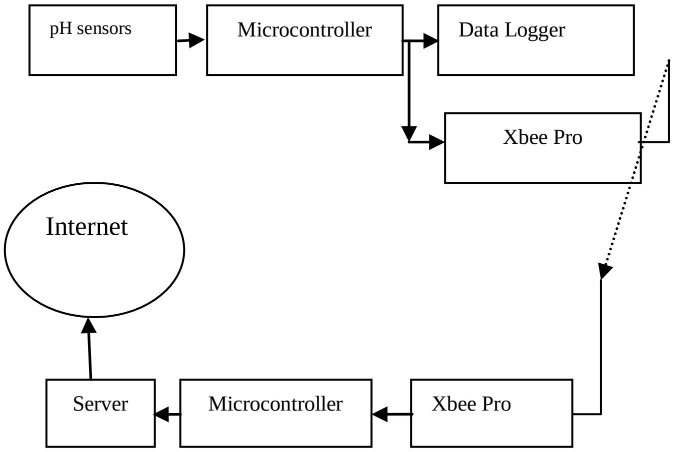

Fig. 1. Block Diagram of Hardware

Fig. 2. BTA sensor [17]

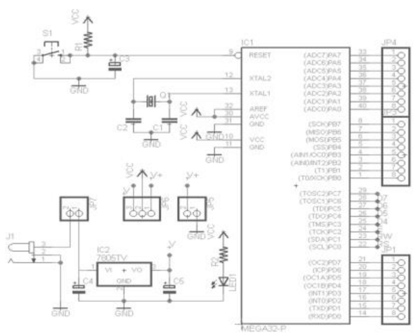

Fig. 3. Minimum system of Microcontroller [18]

In this design, we use Xbee-PRO as the main device for data transmission from field to server. Xbee-PRO is a module of Radio Frequency (RF) modem technology that has a 2.4GHz with low data rate (250 Kbps) and low cost. Xbee-PRO module has the capability of reliable data transfer with low power consumption. In this research, we use Xbee-PROS2B. Xbee-PROS2B capable transmitting the data up to 1,600 meters for outdoor (Line of Sight) and about 100 meters for indoor, with transmit power is 63mW (18dBm). The physical of Xbee-PRO is shown in Fig. 4, while Xbee-PRO specification and PIN assignment are presented in Table I and Table II. Fig. 5 shows the circuit of Xbee Pro.We use four Xbee-PRO as transmitter, repeater and receiver.

Fig. 4. Xbee PRO [19]

TABLE I
SPECIFICATION OF XBEE PRO[19]

Specification	Xbee Pro
RF Data Rate	250 Kbps
Indoor Urban Range	300 ft (92 m)
Outdoor Urban Range	1 mile (1600 m)
Transmit Power	63 mW (18dBm)
Reseiver Sensitivity (1%)	(-100 dBm)
Supply Voltage	2.8 – 3.4 VDC
Transmit Current	250 mA (@ 3.3 VDC)
Receive Current	55 mA (@ 3.3 VDC)
Power-Down Current	< 10 uA

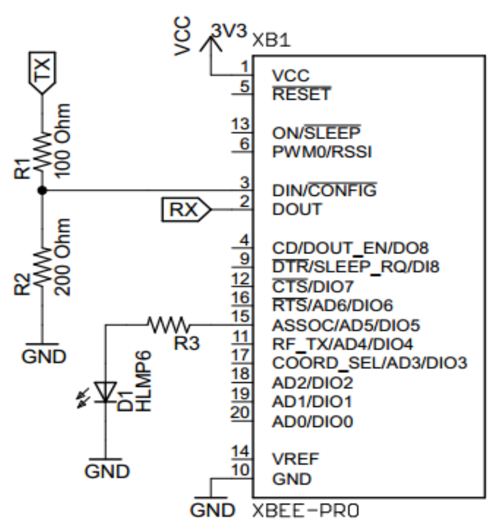

Fig. 5. The Circuit of Xbee Pro

TABLE II
PINASSIGNMENT OF XBEE PRO MODULES[19]

PIN	Name	Direction	Description
1	VCC	-	Power supply
2	DOUT	Output	UART Data Out
3	DIN / CONFIG	Input	UART Data In
4	DIO12	Both	Digital I/O 12
5	RESET	Both	Module Reset (reset pulse must be at le st 200 ns)
6	RSSI PWM / DI(10	Both	RX Signal Strength Indicator / Digital O
7	DIO11	Both	Digital I/O 11
8	[reserved]	-	Do not connect
9	DTR / SLEEP_R / DIO8	Both	Pin Sleep Control Line or Digital IO 8
10	GND	-	Ground
11	DIO4	Both	Digital I/O 4
12	CTS / DIO7	Both	Clear-to- Send Flow Control or Digital I/O 7. C S, if enabled, is an output.
13	ON / SLEEP	Output	Module Status Indicator or Digital I/O
14	VREF	Input	Not used for EM250. Used for progra able secondary processor. For compatibility with other XBEE mo ules, we recommend connecting this pin voltag reference if Analog sampling is desired. Otherwise, connect to GND.
15	Associate / DIO5	Both	Associated Indicator, Digital I/O 5
16	RTS / DIO6	Both	Request-to- Send Flow Control, Digital I/O 6. RTS if enabled, is an input.
17	AD3 / DIO3	Both	Analog Input 3 or Digital I/O 3
18	AD2 / DIO2	Both	Analog Input 2 or Digital I/O 2
19	AD1 / DIO1	Both	Analog Input 1 or Digital I/O 1
20	AD0 / DIO0	Both	Analog Input 0, Digital IO 0, or Comm ssioning Button

B. SoftwareDesign

In this design, we create software in four parts: transmitter section, repeater section, a receiver section and the section in the server interface. At the transmitter, we make software for pH readings, data storage, and transmission of data. At the repeater, we create software for data reception and transmission of data. At the receiver, we develop software to receive data and transfer data to the server. On the server, we make software for the user interface so it is easy to read by the operator. The source codes below are examples of software for pH sensors reading, data recording, and data transmission. The design of the website is made by using PHP, while the design of database is developed by using Mysql.

```
void sensor(void)
  {
      v_ph=((read_adc(0)/10.23)*0.04672);
      ph=(3.5-v_ph)/0.25;
      v_reff=read_adc(3);v_probe=read_adc(5);
    I=(v_reff-v_probe)/10000;
    R=v_probe/I;
          G=I/v_probe;
          buff_K=G*K_cell*correct;
          rho=1/buff_K;
}
```

```
void first(void)
{
sprint
 (buff,"Time\x09Date\x09pH\ \x0d\x0a");
for(p_data=0;p_data<39;p_data++)
   {
buffer[p_data]=buff[p_data];
if(p_data==38){copy_data_mmc();
   }
}
```

```
voidsend_ph(void)
{
sprintf(buffer_lcd,"%.2f",ph);
sprintf(xbee,"p%s",buffer_lcd);
puts(xbee);
delay_ms(10);
putchar(13);
delay_ms(10);
}
```

III. RESULT AND DISCUSSION

The aim of device testing is to analyze the accuracy and the consistency of the system. Fig. 6 shows the human interface of online monitoring. The result of testing is shown in Table III, Table IV, and Table V.

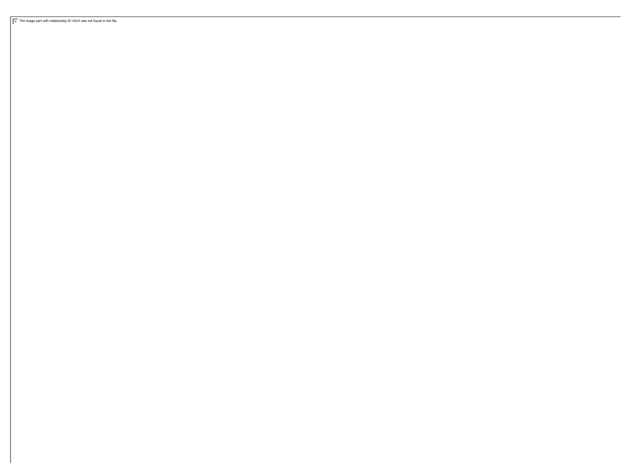

Fig. 6. The interface of online monitoring for water quality

TABLE III
DATA COMPARATION ON LCD AND WEBSITE

Measurement	LCD	WEBSITE
1	6,26	6,26
2	6,28	6,28
3	6,28	6,28
4	6,25	6,25
5	6,29	6,29
6	6,30	6,30
7	6,28	6,28
8	6,30	6,30
9	6,32	6,32
10	6,28	6,28

TABLE IV
RANGE OF TRANSMISSION (OUTDOOR - LOS) WITH 2 REPEATERS

Measurement	Distance T-R (meter)	Status
1	100	Successfull
2	200	Successfull
3	300	Successfull
4	400	Successfull
5	500	Successfull
6	1000	Successfull
7	1100	Successfull
8	1200	Successfull
9	1300	Successfull
10	1400	Successfull
11	1500	Successfull
12	1600	Successfull
13	1700	Successfull
14	2000	Successfull
15	2200	Successfull
16	2500	Successfull
17	2800	Successfull
18	3000	Successfull
19	3200	Fail
20	3400	Fail
21	3500	Fail
22	3700	Fail
23	3900	Fail
24	4000	Fail
25	4200	Fail

TABLE V
RANGE OF TRANSMISSION (OUTDOOR- NLOS) WITH 2 REPEATERS

Measurement	Distance T-R (meter)	Status
1	100	Successfull
2	200	Successfull
3	300	Successfull
4	400	Successfull
5	500	Successfull
6	1000	Successfull
7	1100	Successfull
8	1200	Successfull
9	1300	Successfull
10	1400	Successfull
11	1500	Successfull
12	1600	Successfull
13	1700	Successfull
14	1800	Successfull
15	1900	Successfull
16	2000	Successfull
17	2050	Successfull
18	2100	Fail

Table III shows comparison of data on LCD and Website. There is no difference in the pH data between the LCD and the Website. This indicates that all data transmitted properly. Table IV shows the range of transmission with LOS condition outdoor. By using two repeaters, the maximum distance is 3000m at outdoor. Table V shows the range of transmission with NLOS outdoor. The maximum distance of transmission is 2050 m.

IV. CONCLUSION

The design of Internet of Things (IoT) for water quality monitoring was discussed. Several devices were needed to build the system, such as sensors, microcontrollers, RF modems, and servers. From testing, it was shown that the developed system for water quality monitoring worked properly. The range of transmission for LOS outdoor is 3000m, while NLOS outdoor is 2050m. This research will be continued with the addition features of servers to support IoT like alert to Person in Charge (PIC) if the value of pH is abnormal (automatic notification).

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