Development of Monitoring System using the Internet of Things for Industrial Revolution 4.0

Siti Aisyah Binti Jaafar, Sukarnur Che Abdullah

***Abstract**: The fourth industrial revolution represents smarter systems, faster and more optimized system of artificial intelligence, which involves control systems and sensors networks. In this paper, the concept of the Internet of Things (IoT) was applied preliminarily to create the connection between machine and the user, using a sensor, a processor such as Raspberry Pi, and IoT platform application such as Blynk in the smartphone. The simple IR 4.0 prototype system and IoT apps were developed in order to create a connection between sensors and user through the internet consisting of a temperature and humidity sensor, which is DHT11 and a Raspberry Pi 3 Model B. The smartphone application would be developed through the Blynk application for this simple prototype system. The graphical user interface GUI was built within the Blynk app and link it to the sensor which is already connected to the Raspberry Pi. The analysis that was done upon the system is by varying the stimuli to the sensors, which is a hairdryer with three levels of heat and observe the relative change of the reading of temperature and percentage of humidity on the apps. Therefore, the preliminary result shows an increase in temperature as the heat level increases. On the other hand, the percentage of humidity becomes lower as the temperature goes higher. Based on the results and the analysis, it had shown that the IR 4.0 prototype system of IoT monitoring can connect between the sensor and the smartphone application with real-time monitoring through the internet.*

***Keywords** : Internet of things, Industrial revolution 4.0, ICT, Industrial process, Cyber*

I. INTRODUCTION

Throughout the history of mankind, we have experienced several industrial revolutions. Fig. 1 shows briefly how the industry evolves starting from the 18th century until today. In the 18th century, we experienced going from a manual processes such as steam and coal to machine production. The 19th century presented a mass production revolution [1]. A century later there was the 20th century revolution which was the start of the computerized and automated industrial revolution. The next step in the industrial revolution is the 4th one which is referred to as Industrial Revolution 4.0. The industrial revolution 4.0 involves integrating Cyber-Physical systems into manufacturing and process industries by implementing the Industrial IoT and create networks of connected devices and processes.

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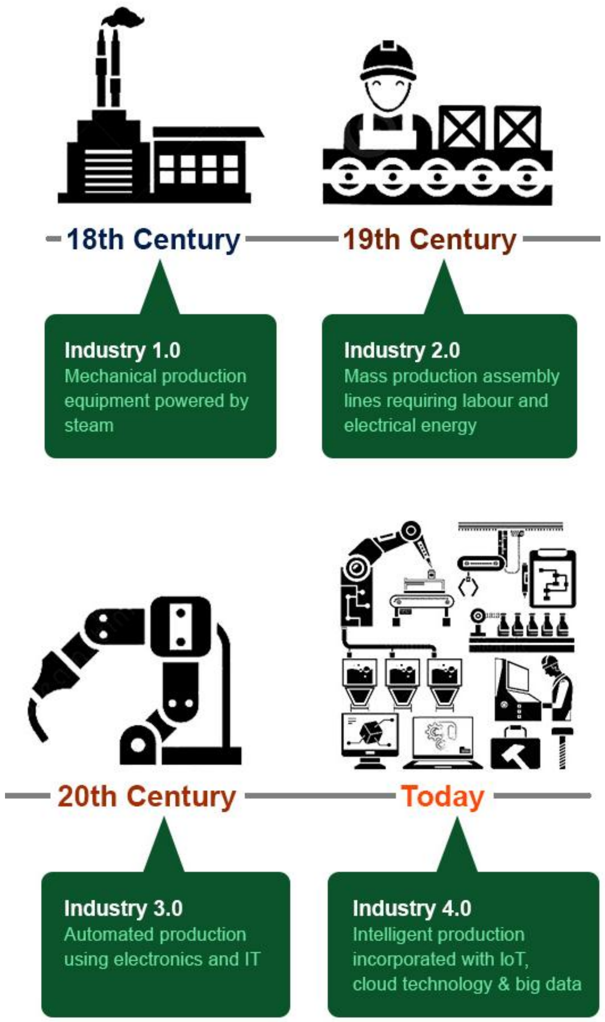

Fig. 1: The industrial revolution from industry 1.0 to industry 4.0 [1]

The Internet of Things (IoT) is the interaction between devices to sense the environment, process the information, and react to actual events accordingly with or without human intervention. It can be understood that the more the number of internet connected devices, the higher the efficiency of the monitoring and controlling of the devices. Furthermore, smart systems, like the smart sensor, are some of the industrial application for the IoT. With mobile communication in hand, mobile devices such as those in control systems of machinery, manufacturing equipment can be connected to the IoT to improve various aspects of the industry. The use of IoT sensors in manufacturing equipment enables condition-based maintenance alerts. Also, IoT not only enable the connection between local users, it also transmit information to other partners of original manufacturers which allows them to remotely monitors the growth of the client industrial company.

The concept of "Smart Sensor", as in Fig. 2 shows the technology of high-tech sensors, since these sensors communicate analog/digitally, a database memory and a network controller in the same platform, enabling pre-processing of the measured parameters, report data with understandable digital language and protocols, able to to decision makings in order to reach the system's needs [2].

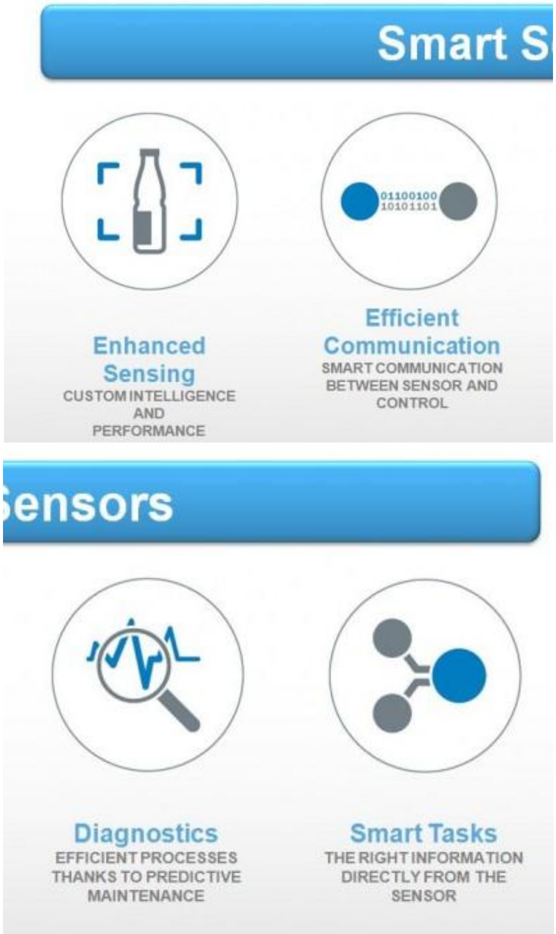

Fig. 2: Smart sensors characteristics and abilities [2]

In an industrial Smart System Network system, each field have different ways of communication. The various language of devices must be integrated in a facilitated gateway. Furthermore, it shall be interconnected with the cloud and the devices used to be embedded in the network system. Consequently, smart sensors and gateways, plays an important role in Industrial IoT (IIoT) applications. Thus, the aim of this study was to develop an application for smartphones and any portable device in order to monitor and manage the industrial activity.

The main objective of this paper is to create a connection between the user and the machine. It was done in this paper with the help of sensors, a processor such as Raspberry Pi and a phone application as the graphical user interface, GUI. To be more specific, the prototype system focused on developing a smartphone application of an IoT monitoring system that is responsible for monitoring the sensors used. The apps shall be easy to operate and clear to the user to see the information related to the monitoring live feed. In addition to that, the system should be able to monitor the sensors in real-time, with the minimum refresh time of 1 second. Despite being able to obtain real-time values, the system must be able to be monitored in a long range. Above it all, this prototype IoT monitoring system would be a huge benefit for various type of industrial use in the future.

In the middle of the growing digitalization world, the IR4.0 is going through its climax in innovativeness and integrity. On the other hand, the most significant changes can be seen in its improvement in process management and monitoring in an integrated way. However, specifically flexible design for the user. To stay in the competitive industrial environment, the companies need to up their standard of digitalization to the latest version. All of these implementation would give an impact to the competitiveness of the industry that applies the IoT digitalization into their processes and increase the competitiveness of the enterprise.

In order to achieve the objective of the paper, the Single Board Computer (SBC), Raspberry Pi 3 B and the integrated sensors are utilized as data acquisition system communicated with external platforms, which is the IoT monitoring apps for data management and storage. Temperature and humidity sensor which is DHT11 is used as the input of the values, attached to Raspberry Pi 3 B as the processor, along with an easy build application from Blynk IoT platform for IoT projects. The setup was then analyzed and tested to achieve the said objectives earlier in this paper.

II. LITERATURE REVIEW

Internet of Things (IoT) was known as one of the essential approaches towards industrial revolution 4.0. There is a large volume of published studies describing the use of IoT that also involves in explaining the importance of it for IR4.0 approach. A considerable amount of study has been published on using IoT system as a monitoring agent in its system. However, there are different methods and technical ways that past study had used to apply the IoT system compared to the one used in this paper.

A recent study was done in 2017 on the development of a wireless sensor for Malaysian forest monitoring and tracking system [3]. This study focused about wildlife extinction and creating a certain measure of control to prevent extinction of the organism in the forests. The hardware that was used in this study is the IR camera, GPS module, wireless XBEE module, Nano microcontroller and PIR sensor.

Other than that, a study was also done in 2017, on water quality monitoring with the internet of things (IoT). The paper suggests an Internet of Things (IoT) based system implementation by implementing the Radio Frequency Identification (RFID) [4] system, Wireless Sensor Network (WSN) [5] platform and Internet Protocol (IP) [6] based communication into a single platform for water quality monitoring (WQM) purpose. [7] The process was done by recording the water PH level using PH analog sensor. The system was then analyzed using the "energy analysis" and "communication read range analysis" to investigate the effectiveness of the proposed system.

There are multiple studies about IoT monitoring that has been conducted using Raspberry Pi as their hardware and software requirements. [8]

One of them is a study that has been published in 2015 about the development of IoT monitoring system for healthcare using Raspberry Pi as in Fig. 3 [9]. In this journal, it had stated that "The system was proposed to continuously monitor the Electrocardiogram (ECG) and other important and related parameter". The data obtained were then kept in a storage database and shall be displayed on the GUI which is only accessible by the authorized personal. The author mentioned that "The idea is familiar with other similar studies however they present a substantive and inexpensive method using Raspberry Pi". Therefore, the system uses GSM module to receive commands and an authorized personnel-only website as the Graphical User Interface (GUI).

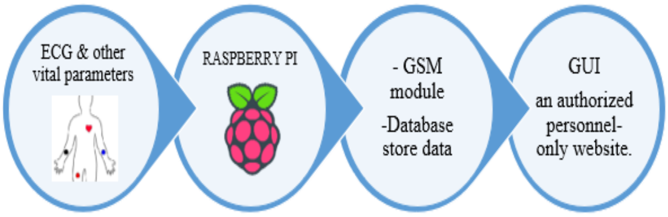

Fig. 3: The equipment involved in Healthcare IoT monitoring [9]

[10] Another study was done on "Industrial Automation using IoT with Raspberry Pi". The paper uses the concept of Raspberry Pi Industrial workstation and Industrial Automation using IoT platform. The system uses the raspberry pi as the main processor and the server. All of the coding is in Phyton language. The webpage is designed in HTML, jQuery, ajax and Flask as a framework for rendering the HTML template in python. The GUI for this paper is the webpage which is using Raspberry Pi as the server.

There are many implementations of IoT monitoring system in the technology nowadays. Not only in manufacturing industrial technology, but it is also important in maintaining the quality of other industries such as healthcare, plantations, education and more. Studies have found that with the introduction of the Internet of Things (IoT), our communication ability will not be restricted to only mobile devices. Rather, it will expand to all things with which we coexist. [11]

Many studies have discussed IoT-related services and platforms. However, there are only limited discussions about the IoT network. Different IoT systems are designed and implemented according to the IoT domain requirements, thus not taking into consideration issues of openness, scalability, interoperability, use case independence and simplicity [12].

Information can flow among IoT systems in a secure and privacy-preserving way, allowing for immediate and easy access through the technology that is used on daily basis such as computers and smartphones.

III. METHODOLOGY

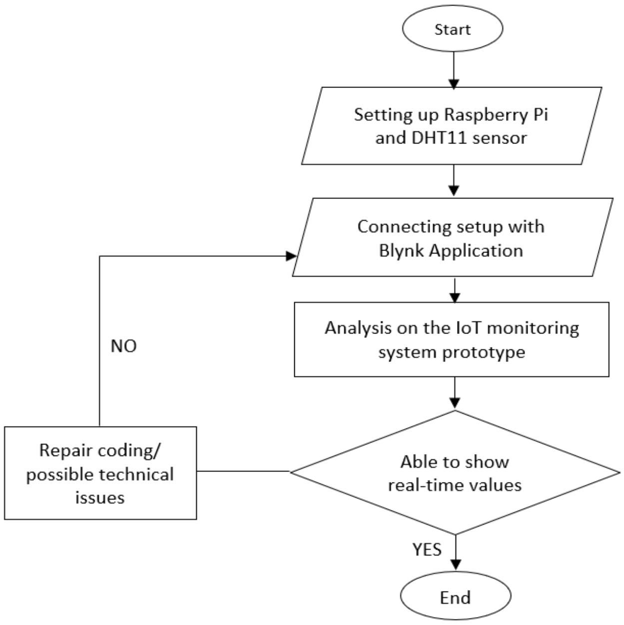

Fig. 4: Flow of the project methodology

A. Setting up Raspberry Pi and DHT11 sensor

The Application uses Raspberry Pi 3 B to operate DHT11 temperature and humidity sensor. See **Fig. 5**.

(a) (b)

Fig. 5: Raspberry pi 3 (a) and DHT11 (b) sensor

The Raspberry Pi was first needed to be set up with its operating system, which is Raspbian. Raspbian can be obtained from the Raspberry Pi website. The process of downloading can be done on a computer or any device where the Raspberry Pi's SD card could be read. After downloading the patch, the OS was installed in the Pi's SD card and was plugged in to the Pi's motherboard. There are several coding and commands involved in the installation such as in Fig. 6. The command line that is in Fig. 6 is as below:

```
Git clone
https://github.com/adafruit/Adafruit_Phyton_DHT.git
```

The command for installing the Adafruit library into Pi

Fig. 6: Command on installing Adafruit library into Pi.

Coding on sensors used (in this project will be DHT11) will be fetched from the Adafruit library. The value of the GPIO pin are as stated in the coding. However, the arrangements of the pins are not exact due to the usage of virtual pins which allows the user to change any GPIO to rename it into any virtual pin number in the coding. The completed setup for the prototype is as in Fig. 7 below.

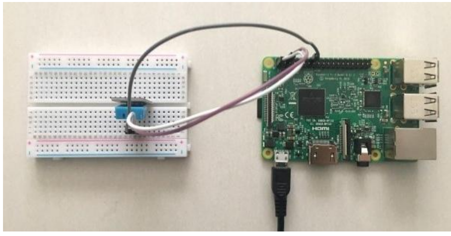

Fig. 7: Setup for Raspberry Pi 3 B and DHT11

The more specific setup image is as in Fig. 8 below:

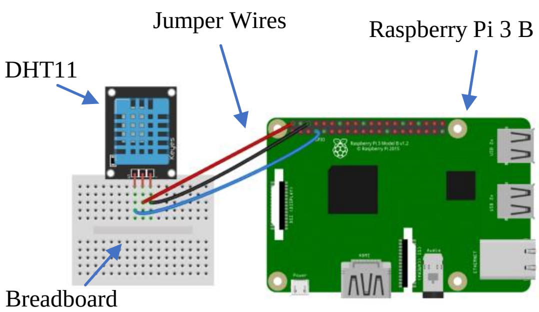

Fig. 8: Setup of DHT11 with Raspberry Pi

B. Connecting setup with Blynk Application

The layout of the apps created on Blynk IoT Platform is shown as in Fig. 9 below where the value of temperature and humidity can be observed when it is online at each of the gauge below:

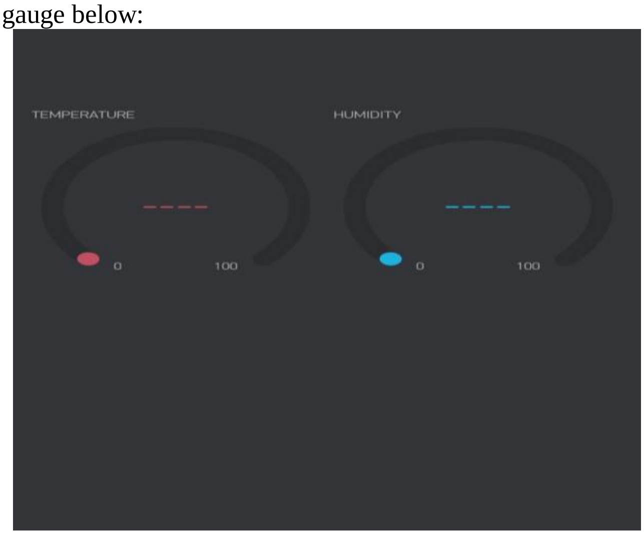

Fig. 9: Layout of IoT monitoring App GUI

C. Analysis on the IoT monitoring App GUI

The temperature and humidity sensor (DHT11) had been connected to the Raspberry Pi and the data taken is shown on the App. The setup was placed in an indoor air-conditioned surrounding for several minutes before these readings were taken as in below.

The reading shows that the temperature is 28℃ which is in red color and the humidity of the air is at 65% which is in blue color. See Fig. 10.

Fig. 10: Reading of Temperature and Humidity on the monitoring App

Some tests were done on the system by variating the stimulation on the sensor and observing the readings shown on the apps. The purpose of this test is to prove the ability to connect between phone application and sensors. Besides that, it is also to confirm that the readings of the values are shown in real-time, responding to the stimuli on the sensors. For the stimuli, a hairdryer was used with three different heat levels. The test was tabulated as in Table I.

Table I. Table of heat level test on humidity and temperature sensor readings on apps.

Hairdryer's heat level	Temperature /°C	Humidity /%
0	28	62
1	40	59
2	52	51
3	60	47

IV. RESULTS AND DISCUSSIONS

From the test, it can be observed that the temperature and humidity changes with the increase in heat level of the hairdryer. This has proven that the sensor is functioning well in communicating with the apps. It also shows that the system was created successfully. The value of the readings was rounded off and calculated in the apps itself.

During the creation of the system, there were several issues such as the failure to run the command. These are mainly due to misplacing of locations of the libraries after installing them. Therefore, the application and the Pi could not communicate with each other. Therefore, the devices would not be connected without correcting the mistakes in the coding.

For improvements in this study, the IoT monitoring apps shall be developed using a more novel way such as developing own application that allows the user to fully utilized the apps without having to pay for some package plans from the developer; which in this case in Blynk. As an upgrade to the system, more sensors shall be utilized in the monitoring system to allow it to be applied in the automation industry machines. Moreover, other than showing real-time values on the apps there also shall be a user interface that allows the user to give commands to the machine such as creating emergency buttons that connects to the emergency power button of the machine.

V. CONCLUSION

From the outcome of this project, it is shown that the sensors can communicate with the user through the Raspberry Pi and the phone application that acts as the GUI. The sensors are operating well when it is connected to the Raspberry Pi, along with the connection to the apps. This shows that the coding for the system is correct that the apps can read the values given by the sensors. The GUI of the apps is seemingly easy to operate an application, that gives an ease to the user as the value of the output is shown clearly on the main screen. The sensors that were connected to the Raspberry Pi 3 B can be monitored by the smartphone app in real time when the value of temperature and humidity changes abruptly when different heat levels were applied on the sensor. Therefore, the prototype system of IoT monitoring had been successful in proving its efficiency in a simple setup. The prototype was able to show its ability to sense the reading from the sensor and project it on the GUI on the Apps. The smartphone Apps manages to be developed with a simple and clean interface design. This shows that the objectives of the paper were achieved at the end of the paper with sufficient testing and analyzing stages. Further upgrading of the prototype shall be applied for future implementations. This is to suit the industrial needs for the preparation towards Industrial Revolution 4.0 with the utilization of Internet of Things.

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S. A. Jaafar was born in Johor, Malaysia on 20th of October 1995. She obtained her Bachelor Degree (Hons) in Mechanical Engineering from Universiti of Teknologi MARA (UiTM), Malaysia in 2018. She is currently pursuing her Master (Science) in Mechanical Engineering in IoT and Industrial Revolution 4.0 research area.

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