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Application Of Internet Of Things

(Applied to Wheelchair for Monitoring and Security Purpose)

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***Abstract*— This paper compares the components to be used with Internet of Things systems. The components are included of sensors, network connectivity, cloud computing, and display. After comparison, the selected components were applied to a smart wheelchair system, allow it to display its location and temperature on the internet. It uses cellular and Wi-Fi technologies to send data of its location and temperature to the network, and uses NETPIE as a middleware to upload and display its data to a web page.**

***Index Terms*—Internet of Things, monitoring, wheelchair, cellular, Wi-Fi.**

I. Introduction

All With the increasing accessibility to the internet, more people have been finding ways to utilize Internet of Things in their respective applications, resulting in gradually increase of Internet of Things research [1]. Some companies start to combine Internet of Things function to their product. For instance, there is a wheelchair that had been developed with some additional functions so they can promote it as new technology and attract more customers [2]. A number of researchers also conduct similar research to this paper such as wheelchair with social media update [3] or patient location monitoring [4], health monitoring system [5] or even improving for security purpose [6]. However there isn't a single paper that writes deepen in sensor selection method, network accessing technology, selection of middleware, and UI design which are all important factors for this topic. Thus, this paper will be mainly focused on selection method for each component used in Internet of Things system applied to electric wheelchair in Fig. 1.

Fig. 1. An electric wheelchair used in experiment.

II. Methodology

The components used in Internet of Things system are needed to be selected by consideration from many factors. Therefore, the system can work steadily. There are 4 things to be considered in creating Internet of Things system.

A. Sensors Selection

In order to select the most suitable sensor, the first step would be to consider what data will be received, how the data will be used, and the precision required for the data. In practical use, each sensor has their own interrupt timers which are overlapping each other. So, we need to select the sensors that can work all together without interrupting each other. The examples for each category are as following.

- Received data: What data do you want to receive e.g. temperature, humidity, brightness, distance, etc. Type of data output from sensors i.e. analog or digital should also be considered.

- Usage of data: If data is constantly processing in microsecond or millisecond, the sensor should be able to work continuously in desirable rate and not interrupt the other sensors. Mostly, it is up to data changing rate.

- Precision and accuracy: The sensor is selected primary by data resolution. The sensor that is too precise will be more costly and requires more storage and computational power, which are scarce on mobile and embedded systems. On the other hand, sensor that is not precise enough will lead to erroneous results.

The most important thing in selection of sensors is their timers interrupt. Every data should be processed and send to network in the same rate. Therefore, the data will be sending without any problem.

B. Connectivity technologies

Selecting type of networking technology will lead to another consideration for other components. Power consumption, area of operation, type of data and data rate will be considered. These two selected networks are the most popular at present.

1) *Wi-Fi (IEEE 802.11)*

Wi-Fi is a type of wireless communication that sends and receives data over multiple frequencies of electromagnetic wave between radio waves and microwave. Wi-Fi is defined by IEEE 802.11 standards.

Wi-Fi is one of the most popular type of wireless networking. Billions of Wi-Fi devices are in households and industries. The most common mode which Wi-Fi operates on is the infrastructure mode, which devices connect to a single access point. Devices can communicate within the same network or to another network through the access point as Fig. 2.

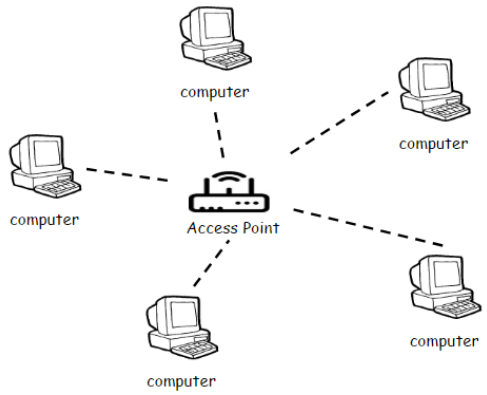

Fig. 2. Infrastructure mode.

Another mode of Wi-Fi connection is the ad-hoc mode. Ad-hoc mode, also known as peer-to-peer mode, does not require a centralized access point. Instead, devices communicate directly between devices within the network as Fig. 3.

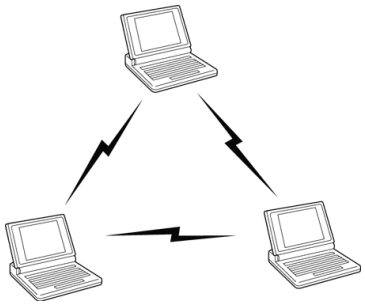

Fig. 3. Ad-hoc mode.

2) *Cellular (GSM/GPRS/EDGE (2G))*

Cellular networks have virtually unlimited range and, as such, suitable for devices that are designed to be used in wide area.

GSM is a second-generation (2G) standard employing time-division multiple-access (TDMA) spectrum-sharing. The process start with changing sound signal to digital signal and compressing data. Then sending compressed data to user. Users always use the same frequency signal. GSM usually use frequency of 900 MHz and 1800 MHz.

TABLE I. COMPARISON BETWEEN GSM AND WI-FI [7]

Market Name	**---**	**Wi-Fi**
standard	***GSM/GPRS CDMA/1xRTT***	***802.11b***
Application Focus	Wide Area Voice & Data	Web, Email, Video
System Resources	16MB+	1MB+
Battery Life (days)	1-7	.5-5
Network Size	1	32
Maximum Data Rate (KB/s)	64-128+	11,000+
Transmission Range (meters)	1,000+	1-100
Success Metrics	Reach, Quality	Speed, Flexibility

Table I show the summary of advantages and disadvantages in both technologies. Cellular network covers considerably larger area and requires less power. Wi-Fi, on the other hand, covers smaller area but come with large advantage in data rate and covers more type of data.

C. Cloud computing selection

Cloud Computing is combinations of many servers. It separates computing layer from storage layer.

1) Computing layer

Computing layer is combination of servers. Even if one server goes down, it has no effect to user because it will automatically change server for user. Normally, website or virtual server is working on this layer. System will share resource like CPU, Memory equally to user. User resource is separate from other user. Furthermore, it has firewall to protect our resource from others.

2) Storage layer

Storage layer is combination of SAN (Storage area network) that very stable and fast. It can change to another SAN immediately if main SAN is not working. At least 2 SANs usually being used so that they will have the replicated data all the time. All of user data will be kept in this layer. This system must have fast internet connection speed to connect between two layers in order to send and receive data all the time.

Nowadays the three cloud services that are usually used are as following. Selecting type of networking technology will lead to another consideration for other components.

a) Infrastructure as a Service (IaaS): Infrastructure provider provides infrastructure and storage to support softwares and applications. Dropbox, Google Drive for business, Amazon Web Services are some examples of IaaS services.

b) Platform as a Service (PaaS): Platform service provider provides developers tools required for software and application development such as database server, web application, etc. User of this service doesn't need to configure it themselves.

c) *Software as a Service (SaaS):* Softwares and applications are provided on a subscription basis, such as Microsoft Office 365.

Cloud used in Internet of Things system is PaaS because the cloud providers support all users with software. So, we don't have to care about protocol. PaaS type cloud, e.g NETPIE or Firebase is working like MQTT Protocol in Fig. 4.

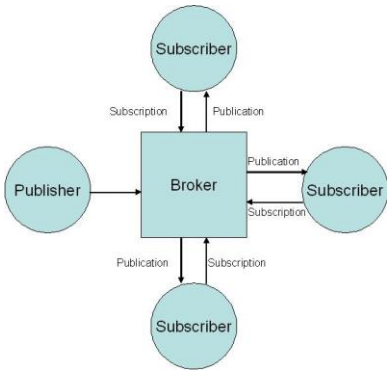

Fig. 4. MQTT Protocol process.

Cloud PaaS is Broker for communicate between devices. It can receive data from publisher by internet. In this case publishers are devices like sensors and microprocessors. It can send data to subscribers. Subscribers are display devices. Platform provider has provided the information about how to use it with its example code and libraries. Thus using PaaS cloud platform is not too difficult for inexperienced user.

D. User Interface Design

Similar to selection of sensors, two things to be considered before design a user interface are what do you want to be displayed, and how to be displayed. The data you want to be displayed may be the data directly received from the sensors or the information obtained through computations. A list of these should be made to assist with the designing procedure. Another thing to consider is how the data should be displayed. For example, a smartphone application may be developed for smartphone user, while a website can serve both personal computer users and smartphone users.

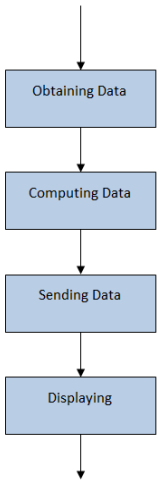

Fig. 5. Flowchart of received data.

III. IMPLEMENTATION

A. Sender

- Wi-Fi/Cellular/GPS

In this part, from our searching for many kind of expansions and antennas, we found LinkIt ONE. It is a microcontroller that meets few of our requirements in one single board. It has Wi-Fi, cellular accessibility and it has GPS module in itself. Moreover, if we want to develop it furthermore, it is possible to do. If we want to try more experiment about connectivity, the board also has Bluetooth accessibility and if we want to try to make data logger, it is also possible to do by saving data to card in SD card slot.

Fig. 6. LinkIt ONE.

- Temperature Sensor

DHT11 temperature and humidity sensor is selected due to its low price, availability, and its compatibility with LinkIt ONE.

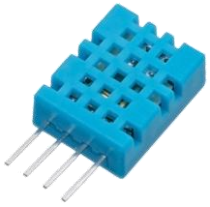

Fig. 7. DHT11.

- Software

LinkIt ONE has libraries to connect with Wi-Fi and connect to PaaS cloud for preparing to sending data. After that, LinkIt One receive position and temperature data from user and send data to cloud. We use this data to display on Website. Meanwhile, it's checking position of user. If user going out of area that we set. It will notify family, relative or the caretaker by cellular network.

B. Receiver

In receiver part, there only have software. We choose to use HTML5 altogether with CSS as main language for the webpage. So the web page can display on many device like Computer and smartphone for display data that receive from cloud. It's showing both position and temperature from user.

C. Cloud

In cloud computing, we use NETPIE platform. NETPIE is PaaS cloud. NETPIE platform has many libraries and support many devices e.g ESP8266, Arduino, Raspberry Pi. It makes this platform easy to work with Internet of Things.

IV. Test Results

A. Displaying data send by Wi-Fi network on webpage

- Able to show the actual wheelchair's location in real-time. The board's GPS sensor has same error rate as normal GPS module.

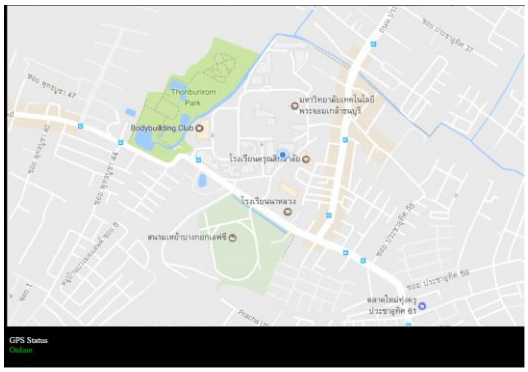

Fig. 8. Webpage showing wheelchair's location.

- Able to show temperature with exact value from environment temperature in real-time.

Fig. 9. Webpage showing temperature.

B. Alert notification through Cellular network

From experiment, we set it so that notification system will be activated after detected the temperature is higher than 30 degrees Celsius. The wheelchair able to send notification with temperature and location data in form of SMS as soon as sensors detected that the temperature is higher than the threshold.

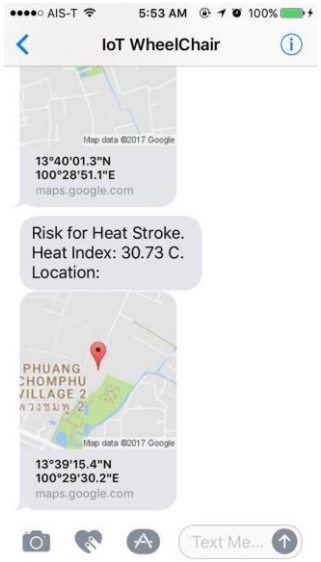

Fig. 10. SMS alert notification.

C. Result analysis

The major factors for Internet of Things applications is about will the devices be able to communicate to each other or not. Their data can be send in the same rate or not, are they interrupting each other or not. If it is, then the problem is occurred and data error will come after that. As in this experiment, LinkIt ONE processing board couldn't process the data in microsecond level, and by NETPIE Cloud data limitation, the data can't be send continuously with frequency more than once per 3 seconds so the data's delay is unavoidable to be occurred. If the data is being send in higher frequency than mentioned, the board will be disconnected from NETPIE network and need some time to reconnecting, thus the data is discontinued.

V. Conclusions

In application of Internet of Things, first thing to execute is selection of sensors. The wheelchair uses DHT11 in temperature measurement because it has high accuracy that is essential in sending continuous data. In connectivity section, the board use Wi-Fi access for sending amount of monitoring data continuously, and use cellular access to apply SMS system. In cloud computing section, we select the PaaS type cloud from NETPIE because it support many IoT devices and has libraries that are easy to apply. Lastly, in display section, we create HTML5 webpage showing location and temperature so the

data can be watched from any devices, e.g. mobiles or computers.

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