A Smart Home Automation via Facebook Chatbot and Raspberry Pi

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***Abstract*— This work demonstrates an experimental implementation of smart home automation using Raspberry Pi, Facebook chatbot and Google Maps APIs. The development process was shortened and additional functionalities like estimated time of arrival, interactive chat and secure communications were incorporated. More importantly, this home automation system is extendable and scalable without needing an architectural redesign and other complications.**

Keywords - Raspberry Pi; Home Automation; Google Maps APIs; Facebook; chatbot; messenger; Cloud computing

I. INTRODUCTION

In general, any traditional house comprises of structure and system. Under "structure" category, foundation, frames, roof truss and flooring are among the most significant components for civil engineers to design, build and construct according to the design by an architect to fulfil appearance and functionalities of the house owners. On the other hand, under "system" category, plumbing and electrical engineers need to work on hot/cold water and electrical systems respectively. These two systems can be perceived as fundamental elements for any house. As time progresses, it is apparent that newer system like network connectivity of any sorts are becoming the norm or one of the necessities in newer generation of houses. Telephone and cable TV network system were among initial attempts to establish connectivity of some sorts in any houses. Those technologies evolved into ADSL (Asymmetric Digital Subscriber Line) and DOCSIS (Data Over Cable Service Interface Specification) respectively, which were initially aimed at resolving and providing Internet connection that supersedes their initial voice and media solutions.

The demand for higher-speed network rises unquestionably in response to an emergence of higher-speed cellular technology that is in a timely manner with the concept of reinventing the phone proposed by Apple Inc. in 2007, which subsequently resulted in the original iPhone that has presumably set the era of smart phones [1].

Fiber-to-the-Home (FTTH) has recently become the norm for new generation houses and has overcome the boundary for high-speed data network. Wireless sensor networks (WSN), which was originally invented for sensory data acquisition and distribution [2]. There are a number of network protocols for Building and home automation but one of the most widely are IP-based [3]. Jim Chase from Texus Instrument Inc. explained that IoT are not only things that were equipped with Internet connectivity but also a communication across multitude of devices to allow further and deeper control of the system surrounded by them. More importantly, the current trend of IoT predicts that there will be 50 Billion connected devices by 2020 comparing with 5 Billion ones to date [4].

According to Madakam et. al., Internet of Things (IoT) is the term coined in 1999 by Kevin Ashton, the British Executive Director of MIT's Auto-ID labs after he came up with an idea of RFID inventory to resolve supply chain problems of missing items [5]. Ashton is also referred to as a "Father of Internet of Things" who finally makes IoT an easily accessible term to both tech-savvy and non tech-savvy people [6]. IoT is, particularly, a system that has the ability of end terminals to transfer data into and out of the network for monitoring based on WSNs that work as a nervous system with event-based actions through good use of big data and cloud computing across the Internet to help justify those actions [7]. Home and Building automation can be implemented with variety of network protocols to increase security including IP-based protocols [8].

Automation is usually refer to an automated system that works on its own with minimum human intervention as a part of manufacturing process. On the other hand, similar concept applies for home automation with Internet of Things as its key enabling technology to ensure connectivity and control over household appliances. Silfra technologies presents the implementation of home automation to include motion sensor, remote control, door control, environmental monitoring, Set-top box, Heating, Ventilation and Air-conditioning Control (HVAC), Light control, window control, temperature monitoring and security & alarm [9]. According to Gunge and Yalagi, there are several components to be referred to as home automation as illustrated in Fig. 1 [10].

According to Ms. Kendall Walters, a digital marketing specialist at Hootsuite, Facebook is still ranked no.1 social media with 1.65 billion monthly active users and 1.09 billion daily active users, on average [11]. It would, therefore, be in favor of Facebook users to enhance their experience further by enabling home automation feature.

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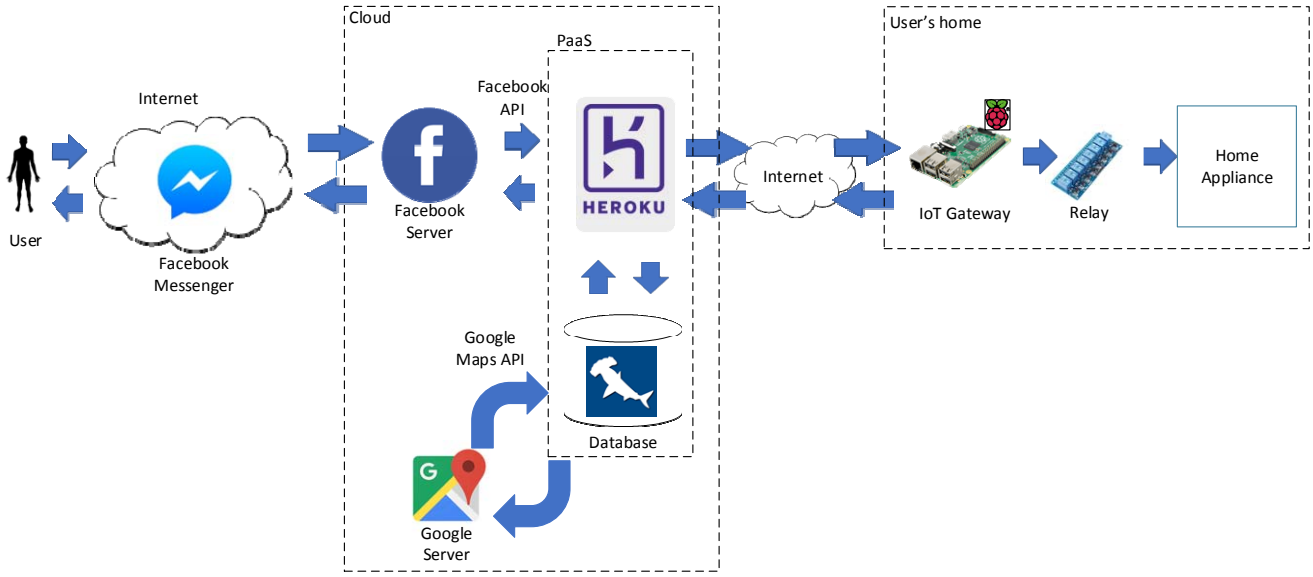


Figure 1. System Architecture

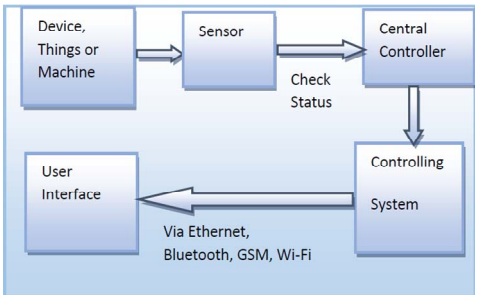


Figure 2. Block diagram of a generic smart home automation [10]

To continue further enhancement of an existing in-house home automation platform, the framework named "PiFrame" that was initially developed at Vincent Mary School of Engineering is used as the framework was initially developed under the concept of utilizing an off-the-shelf affordable system like Raspberry Pi with support of full-stack web application development [12]. The part of cloud computing based on Raspberry Pi as further improvement on the original AU-PiCC (Raspberry Pi customer counter) covered in [13] and proposed in [14] is partially experimented in here.

The remaining part of this paper consists of the following sections: section 2 Smart home automation system; section 3 Architecture & Design; section 4 Implementation and deployment; section 5 Advantages and Disadvantage of system; and section 6 Conclusion.

II. SMART HOME AUTOMATION SYSTEM

The design of smart home automation system in this project was targeted at its simplicity, non-intrusiveness and user-friendliness. Any typical user would prefer to use a software with familiar User Interface (UI), send simple instructions/commands seamlessly and finally get expected outcomes.

With this intention in mind, Chatbot (Chat robot or sometimes merely bot) was selected for this purpose to help provide nice UI and create good feelings in resemblance of human interaction. Chatbot is one of the technologies that simulates human conversation by providing feedbacks /echoes and can interact very intelligently thanks to machine learning and artificial intelligence (AI) [15]. Developing our own chatbot application can take times and may become pointless to reinvent the wheel in this cloud-computing era. We would rather take advantage of a widely popular platform with billions of users around the globe like Facebook to shorten development time and enrich users' experiences for their smart home automation. Facebook's official launch of its chatbot API (Application Program Interface) for Messenger is officially named "Messenger Platform" will allow us to create a simple yet versatile chatbot for home automation. Even though chatbot is initially aimed at business purpose for automated customer service, chatbot can provide richer features than Private Automated Branch Exchange (PABX). A Messenger bot can do things like sending links, showing images and providing detailed descriptions of items, services or features. Similar functionalities of Facebook messenger is planned for the web version too, where Live Chat buttons will redirect Web users to Messenger and either a chatbot or real human (or a combination of the two) can take over the ongoing conversation. It's also possible to configure Live Chat/Messenger to send automated responses to some questions and prompt a real human to respond to you when answers cannot be provided by a chatbot.

The objective of this project is to develop the chatbot in Facebook to serve as a point of contact to control the home appliances over the Internet. Additional features like a calculation of duration of user's current location to his/her home by using Google Maps APIs. In this context,

Raspberry Pi is the key component to operate as the IoT gateway at user's home.

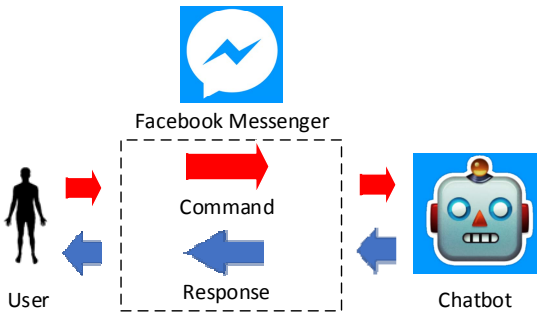
III. System Architecture & Data Distribution

A. System Architecture

Fig. 2 illustrates system architecture of this project and it mainly comprises of two major parts, namely, cloud and home service. To utilize home automation in this system, a user must be the one who initiate the conversation with the chatbot through Facebook chat service. Whenever our bot receives the message, Facebook server will convey that message to the cloud server through services provided by Heroku, where both data and database processing have been programmed to work cooperatively as per design. Three main features of this bot are: Case 1 "Turn on" - the device will turn on. Case 2 "Turn off" - the device will turn off. Case 3 "Home" - bot will response with question to ask user location.

Status of the output to Raspberry Pi is stored in this database at Heroku's server for retrieval. Additionally, certain services has to be developed to connect and process the data between Facebook API and Google Maps APIs to enable on-timer feature based on user's current location.

To achieve this, Heroku has to analyze the message sent from a user through webhook with proper authentication from Facebook to Heroku server, and then update the state of the home appliance in the database accordingly as shown in No. 1 and 2 in Fig. 3. If the message is time and space dependent (No. 3 in Fig. 3), current user's location will be queried through Facebook API and once granted, its longitude and latitude of user will be sent to Google Maps APIs for further analysis. The result of this analysis will lead to information about distance and estimated time of arrival (ETA) as illustrated n Fig. 4. Then Heroku will use these information to predict and update the state of the appliance(s) accordingly. The key function of IoT gateway or Raspberry Pi, is to regularly check the state from the database stored at Heroku and trigger the relay accordingly.



Command to Facebook Messenger		Response from chatbot
1	"Turn on"	Device is ON
2	"Turn off"	Device is OFF
3	"Home"	Send Location Your Coordinate: [lat, lng] The device will turn on when you arrive. Device will be on in : ? Mins

Figure 3. User-Chatbot Interaction

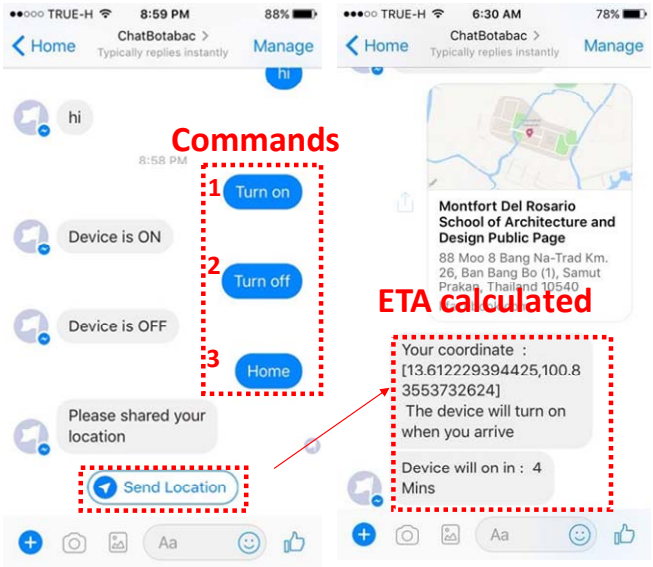


Figure 4. Facebook Messenger Screenshot based on Fig. 3.

B. Data Distribution

Due to an outsourcing of local processing to the cloud, data distribution can be slightly complicated in terms of flow and the location where the actual processing is taking place. With reference to the operation flow as shown in Fig. 5., the information of this system was distributed from cloud database. The database store the data record from user. The system will allow only specific Facebook's ID to access the data. Cloud server provides the database and exchange data with Google map API to calculate the estimated time of arrival (ETA). Due to the fact that an auto-reply messenger makes user feels comfortable with human-like response, this echo implies a back end interpreting the command sent through the cloud.

IV. Implementation and Employment

C. Software Configurations

Major parts of the smart home automation system in this article are a number of cloud servers with high availability and security of Heroku where the system is deployed and coordinated with data analysis from Google Maps APIs. Regarding security features, the system were deployed on server which contains security services (SSL, Penetration testing and Websocket) to acquire data from Facebook messenger and Google Maps APIs. The core purpose of this project is to ensure data distribution are according to the design and functionalities of each element in the system. Namely, Facebook chat is directly adopted and programmed with proper authentication to grant permission for a successful communication between Heroku and Facebook.

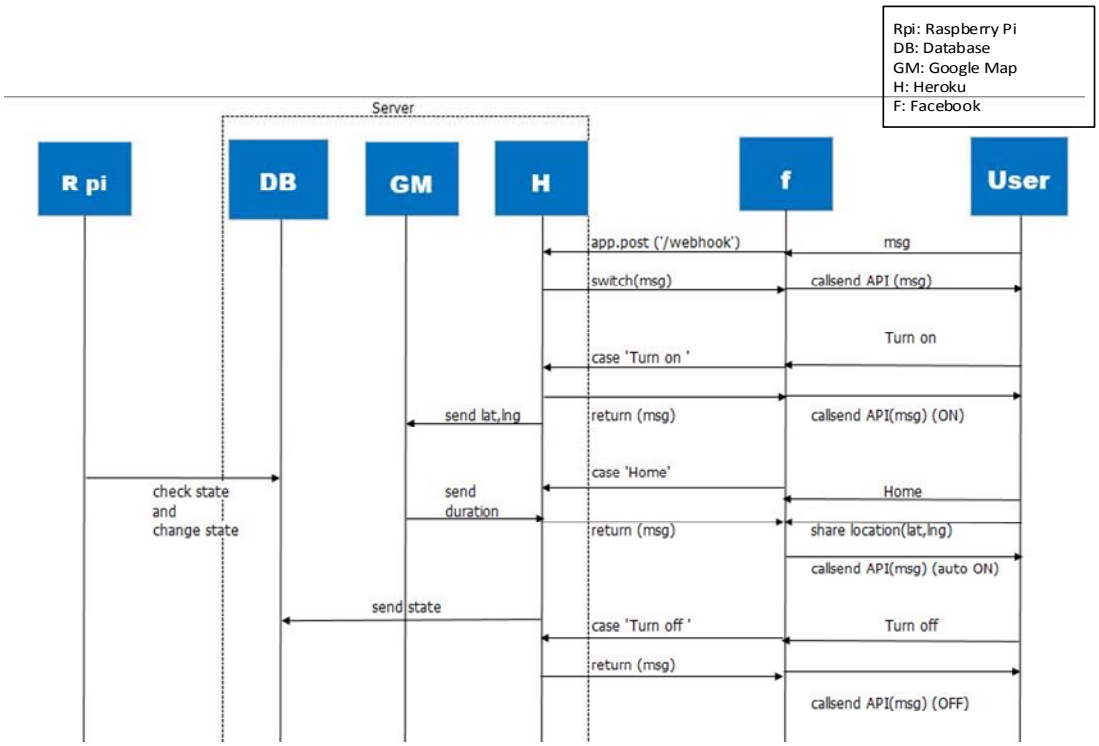


Figure 5. Operation Flow

D. *Hardware Configurations*

The Home service was deployed on the Raspberry Pi 2 Model B with Rasbian operating system to serve as a controller for home's appliances. Relays are provided for connection to home appliances.

E. *Operating Modes*

Two operating modes were implemented to automatically synchronize the data between cloud server and home service, as follows:

A. On-demand control

Smart home system has been designed to assist the user in controlling home's devices. With demand of the user can control devices by communicate with bot by typing in Facebook messenger. The chatbot can show the status of devices and control them follow by user-demand as shown in Figure 2.

B. Time and space-dependent control

As illustrated in Fig. 3 and 4, our smart home automation system is also able to calculate the time needed for user from the location sent by user when he/she is on the way home.

V. ADVANTAGES AND DISADVANTAGES OF SMART AUTOMATION SYSTEM

F. *Advantages*

The strong advantage of this system is the on-demand control, in which the user can access to home's appliances anytime, anywhere. Smart home automation features the ability to control home's appliances in both on-demand and time and space-dependent operating modes. The strong security from Facebook and Heroku server such as HTTPS authentication, Penetration testing were also presented to ensure system integrity. Smart chatbot is another main advantage of this system as users can type their commands simply in human language (English).

More importantly, the low cost for implementing the system makes it much easier for maintenance and hardware replacement in case of hardware failures.

G. *Disadvantages*

The main disadvantage was the requirement of the Internet to communicate between server and Home automation. Also, it largely relies on Facebook and Google server implying that slow Internet connection may cause unexpected delay in the operation. Moreover, users who are not on Facebook may consider this as another disadvantage because it is only implemented on Facebook's messenger. More importantly, a lack of internet access will also disallow the proposed system to work.

VI. CONCLUSION

Smart home automation via Facebook chatbot has been proposed to allow users to access and take control of their home appliances remotely and literally from anywhere. The system in this article illustrates the convenience for user to use Facebook Messenger to communicate and send their commands with ease. The strong advantage is to access Facebook from any internet-connected devices to control home's devices.

For future work, some additional features that can be implemented are in terms of machine learning, voice command and Natural Language Processing (NLP). This will allow a more intelligent approach to understand user's inputs with discrepancies.

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