Smart e-Public Locker Engine Assistants for Social Distancing Services

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Abstract: This paper presents the prototype module of smart electronic engine assistant system for servicing as public automation engine services is present here. The aim of this objective is approaching to develop the ordinary public locker that based on keypad control with coin access to smart transform with digital transmissions via on wireless communications or personal mobile phone access which suitable for digital Thailand 4.0 and also changes the customer's life styles with keep the social distancing in the new normal of COVID-19 situations. A digital locker system is an equipment that uses the digital information data such as a prime or user code, accessing code, booking access, Short Message Service (SMS) alert and time metering fee services that act as the key method for authentication and released the digital locker system. The Raspberry-Pi with data based program is embedded design in digital locker structure and acts as a main central controller of the overall public locker automation system. A public lock system proposed here consists of four parts; first part is for the electrical and mechanical structure module that aim to design with user friendly especially for ageing society that increase rapidly today and quite lack of public engine assistant for their life activities focus on public services. Controller, sensor and display unit are designed for second part that based on the Raspberry-Pi board included with its liquid crystal display (LCD) interactive display. Third part is designed for data based system that can serve for this system and open wide up to develop in the next future. The final part is digital communication which for short message service (SMS) or alert message sending both for accessing and cancelling of the system. The all of experimental results are shown that the prototype module can work well as design concept and practical used but must be improved for real public areas installation or the way to allow any users to remote or monitor the real time working system through internet or any other public communication network easily as a new and next normal lifestyle.

***Keywords*— Electronics Public Locker, Raspberry-Pi, Arduino, Cloud Key-pad control**

I. Introduction

Recent year, the coronavirus diseases 2019 (COVID-19) is the global crisis of our world and WHO declared them as a pandemic [1]. One of the best spread stopper way in the present scenarios is the social distancing [2] and all affected countries are applied to implement this method in the universal ways especially in the public or crowded area as new normal of people day life behaviors that must be private sector areas or keep 1 or 2 meters between each of other, so the smart facilities that many development countries are developed the smart public area for more convenience of their people life called as smart city. Smart city [3] as a collaborative ecosystem that compose of private sector, public sector and other such residents. The three layers of the smart city which can change the traditional infrastructure to the modern infrastructure are composed of technology based network of connect devices and sensors especially for Internet of Things (IoTs) technologies and cloud computing services [4-6], applications data analysis compatibilities and tools especially for big data analysis technology [7] and finally for public adaptation and usage. In the public area section is the main issue of this work assume that if we have more of public engine personal assistant [8], they will be improving quality of their life such as suitable cost of living or time reduction and convenience to access to any of public facilities. So our proposed a smart e-public locker system that is focusing for assisting the new normal of people day life in public area facilities which smart technology usage friendly. The main idea concept of this e-public locker assistant engine is designed by V-shape model analysis that is shown in Fig. 1, which it is based on an essential knowledge of electronic system design and an idea concept of engineering mindset combined with IoTs and cloud communication for a long distance control. Also, this paper aims to study the effects of the feedback delay (FD) on the system performance metric in terms of the average number of successful users in media access control (MAC) of contention reservation systems [9] in wireless access mode.

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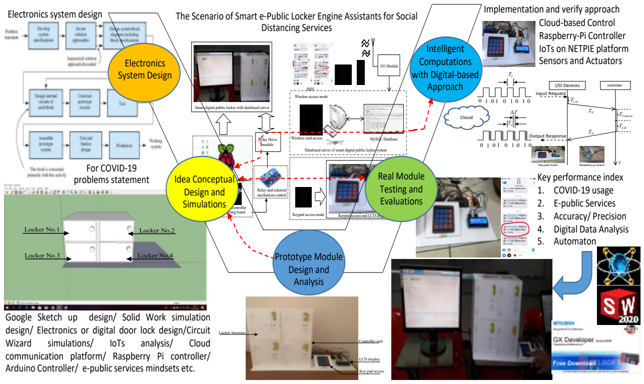

Fig. 1. The V-shape model design of smart e-public locker engine module

The system block diagram is shown in Fig. 2 that is shown the overall of system components and system integration. For any user who attempt to access to this system will be accessing in two ways. First, it will automatically detect with wireless fidelity (Wi-Fi) connection between the Raspberry-Pi [10] controller board act as the base station and user mobile phone in wireless access mode or likely MAC that seem too easy to used, but it quite limit by Wi-Fi coverage area, signal quality and slot reservation of contention resolution methods. The second way is direct access by use the keypad accessing mode in step by step of command process that seem to real place usage, but it quite limit by the locker was already occupied in full capacity of system and must be wait for available status again.

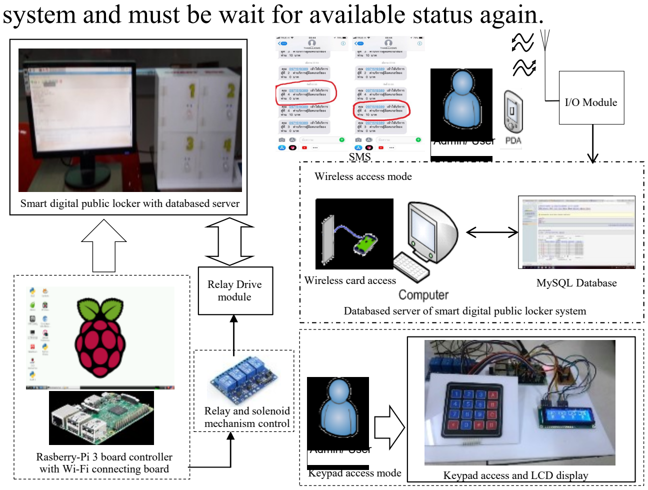

Fig. 2. The system block diagram

The accessing signal is sent to the controller board that used Raspberry-Pi to execute a series of commands in work flow diagram of databased software process. After that the user can use this system and time metering service fee will be automatically operating for service fee execute and send SMS to the user via their mobile phone or cloud platform (optional). The locker status can be monitoring and controlling in real time via on their mobile phone until user logoff from the system the locker door mechanism will be released or unlocked when the service fee was already payment. The remainder of the paper is organized as follows: Section II presents the mechanical structure design. Section III presents the SMS sending process. Section IV shows the databased software design and system accessing approach. Section V illustrates the experimental results and finally section VI for conclusions.

II. Mechanism Design of Smart E-Public Locker

A. *Modelling Module Design*

The simply modeling module is designed by Google Sketch Up program in the first time and next is simulating again by Solid Work simulation program that is focused on user friendly interface as is shown in Fig. 3.

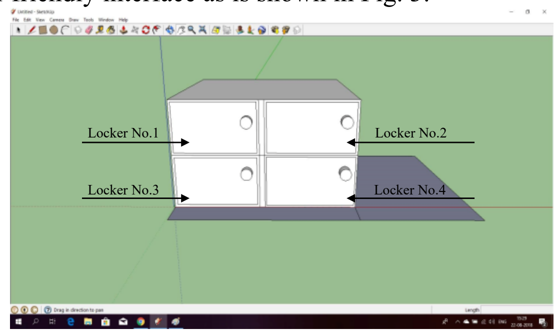

Fig. 3. The modelling module design of smart e-public locker engine

B. *Prototype Module Design*

The Solid Work simulation program is used to design again with the real prototype structure module shown in Fig. 4 that it is construct from hard acrylic based for convenience to use and light weight but stronger enough. They have four small lockers number 1 to 4 that can be individual used in the same time. The Raspberry-Pi board controller, keypad unit, LCD display unit and other supporter circuit boards are install behind the locker box.

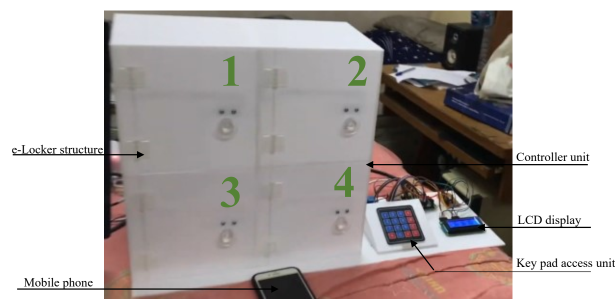

Fig. 4. The real prototype structure module of smart e-public locker

The high of this e-public locker module which measure from base ground to the top has not more than 150 cm, while the LCD has a two rows display with 16 texts message that is having enough for all service. The digital door lock mechanism with Arduino Control and light emitting diode (LED) status display as shown in Fig. 5.

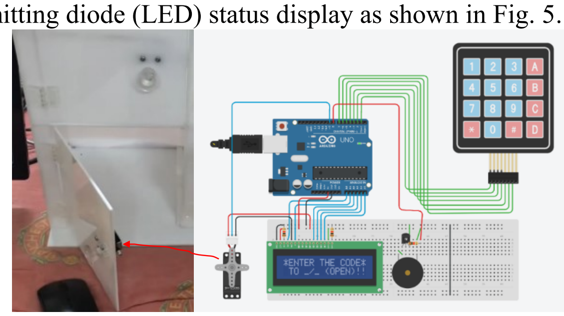

Fig. 5. An example of digital door locking circuit system

III. MESSAGE SENDING AND RECEIVING DESIGN

The Raspberry-Pi devices are used as main controller to control the all of system operations. The normally status of the system is shown in Fig. 6. The status of sub-lockers number 1 to 4 (LK1, LK2, LK3 and LK4) are shown 0 (zero) in vacant status and 1 (one) for occupied status.

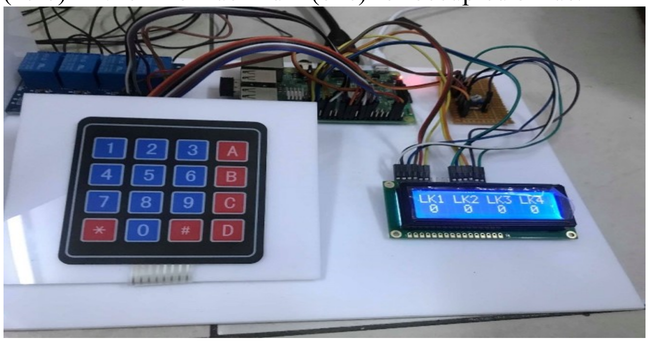

Fig. 6. The LCD display of the normally status of smart e-public locker

When user who access to use this system as the LK1 with their mobile phone number in Fig. 7 they can be receiving the SMS that send from the e-public locker system to their user's mobile phone for service details as shown in Fig. 8.

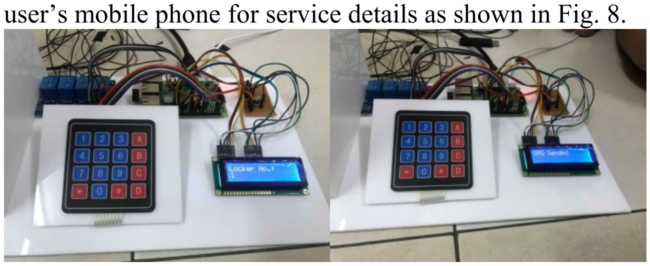

Fig. 7. An example of digital door locking circuit system

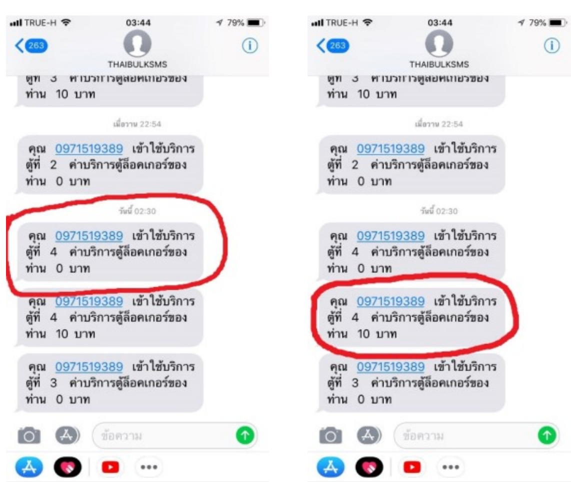

Fig. 8. An example of SMS display (in Thai language) on mobile phone

The advantage of SMS method is not real time communication required and can be kept in the sending buffer memory for a long time until the user's mobile is available or ready to accept its sending signal and can be distributed the message to many destination users in the same time. The SMS process is divided in to text mode and protocol data unit (PDU) mode. For text mode it must be encoding first to PDU mode before send message, while the PDU mode it can send by AT command easily.

IV. SYSTEM ACCESSING DESIGN

A. *Databased System Design*

The design of work flow diagram of this system is shown in Fig. 9 that based on MySQL Database for databased server management while phpMyAdmin is the program for managing the MySQL via by website and PHP Hypertext Preprocessor is the processing program by PHP language. The Raspberry-Pi act as the main controller of this system as shown in Fig. 10 that is operated together with the databased server which is installed with Raspbian operation system and used the Python language for operating the interactive process between user interface and Raspberry-Pi board interface and also for including with SMS alert process. Any user who prefer to use this system they can access by two ways; first is for keypad accessing that usually served for classical method and second is designed for wireless accessing approach such as Wi-Fi (in this paper), Bluetooth or NFC methods, Quick Response (QR) codes or Radio Frequency Identifications (RFIDs) and then the system can detect the mobile phone automatically.

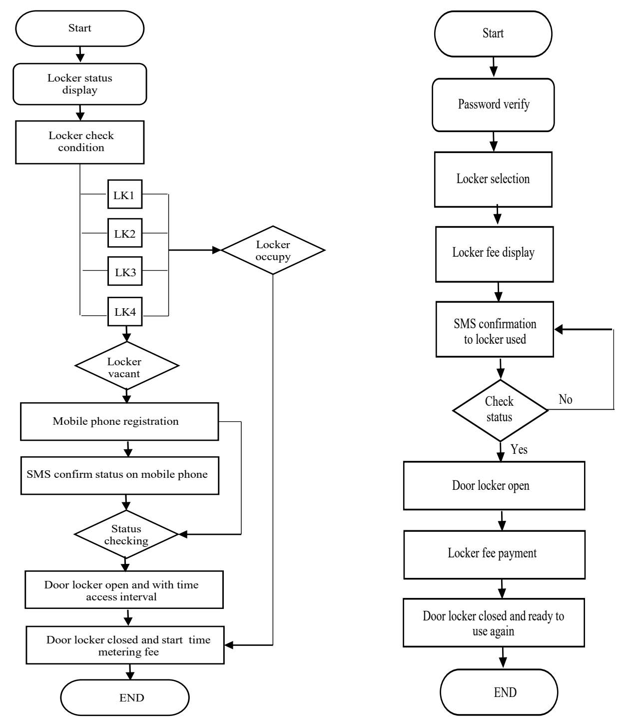

Fig. 9. Work flow diagram of smart e-public locker services

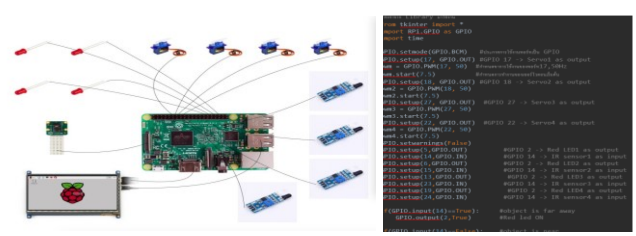

Fig. 10. The Raspberry-Pi 3 source code program development

The user who already access to the system they must be register their mobile phone number in the first step as shown in Fig. 11 for select the available locker number.

Fig. 11. An example of key pad or mobile phone registration process

When user who can access to the system already, the system time metering fee process (diagram in the right hand side of Fig. 12) will be operated automatically and sent the locker status with time service fee to the user via by their mobile phone with SMS or alert message and recorded this service list in to the databased system as shown in Fig. 13 and after that they can easily payment by any of electronics payment agents (optional) and the locker status will show the unlock status and available to use again as in Fig. 14.

Fig. 12. An example of time metering fee display on user mobile phone after log-off from the smart e- locker engine system

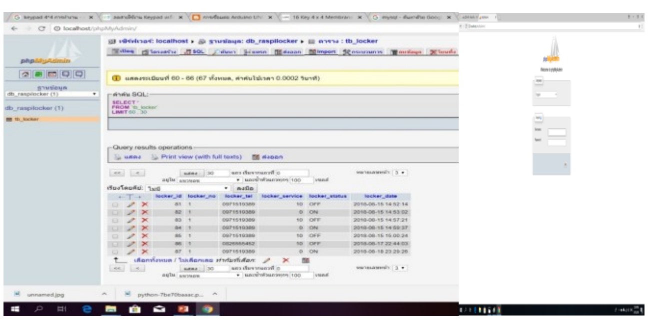

Fig. 13. An example of data based record tested as the data logger system

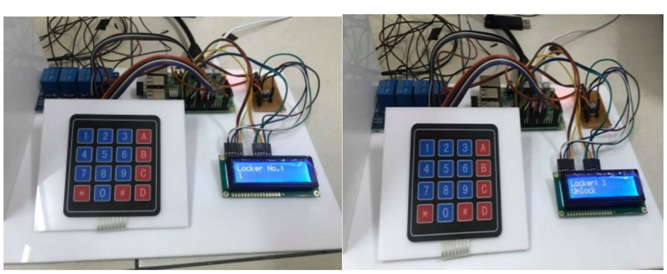

Fig. 14. An example of LK1 is in locked and unlocked status

For battery storage, lithium-ion batteries have been widely used and believed to exhibit no memory effects, but some mainly caused damaged was belong to the thermal runaway effect that must have a way of temperature rises controlled. For battery control usage, the Battery Management System (BMS) is designed here as shown in Fig. 15 which can be controlled and monitored the battery charger circuit of Lithium Iron Phosphate ($LiFePO_4$) package in the charging and discharging state for more efficiency of used and will span a long life cycle in the same time that may be caused by overcharging or over discharging.

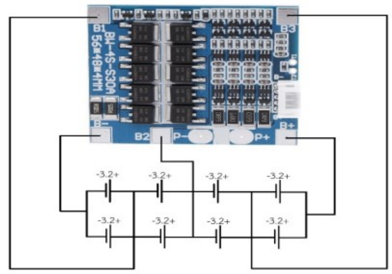

Fig. 15. An example of battery management system (BMS) of $LiFePO_4$

The battery charging circuit per one cell of $LiFePO_4$ is shown in Fig. 16 that must be controlled the constant current (CC) charging mode in the first time until upon to 70% of state of charge (70%SOC) and after that will change to constant voltage (CV) mode until equal to full %SOC. The simply battery charging circuit per one package of 12V battery is shown in Fig. 17 that can be controlled easily by transistor and single pole double throw (SPDT) solid state relay that in charging mode the green LED will continuous turn on until it quite overcharge status the red LED is turn on for warning status. For the overload or over current protection circuit is simulated here as shown in Fig. 18 that is used to limit the current load consumption must not more than some limit of loading effect such as 702.48mA to protect the overheat of battery in the loading condition that must be prevent the battery damage by the thermal runaway effect. The voltage level indicator of battery usage is simulated in Fig. 19 for voltage monitoring and warning status that is used the LM3914N controller which will be 10 digit of LEDs display both in dot and bar graph display mode. The three red LEDs will be turn on when the battery voltage is lower than 30% of normally voltage, while the four yellow LEDs will be turn on when the voltage level is quite fairly available voltage to use for 40% to 70% and finally three green LEDs are shown for the battery voltage level is more than 70% consequences.

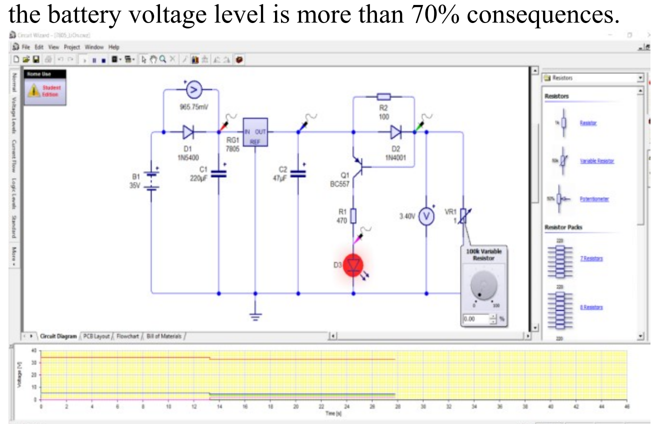

Fig. 16. The circuit wizard simulation of battery $LiFePO_4$ charging circuit

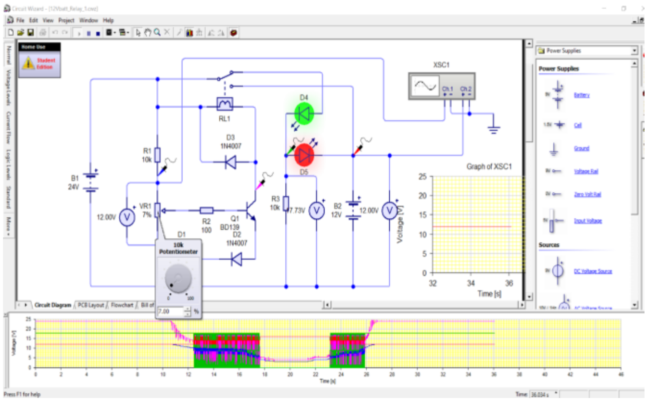

Fig. 17. The circuit wizard simulation of 12V battery charging circuit

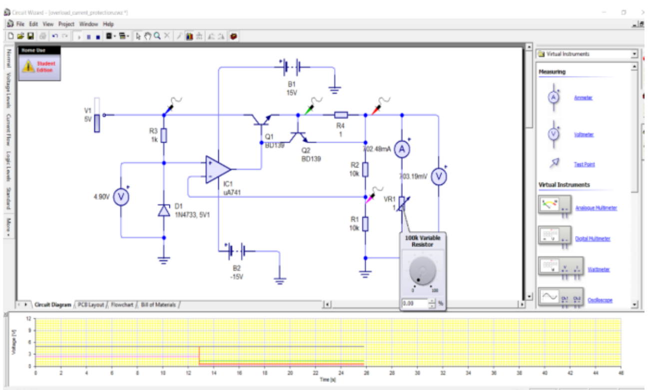

Fig. 18. The circuit wizard simulation of over current protection circuit

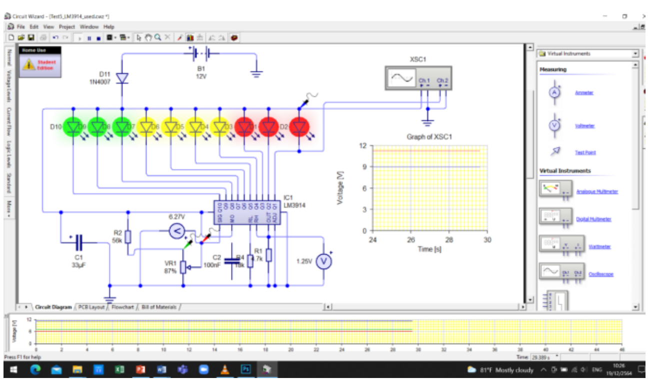

Fig. 19. The circuit wizard simulation of voltage level indicator circuit

B. *Wireless Accessing Design*

In this section, we will study a MAC protocol of wireless access that is needed for one service area which consists of a central base station (Raspberry-Pi) and several mobile users who communicate between them over a shared wireless channel such as a slotted ALOHA protocol [11]. For the fixed probability technique, each user will consider making reservation on each contention slot in sequence from the first slot to the last. In each slot, the users will decide whether to access the current slot with a certain probability, referred to here as the permission probability (p) that is assigned equal to 1/M where M is the total number of users. It is assumed that the value of this probability is the same for all users which quite fair and it is also fixed throughout [12-13] for all request slots. This scenario was designed for a MAC system with a relatively short round trip propagation delay between the base station and users compared to the contention slots period in the real mobile base station as shown in Fig. 20.

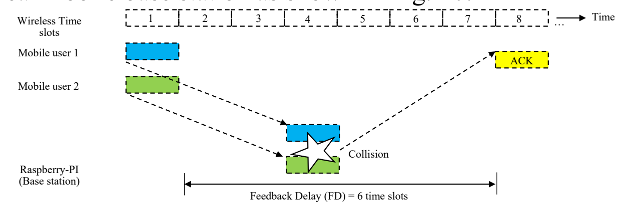

Fig. 20. An example of contention resolution scenario of wireless access

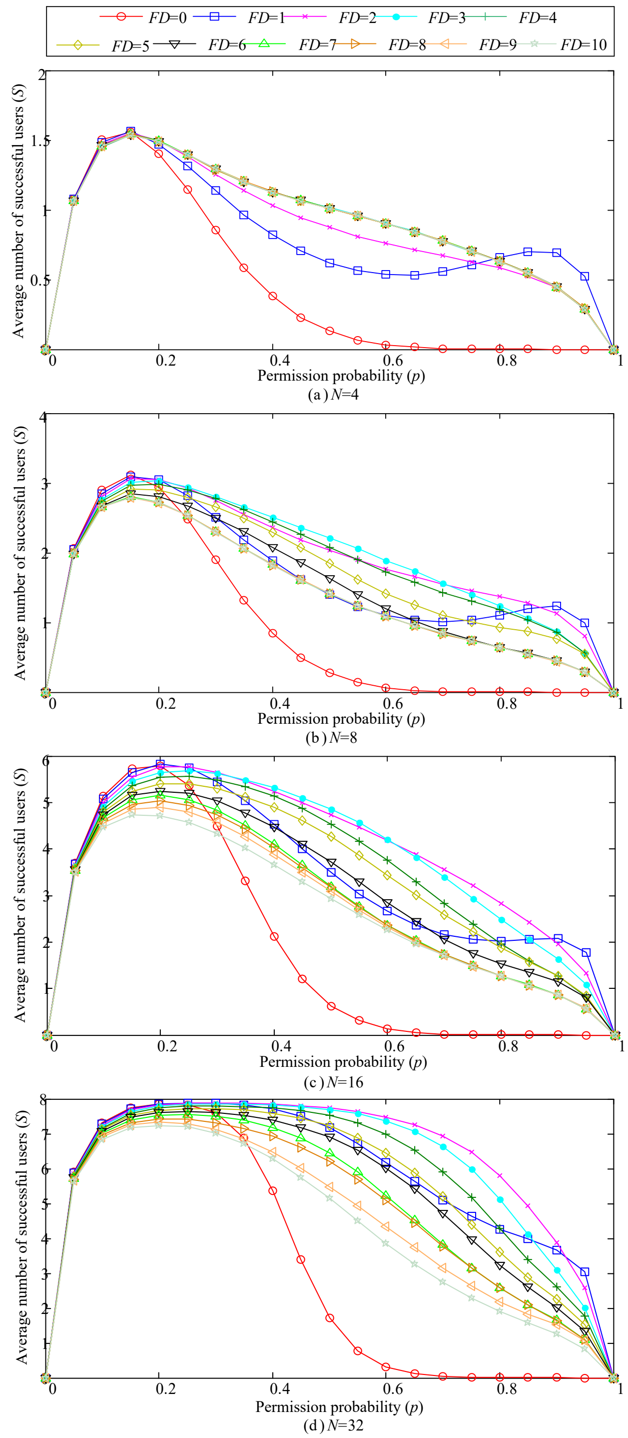

Fig. 21. The simulation results of the average number of successful users (S) versus the permission probability (p) when N = 4, 8, 16, and 32 slots.

However, if the system has long round trip delay [14], users will receive the outcome of their requests from the base station after a number of slots referred to here as the feedback delay (FD) has expired. To study the effects of the FD on the system performance metric in this paper, we consider only the average number of successful users that the number of contention slots available in each frame is set at a certain or limit value and we examine how different values of FD will affect the average number of successful users. The number of total users (M) is fixed at 8 in all tests, whereas the number of contention slots (N), is varied as 4, 8, 16 and 32 respectively. The simulation results in Fig. 21 are shown that if the FD = 0 (no feedback delay) the all of four curves appear to have the same trend. In Fig. 21(a), the number of available contention slots is set to 4, which is only half of the number of users that seem rather extreme case. The average number of successful users (S) increases with p until the maximum value of S is reached (S_{max}=1.57) and after that as p increases it turns out that the fixed probability performs better when the channel has feedback delay than when the channel has no delay and corresponding perform in the same way as the FD is increase as the maximum values of S achievable for FD = 0 are 3.12, 5.81 and 7.86 for Fig. 21 (b) to Fig. 21 (d) respectively. This is shown that when users are given more contention slots, there will be more successful users. However, when the FD gets larger, the same level of maximum values of S can no longer be maintained and caused the maximum achievable values of S begin to drop as the feedback delay increases. The relationship between the average number of successful users (S) and the number of available contention slots (N) is shown in Fig. 22.

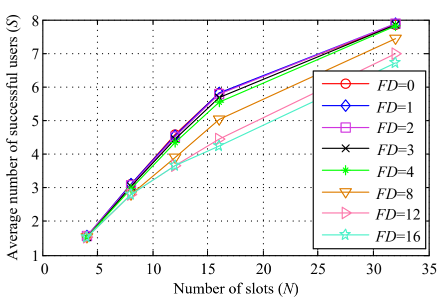

Fig. 22. The simulation results of the average number of successful users (S) versus the number of reservation slots (N).

In Fig. 22, these results are indicated that under these certain circumstances the problem of channel feedback delay can become beneficial, but very limited. However, for longer feedback delay, no performance advantages can be attained. It is basically results because with larger values of FD, users have to wait for longer time to get their feedback acknowledge, and it means that users have less chance to access the slots in the same time.

C. Cloud Communicating Design

The cloud communicating of this system is designed based on NETPIE platform [15-16] as a platform-as-a-Service (PaaS) that developed for IoTs applications. Many IoTs devices can be communicated which each other by this platform with micro gear library software and MQTT protocol. Node MCU (ESP8266) [17-18] that set as a Wi-Fi shield tools or Raspberry-Pi 3 are used for digital data controller with AT commands for a long distance access control as a Transmission Control Protocol (TCP) as a master/slave protocol stack procedure as shown in Fig. 23.

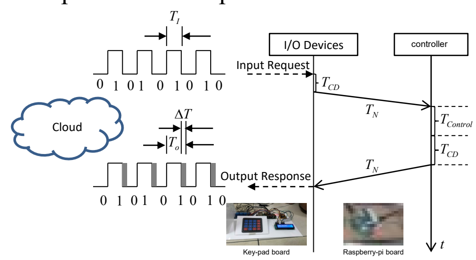

Fig. 23. The sequence of timing diagram based on the cloud-based devices approach to the cloud-based network

Define the accessing time interval of input and output command signal is T_I and T_o respectively which will be effected by some propagation delays in wireless communicating area called as ΔT shown in equation (1).

$$T_o = T_I + \Delta T \quad (1)$$

In the first time, the network is not completely synchronized, so the initial setting conditions are required for fulfilling update time cycle of any devices is called as T_{CD}. The network delay time is called T_N, while the $T_{Control}$ is defined as the control task interval time plus execution time that is performed by the controller in each of command process. Let T_{E2E} is the End-to-End delay time of the system that is arrived for the worst case scenario of $2T_{CD}$ and $2T_N$ which will cause the variance ΔT for each of output commands shown in equation (2).

$$T_{E2E} = 2T_{CD} + T_{Control} + 2T_N \quad (2)$$

V. EXPERIMENTAL RESULTS

The specification Pentium (R) 4 CPU 3.01 GHz and Lenovo ThinkPad notebook are used to evaluate the system programed. The solid work version 2011 is evaluated the mechanical designed, while Node MCU (esp8266) and Raspberry-Pi 3 is used for digital data controller and cloud connection. Many of experimental tests both for mathematical analysis and simulations with many of digital data computations and real take place installed with several tested were present here in Table I and Fig. 5 to Fig. 25.

TABLE I
EXPERIMENTAL RESULTS OF SMART E-PUBLIC LOCKER SYSTEM

Test No.	Locker No.	Mobile phone	Locker status	Time and date
1	1	0971519389	ON	17-08-61: 22.00
2	1	0971519389	OFF	17-08-61: 22.10
3	4	091123561	ON	17-08-61: 22.30
4	4	091123561	OFF	17-08-61: 22.40
5	3	095561232	ON	17-08-61: 22.50

6	1	0971519389	ON	17-08-61: 22.55
7	3	095561232	OFF	17-08-61: 23.22

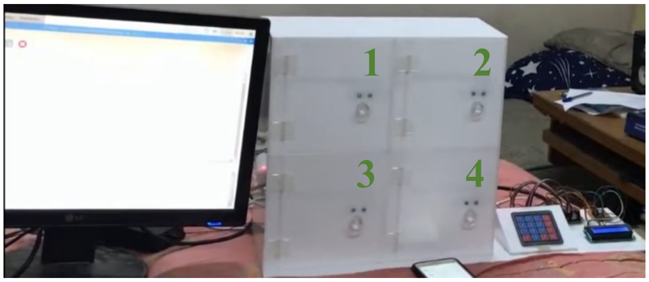

Fig. 24. An example of real testing of smart e-public locker engine system

Fig. 25. An example of real testing of SMS sending/receiving process

The overall system can work well as design concept and high precision enough to use in laboratory room, but for some real public area that the Wi-Fi signal is quite lower power, attenuation loss or lack to use it may be some inconvenience to use by Wi-Fi accessing method. The simulation results of contention resolution method of wireless accessing mode reveal that longer feedback delay usually postpones the reservation success of users and makes the system require more number of slots to have all users succeeded and the average number of successful users degrades as the system has the longer feedback delay when the number of available contention slots is limited. So, it can be easily used by the cloud keypad access instead.

VI. Conclusion

In this paper, we proposed a prototype module of electronics public locker automation system based on digital communication platform with Raspberry-Pi controller, databased system and SMS information which integrates the e-public locker automation with personal security via on their mobile phone. The overall system can work very well as design concept. Since our proposed system is built over wireless accessing channel that the channel throughput seems reasonable both with cloud-based communicating control for digital information usage paradigm, so it smart to use for the new and next normal upon on digital lifestyle of smart city or Thailand 4.0.

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