

Door Locking System Using Android Mobile Device Based On Arduino Microcontroller

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Abstract—Smartphone has become a very influential and vital device as it can do almost everything. Most of us would probably hate to carry a lot of things in their pocket when leaving the house. In this project, a door locking and turning off home appliances system using Android smartphone connected via Bluetooth connection protocol developed based on Arduino microcontroller was developed. The developed keyless system is hoped to assist user to lock and unlock the door without using keys and able to switch off or on the home electrical appliances by exploiting their smartphone. This system use an Android application which is specially designed to be connected via Bluetooth to the main system located in the house. Thus, the system developed is expected to help reduce the electricity bills and ease the user by just bringing their smartphone rather than having to carry a bunch of keys when leaving their house. User will find it much more convenience to lock the door just using smartphone rather than bringing keys.

Keywords—Arduino, NFC, Android apps, Bluetooth transceiver, MIT App Inventor.

I. INTRODUCTION

Today, wireless technology has been developed for a lot of purposes that will ease mankind. An example of the use of wireless technology is for home automation and security system. In the security system especially door lock, system using wireless technology has been widely developed. A lot of security products available in the market that facilitate mankind such as SCHLAGE LiNK™ Wireless Remote Security [5]. According to Potts, J and Sukittanon, S [1], this type of lock use Near Field Communication (NFC) to provide security using virtual keys in mobile phone. One of the examples of wireless technology is Bluetooth which is a short range wireless communication system. This network can be used for information exchange that replaces wires [1].

The Bluetooth network protocol is also applicable in most electronic devices especially mobile phones. Android OS is one of the mobile operating system that fully supports Bluetooth network protocol. It is currently leading in the market share of mobile [1].

Before it came into market, Apple's iOS and Blackberry OS were two biggest operating systems in smartphone field. 5 November 2007, Android OS was introduced and it has gotten stronger since then. This OS is based on LINUX V2.6 Kernel. Android OS was first used in G1 by HTC working with T-Mobile. There are many advantages of Android such as it can be customized, has a lot of features and can easily be debugged. Moreover, this OS is an open source that has wide range of support [9]. By the time this project is developed, there have been 17 versions of Android OS available from version 1.0 until version 4.2. Each with different API level. API stands for Application Programming Interface. Android APIs consists of many packages and also classes that will ease the developer to access any model of Android smartphone's features [12]. In easy word, higher API level makes it easier for developer to develop an application because it provides more building blocks.

Having a bunch of keys in pocket is really annoying for most people. It is uncomfortable to have a lot of things in pocket when leaving the house. Having a virtual key application in the smartphone should be the answer of this problem. We just need to bring our smartphone with us when we want to go out. Other than that, we always forget to turn off our home appliances before going out especially lights and fans, thus, this will lead to waste of electricity. Imagine how much we will saved if we turn off all of unused electrical appliances before leaving the house. It would be much easier if the door that we lock before going out will automatically turned off our home appliances too. By that way, there is no reason why we could not minimize electricity usage.

In this project, Android application is integrated with Bluetooth network protocol to control door locking mechanism as well as home automation system. Android apps is developed using MIT App Inventor software. This application will communicate with Bluetooth modem that is connected to Arduino MEGA microcontroller. The microcontroller will control the

door locking mechanism as well as home automation. The home automation will be limited to only turning on and off light.

The objectives of this project are to develop a door locking system that uses Bluetooth connection as the data transfer medium, to develop an Android application that is unique for this system and to build a prototype that implement the door locking system based on Arduino MEGA microcontroller.

There are no door locking system that uses Android application in the market due to factors such as cost and reliability. Among the famous digital door lock available is using face recognition system and thumb print. This system can be developed to exploit home appliances control, e.g control the fan speed, to give more functions to the system. Without doubt, it will be very useful in the future.

II. METHODOLOGY

This chapter is about the construction processes that have been done from research until building and testing the prototype. Figure 1 shows the approach to design the system. The approach will be discussed in detail later on.

A. Research

The first step of design approach is research and gathering information. At this stage, research was undertaken by various means for example reading journals, technical papers, books, and web pages about things that are related to digital door lock, Bluetooth and Android application. The objective is simple, gather as many information as possible that can help in the upcoming phases of design.

It is understood that majority of people all around the world are looking towards an easier life, which in this case is multitasking using a single platform that is the smartphone. Therefore, this project is designed to exploit the use of smartphone in the home security field that is door lock. The idea is to use smartphone as a device that can control the door lock and home appliances.

B. Hardware Development

The design of hardware includes the schematic diagram of the connections between components and the Printed Circuit Board (PCB). The basic ideas of how the system works is shown in Figure 2.

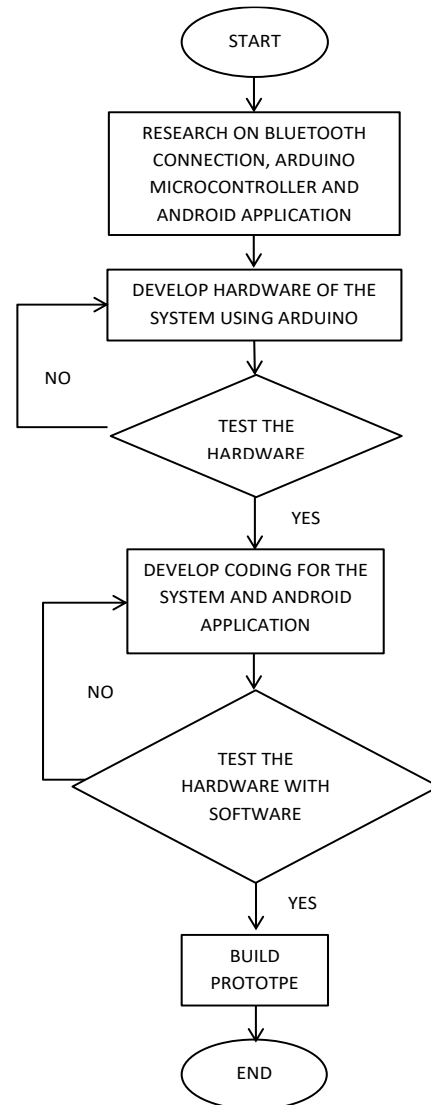


Figure 1. Design Approach

Basically, the application running in Android OS sends command via Bluetooth connection. The command is captured by the Bluetooth transceiver and sends to Arduino to process. Arduino will gives output in terms of locking or unlocking the door as well as switching on or off home appliances.

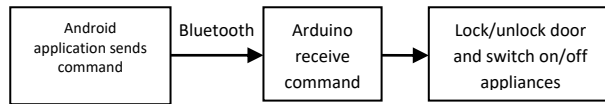


Figure 2. Block Diagram of System

The schematic diagram of the system is shown in figure 5. Among the components used is DFRobot Bluetooth V3, electric door strike, 16x2 Liquid Crystal Display, 9v relay, 4x4 membrane keypad, NPN transistors, capacitors, resistors, voltage regulators and Arduino MEGA 2560 microcontroller as the brain of the system.



Figure 3. Arduino MEGA 2560



Figure 4. DFRobot Bluetooth V3

Arduino MEGA 2560 microcontroller is chosen because it has 54 digital I/O pins which is enough for the system that needs 18 digital I/O pins. Moreover, the system needs 5V DC voltage at the pins which is supplied by Arduino MEGA 2560.

Bluetooth transceiver module used is DF-Bluetooth V3 module (TEL0026) from DFRobot. Bluetooth is chosen as the medium for connection because it serves the purpose of wireless connection. Furthermore, it is a low power device with transmission distance covered by Bluetooth, specifically this module, is 20 to 30 meters in spaces without obstruction [13] which is enough since the application of the system is for NFC. Other than that, it is password protected where code needed to able it to pair with a device. Therefore, it is not easily hacked and has high value of security.

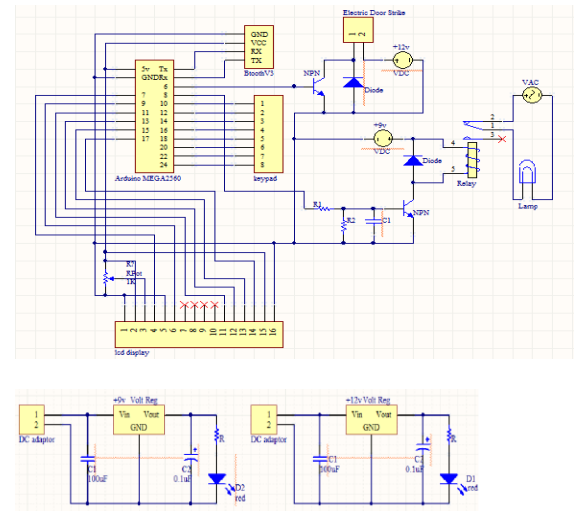


Figure 5. Schematic Diagram of the System

The schematic diagram is drawn using Altium Designer. It has two separate circuitries for the relay and the electric door strike whereas, Bluetooth transceiver, LCD display and keypad is connected directly to the microcontroller. LCD display and Bluetooth transceiver are both supplied by 5V DC voltage which the regulator circuit is already built-in the microcontroller. The relay circuitry uses 9V DC voltage whereas the electric door strike circuit uses 12V. The function of voltage regulator circuit is to regulate the input DC voltage to a steady 12V and 9V DC voltage.

The lamp connected with relay circuit is used to represent a simple home appliance that is used in house. Potentiometer is used to control the brightness of the LCD character. Diode is placed in the electric door strike circuit as a cover from back voltage when the system is switched off.

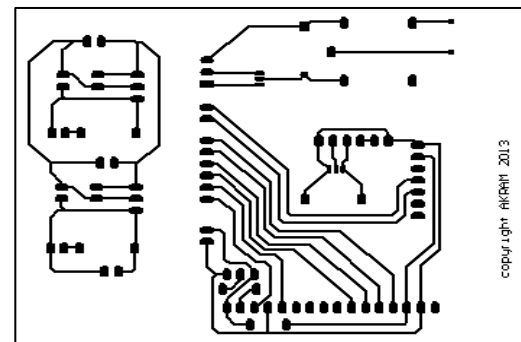


Figure 6. Designed Printed Circuit Board

The schematic diagram sketched is converted into PCB. This is done for prototyping purpose where the objective is to produce a very neat prototype. The PCB is also designed using Altium Designer. The PCB designed shown in figure 6 clearly shows two parts; main circuitry and the voltage regulator circuit. The PCB design is converted into Gerber File and sent to the lab to be printed out.

C. Software Development

Another reason of choosing Arduino microcontroller rather than other microcontrollers is because Arduino is an open source, easy prototyping platform where it has its own compiler called Arduino Environment. This Integrated Development Environment (IDE) uses a C++ like language but a more easy and simple syntax.

The coding for the system is developed using Arduino Environment IDE. The library for keypad, LCD display and password is included in the coding to enable some features and syntax to be used.

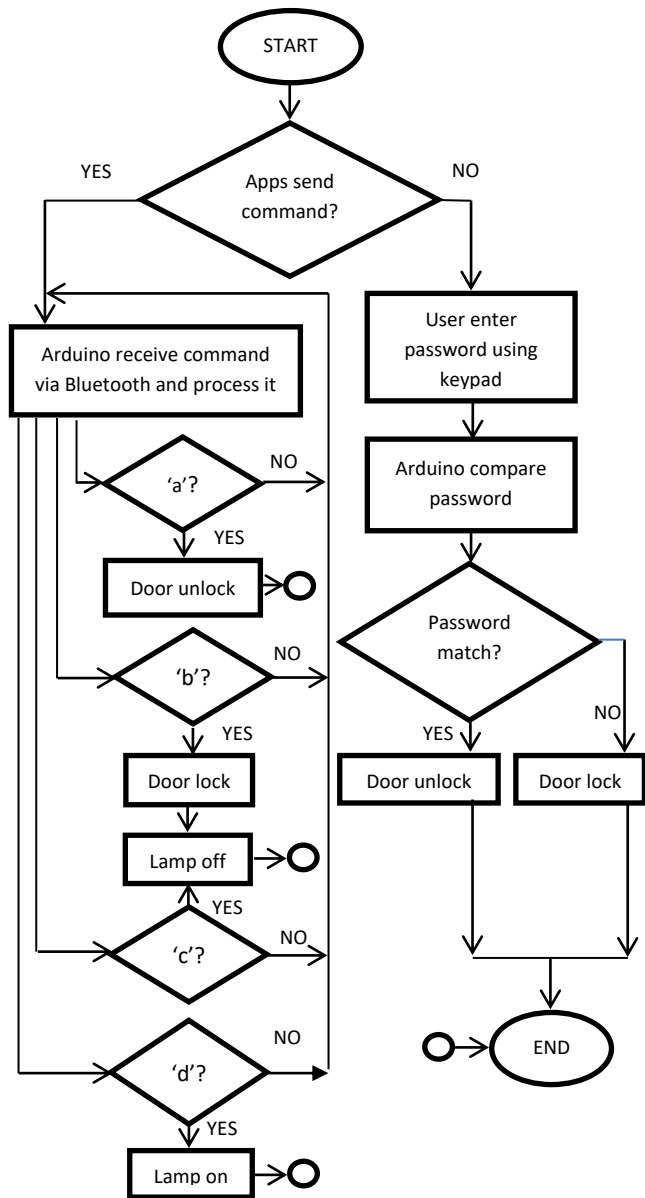


Figure 7. System Flowchart

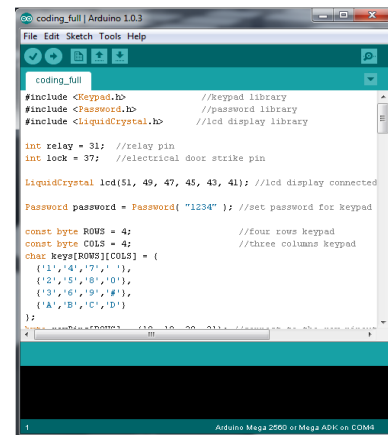


Figure 8. Arduino Environment IDE

Figure 7 shows the system flowchart. There are two ways to unlock the door; using Android application and using keypad. Using application, it sends command to the microcontroller via Bluetooth connection. Here is the role of Bluetooth module, as a medium to retrieve command from the application. Arduino retrieve the data, process it and gives the output based on the command received which are locking and unlocking the door and turning on and off the lamp. The difference between using Android apps and using keypad is just the medium of transferring command as well as password needed to use keypad. Android apps uses wireless network whereas keypad uses direct wire.

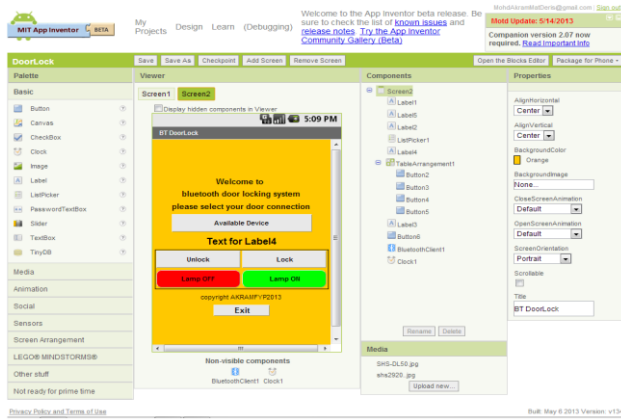


Figure 9. MIT App Inventor Software

Android application for this system is developed using MIT App Inventor software. Differ from any other Android development software in the market, this software is totally GUI-based which is very suitable for a beginner to start getting involved in development of application. It is very unique software because the layout of the apps is done using internet browser and the behavior of the layout is using the block editor which is installed in the computer. Figure 8 shows the layout of the application.

D. Prototype Development

The hardware part and the software part of the system are assembled into one system. Prototyping is important as a complete view of the system so that it will look as it is possible to be implemented. Figure 9 shows the prototype built for this system. A door model is needed to make the system looks really implementable in the real life. All the circuitry is placed inside the black box.



Figure 10. The Prototype

III. RESULTS AND DISCUSSION

Before using the application, the mobile device is paired with the module first. A set of password is needed during pairing. The default password for pairing with DF-Bluetooth V3 is 1234. It can be changed by using AT command.

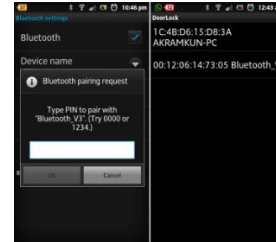


Figure 11. Android Mobile Device Pairing With Bluetooth Module and (b) List of Available Device

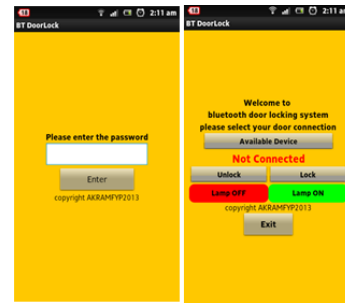


Figure 12. Application Layout

The application developed consists of 2 screens which are screen 1 and 2. At screen 1, there are a password box and a button. User need to enter the correct password and touch the button in order to go to screen 2. The password is defined when developing the application where the default password is '1234'. If incorrect password is entered, the application automatically exits.

The layout of the system in screen 2 is developed such that it has 6 buttons with different functions. All buttons functions properly. Button named Available Device pop-up the list of available device around the mobile device when touched. Unlock button unlock the door and Lock button is lock the door as well as switching off lamp at the same time. LampOFF button turn off lamp and the LampOn button turn on the lamp. The Exit button exits the application to go back to the home screen. Each button sends a different value to the Arduino to process. The word above the white box shows the connection status.

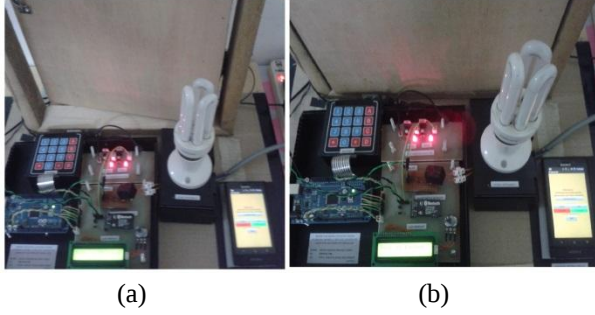


Figure 13. System Condition when (a) Unlock Button and (b) Lock Button is Pressed

The correct password pressed using keypad unlocked the door whereas a wrong password locked the door. The LCD display shows the status of the system when a certain button or keypad is pressed.



Figure 14. System Condition when (a) LampON Button and (b) LampOFF button is Pressed

Some testing is done to the project. First, the application is tested using 3 different Android OS versions. The objective is to see whether the applications created can be run on different version. The application is installed in Android version 2.3.7 Gingerbread (API level 10), version 4.0.3 Ice Cream Sandwich (API level 15) and version 4.1.2 Jellybean (API level 16). Sony Xperia Sola is used to represent Gingerbread, Sony Ericsson Activ is used to represent Ice Cream Sandwich and Samsung Galaxy SIII mini is used to represent Jellybean version. It is observed that all Android OS versions that have been installed with the door lock application can perform tasks of locking and unlocking the door well without any problems.



Figure 15. Door Lock Application Installed in SONY Xperia Sola, Samsung Galaxy SIII mini and Sony Ericson Activ

TABLE I. COMPATIBILITY OF DIFFERENT ANDROID VERSIONS

Android version	Code name	API level	Compatibility
2.3.7	Gingerbread	10	Compatible
4.0.3	Ice Cream Sandwich	15	Compatible
4.1.2	Jellybean	16	Compatible

The Bluetooth connection protocol is also tested under different conditions. The objective is to measure and observe the range it can cover with and without obstruction because the system should be installed inside the house. With the presents of obstructions, there must be a slight attenuation in terms of range of operation and the quality of the signal. This test is important because there is probability that user will lock the door when they are already in car or far from the door itself.

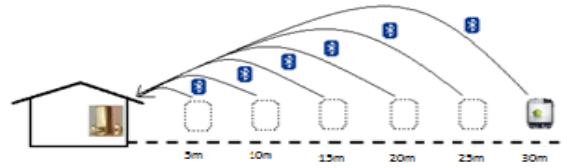


Figure 16. Setup Range Test

The test is done under 2 different conditions. The first condition is the main board and the mobile device is at open space and the second condition is the main board is placed inside the house and the mobile device is outside the house. Table 2 shows the results obtained after 5 attempts. From the test, it is observed that the safe range is at 25m at open space and 15m when there is obstruction. The datasheet shows that the range of data transfer is between 20m to 30m in an open space. This condition had been proved as true.

TABLE II. RANGE OF BLUETOOTH TRANSMISSION

Attempt	Range (m)	
	Door closed	Door opened
1	15	25
2	17	26
3	15	25
4	15	27
5	16	27

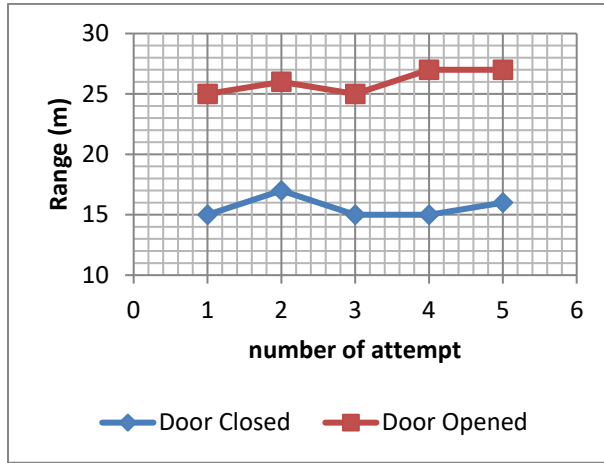


Figure 17. Graph of Number of Attempt vs. Range

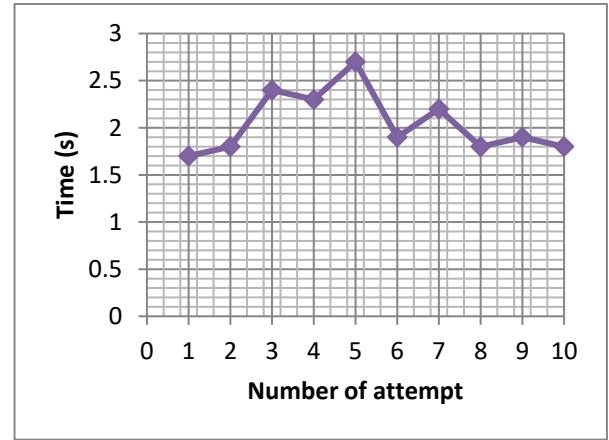


Figure 18. Graph of Number of Attempt vs. Time

The time taken for the application to establish connection with the Bluetooth module is also tested. Shorter time taken is the better. The time taken is recorded using stopwatch. 10 readings are taken and are placed in table 2. The average time taken for a connection to be established is 2.05 seconds.

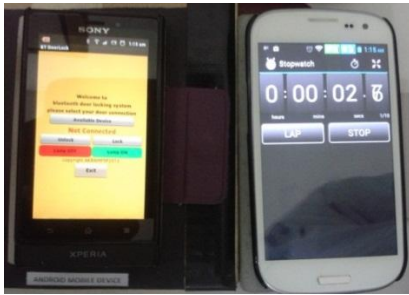


Figure 19. Observing Time to Establish Connection

TABLE III. TIME TAKEN TO ESTABLISH CONNECTION

Attempt	Time (s)
1	1.70
2	1.80
3	2.40
4	2.30
5	2.70
6	1.90
7	2.20
8	1.80
9	1.90
10	1.80

IV. CONCLUSION

The system is reliable to perform locking and unlocking of the door as well as switching on and off the lamp. From the analysis, it can be concluded that the application can be used to all mobile devices running Android OS. Therefore, there are no issues regarding the compatibility of the application with a certain version of Android OS. The analysis also shows that the time taken to establish a connection between apps and Bluetooth module is at an average of 2.05 seconds which can be considered lengthy since the system is intended to be used daily. Other than that, the range of command transfer from the application to the Bluetooth module is shorter when there is obstruction but it is still acceptable since it is meant for NFC. All and all, it is hoped that this type of system will be a pioneer to a greater inventions in the future.

V. RECOMMENDATION

This project can still be developed by adding more features to it. The system can be expanded to not just locking and unlocking the door but also to check the condition of the door from time to time. To achieve that, Bluetooth connection cannot be used because it does not support long range connection and can be replaced by internet connection. The application can alert the user when the door is unexpectedly unlocked and can immediately lock the door. Alarming also can be exploited by detecting the position of user and remind if the door is left unlocked when user is at a certain distance. Moreover, home appliances control can be developed and expanded to not only switching on or off

the appliances but also to control it. For example controlling fan speed or the temperature of the air conditioner. Lastly, there should be a backup power supply for the system if in case there happen to be power shortage. Those developments can ensure that mobile phone to be a very versatile device.

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