



## Android Application Controlled Smart Lab Using Internet of Things

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### Abstract

The objective of this paper is to create a network of connected things and people, so as to make a smart lab with the help of android application using a Message Queuing Telemetry Transport (MQTT) protocol. Internet of Things (IOT) is a recent technology where things like light, fan, door lock which are equipped with microcontroller, transceivers will communicate using communication protocol. The availability of internet enables these appliances to publish and subscribe data. This project work aims to automate the operation of electronic appliances and door lock. It helps to automate the operation of electrical appliances. Thus, it mitigates manpower and helps in secure and energy efficient Laboratory management.

**Keywords:** MQTT; IOT; Automate; Laboratory management

### Introduction

In the near future we will see billions of appliances such as light, fan, electronic lock etc., can sense, communicate and initiate action, which are interconnected over public or private Internet Protocol (IP) networks. These interconnected objects have regularly collected data which are processed, and used to initiate action, thus adding intelligence for planning, management and decision making. Internet of Things plays a major role in automation and security where reliable Internet connectivity becomes necessary. The internet which was previously the network of computers has now evolved into a network of device of all type and sizes such as lights, fans, air conditioners, door lock with added intelligence which are all connected, all communicating and sharing information based on stipulated protocols in order to reduce manpower and achieve energy efficiency and security [1]. It has emerged with the potential to ease human life and enhance safety.

### Proposed Work

The objective of this project work is to develop android application and TI CC3200 controlled IOT based Smart Lab as shown in the

Figure 1 which depicts the block diagram. The following are the tasks to be accomplished to successfully implement the above objective.

- To develop an android application using android studio software.
- To provide authentication and real time database using firebase application.
- To use Message Queuing Telemetry Transport (MQTT) as the communication protocol using MQTT box application.
- To program TI CC3200 launch pad using energia IDE.

### Block Diagram

An android application has been developed using Android Studio Software which will run on a mobile platform. Using a Message Queuing Telemetry protocol (MQTT) the message capsuled in topic is sent to the MQTT broker from which TI CC3200 launch pad subscribes the necessary topics. Then the received message is used to control Electronic Door lock which is connected to the board through a relay (Figure 1) [2].

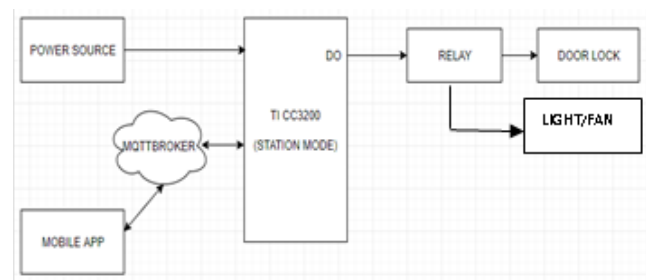


Figure 1: Block diagram.

### Hardware and Software Description

#### TI CC3200 launch pad

The TI CC3200 device has a rich set of peripherals for diverse application requirements. The device gives the application developer the needed advantage by optimizing bus matrix and memory management. The high-performance ARM Cortex-M4 processor meets the needs of minimal memory implementation, reduced pin count, and low power consumption by providing a low-cost platform which delivers outstanding computational performance and exceptional system response to interrupts [3]. To completely offload the host MCU along with an 802.11 b/g/n radio, baseband, and MAC with a powerful crypto engine for a fast, secure WLAN and Internet connections with 256-bit encryption the Wi-Fi network processor subsystem includes a dedicated ARM MCU.

#### Relay specifications

- High current relay, AC250 V 10 A, DC5V 10 A 2-Channel Relay interface board.
- It can be controlled directly with 3.3 V or 5 V logic signals from a microcontroller.
- 2 LEDs to indicate when relays are on.

#### Android studio

Android studio has been used to develop an android application with activities such as login page, User Registration page, options

page, light/fan switch page and door lock button page. Android Studio provides more features to developers such as [4],

- Gradle-based build system which is flexible
- Instant Run option enables to make changes in running app
- Built-in libraries for Cloud Platform namely Firebase and also for messaging protocol named MQTT.

Constraint layout is used to design the activity pages and the login activity page outlook in the device is shown in the Figure 2. When the user logs-in with correct credentials, then, 'Login Successful' pop-up appears and the next activity which is the options activity appears. Firebase authentication is used for user authentication. Firebase realtime database is used to store the user information.

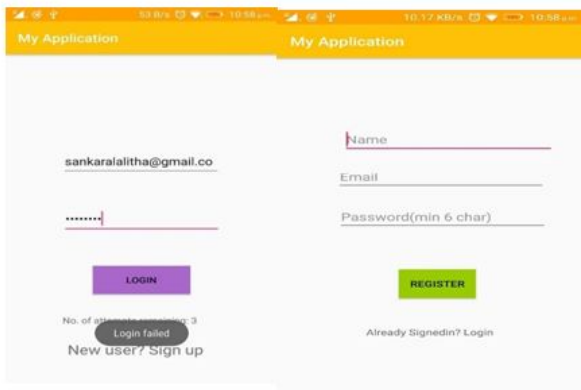


Figure 2: Application outlook in the device.

### Firestore

Firestore is a mobile platform that helps to quickly develop high-quality apps and grow the user base. Firestore supports the following features [5].

- Cloud Storage
- Real-time Database
- Authentication

The firestore realtime database is a cloud-hosted database. Data remains available even when the app goes offline as it is synced across all clients. This feature is used to store the information of users who login into the app. Firestore Authentication provides backend services, easy-to-use SDKs, and ready-made UI libraries to authenticate users to the app. It supports authentication using passwords, phone numbers, popular federated identity providers like google, facebook and twitter, and more.

To sign a user into the app, first get authentication credentials from the user. The user's email address and password are used for authentication as shown in Figure 3. Then, pass these credentials to the firestore authentication SDK. Firestore back end services will then verify those credentials and return a response to the client. The firestore libraries are integrated into the Android studio project by adding the necessary dependencies for the Firestore SDKs.

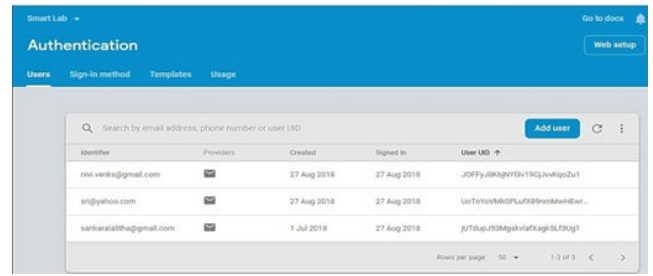


Figure 3: Realtime database and authentication using firestore.

When the user has logged in, an options activity page appears as shown in Figure 4. Now, when the user selects the door button or light/fan button, Third Activity appears, where the user to control the electronic door lock or lights and fans in the lab respectively.



Figure 4: Outlook of options activity in the device.

### Third activity

When the user enters this activity page, it gets automatically gets connected to the MQTT server as shown by the pop up 'Connected' in the Figure 5. Now, when user clicks the Light or fan button, the message is sent to the MQTT server.

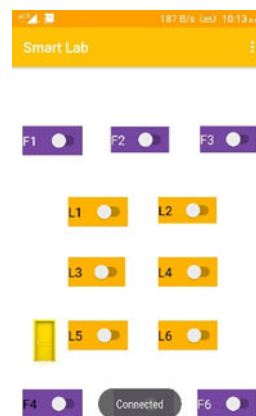


Figure 5: Outlook of third activity in the device.

### Fourth activity

In this activity, a database with a set of passwords is created in android studio. When the user enters the password, it is authenticated by the app and if the password is wrong, 'Enter Correct Password' pop-up appears as shown in Figure 6. When the user clicks the Unlock

button, the message is sent to the MQTT server. The application automatically gets connected to the MQTT server as the user enters the fourth activity.

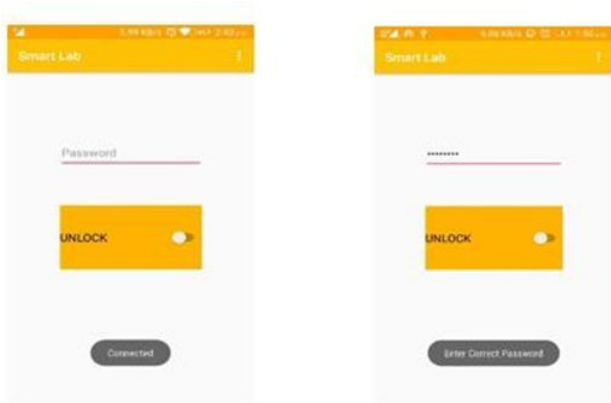


Figure 6: Outlook of fourth activity in the device.

### MQTT- Message Queuing Telemetry Transport

MQTT is a machine-to-machine (M2M) connectivity protocol commonly used in Internet of Things. The MQTT protocol is based on TCP/IP. Both the client and the broker need to have a TCP/IP stack below the MQTT layer.

It is an extremely lightweight publish/subscribe messaging transport protocol. This protocol is bandwidth-efficient and uses little battery power. Publish/Subscribe is event-driven and enables messages to be published by the clients and pushed by the broker. The connection between the client and broker is established using handshake signals. The CONNECT message contains fields like client Id and clean Session. MQTT client is identified using client Id filed. The clean Session flag tells the broker if the session is persistent or not.

When a broker receives a CONNECT message, it acknowledges with a CONNACK message. The CONNACK message contains two data entries:

- The session present flag.
- A connect acknowledge flag.

The session present flag shows the client if the broker already has a persistent session available from previous interactions with the client. The connect acknowledge flag contains a return code that tells the client if the connection attempt was successful.

Now, the Client (Publisher) publishes the topic to the Broker and the client (Subscriber) subscribes for the topic from the broker as shown in Figure 7.

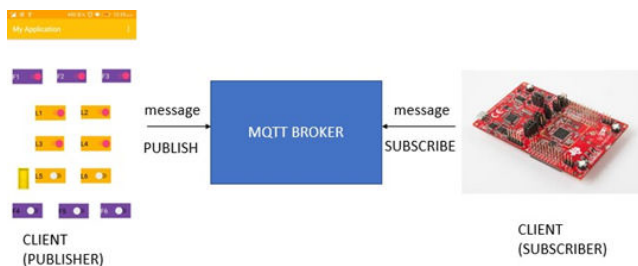


Figure 7: Communication between the mobile application and TI CC3200 launch pad.

The paho android Service is used as an interface to the paho java MQTT client library for the android studio.

### MQTT box

MQTT box is a helper program to develop and load test MQTT based clients, brokers, enabling the users to view the published MQTT messages. The client connection status can be seen in the dashboard as shown in the Figure 8.

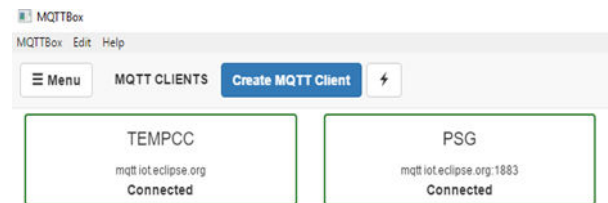


Figure 8: Display of MQTT clients in MQTT box.

All the topics and the corresponding messages which are published by the client can be viewed as shown in the Figure 9.

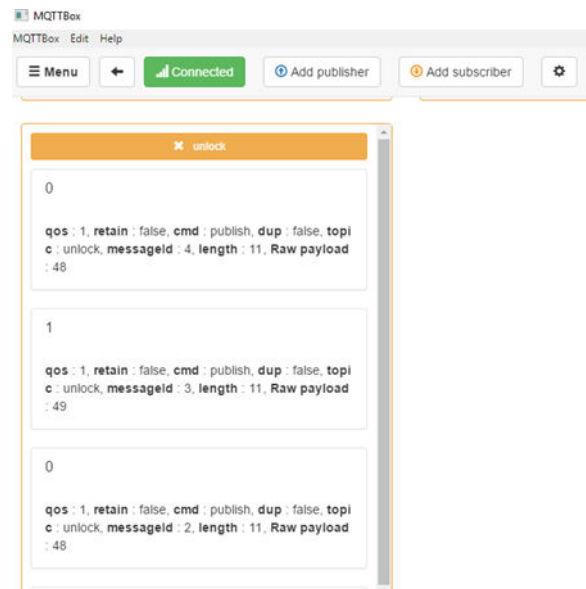


Figure 9: Display of topics and messages published by the client.

## Implementation and Results

### Energia

Energia is an open-source electronics prototyping platform started to bring the wiring and arduino framework to the Texas Instruments MSP430 based Launch Pad. The energia IDE is cross platform and supported on Mac OS, Windows, and Linux. Energia uses the mspgcc compiler and is based on the wiring and arduino framework.

### Implementation details

- Initially, when the user logs in into the android application, the connection is automatically established using MQTT Handshake

protocol between the client (Android Application) and the MQTT Broker.

- When the user presses the appropriate button in the android application, the message is published to the MQTT broker using MQTT Protocol.
- The Client, which is the TI CC3200 launchpad, subscribes the message from the MQTT Broker for every 1000millisecond.
- Depending on the received message, the launchpad controls the relay which in turn controls the electronic doorlock [6].

The implementation setup is shown in the Figure 10. User can choose between IOT and manual mode by using a switch indicated by the box in Figure 11. 34-channel relay are used for 6 fans and 6 lights in the lab.



Figure 10: Demo setup for IOT controlled smart lab.

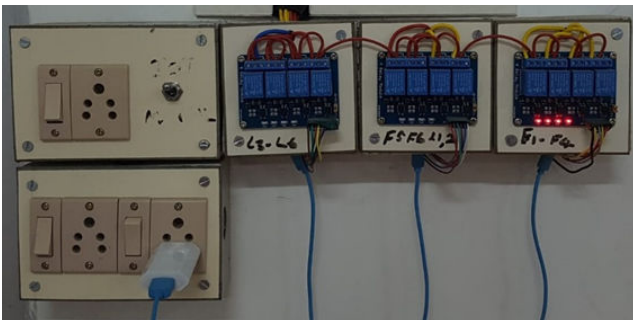


Figure 11: Implementation setup for light/fan control at COE DSP lab.

Door lock which has been implemented in the lab has the following features:

- Unlock continuous electrify time could not exceed 7seconds
- Use a DC 12V, rated current 0.6 A, Size: Approx. 53 × 26 × 23 mm/ 2.08 × 1.02 × 0.9"(L × w × h) (Figure 12) [7, 8].

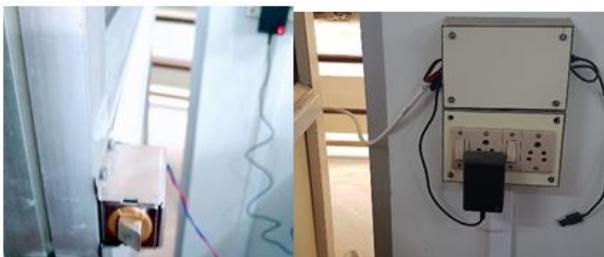


Figure 12: Implementation setup for door lock at COE DSP lab.

## Conclusion

The attempt to implement an android application controlled IOT based smart lab using TI CC3200 launch pad has been performed using message queueing telemetry transport protocol and the results are analyzed. The complete work has been demonstrated and implemented in the centre of excellence laboratory for digital signal processing. The major challenge involved in this work is to establish a reliable network and to include security measures to avoid malicious attackers. Thus, this project mitigates the barriers of time and manpower and helps in laboratory management. This work can be extended to control further many appliances such as air conditioner, projector and computer power supply. Also, this work can be extended to be controlled by voice with IOT.

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