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PRACTICAL IMPLEMENTATION OF IOT BASED CLOUD SERVICES USING TEXAS INSTRUMENTS

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ABSTRACT:
One of the dominant technologies that correlate the things in all directions to web is Internet of Things. Integrating IoT and cloud leads to a new approach called Cloud IoT. This cloud IoT has turned up as an advanced scientific discipline and furthermore anticipated to switch both the future and prevailing internet. The main objects included in this paper are: In detail explanation of cloud computing types along with their service layers. The authors illustrated constructive approach to IoT with a simple link Wi-Fi microcontroller CC3200 along with hardware and respective software. Showcasing a methodology how experimentally measured real time parameters can be accumulated in the particular cloud, accessing and exhibiting the parameters from cloud to external devices/laptops. In Specific, the paper covers the architecture of CC3200 and its supporting clouds, the tools employed in connecting the selected clouds.
Keywords: Temboo, CC3200, M2X, Thing Speak, Cloud computing

INTRODUCTION :

The term IoT is a paradigm refers to a structure of collective network organization of various physical devices [1]. The device may be a object, sensors, humans and things. This typical system facilitates intercommunication between devices and the external world with relevant protocol through wireless sensor networks [2]. Multiple technologies evolved into this field like Zigbee, Wi-Fi, Ethernet, ubiquitous computing, Bluetooth to integrate and transfer the existing data wirelessly using regulatory ambiguities [3].
Improvement in the standardization of these technologies along with internet enlarged the web traffic. Execution of traffic management analysis can be fixed in two ways namely Packet level Traffic measurement and Open platform monitoring. Description of packet level is explained in the context of Packet size and Packet time by encrypting the Transform security and socket layers. Appearance regulation platforms are used to attain and evaluate the traffic and transport layer protocols along with approved architecture to provide measurement parameters. The cloud computing service is a metaphor as it enforces the processing power and limitless storage repository [4]. Cloud technology signifies storing and accessing data over the internet. The cloud platform connects devices, data, apps and services, everything and it provides security to the data [5].Cloud computing prime benefits includes high attainability, resilience, machine dependence and compliance. [6].Figure 1. Shows the service layers of cloud IaaS, SaaS, PaaS.

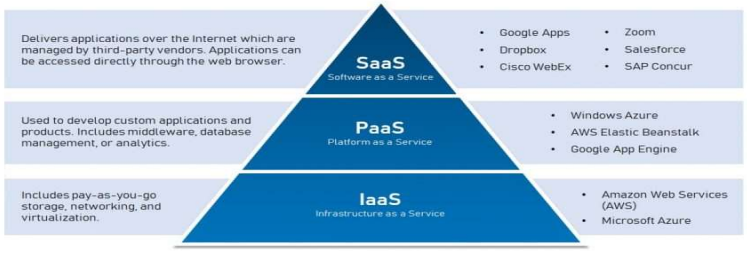

Figure 1: Cloud computing Layered services

Cloud computing gives details about the infrastructure related to hardware and software application and gives control access to providers, suppliers and consumers [7]. It starts working by incorporating the data resources, storage capacity and the captured data from all the interconnected devices [8]. Hence the acquired data can be processed in real time. Computation and storage of data over the cloud can be done in free and pay service. The several layers network, user, OS, hardware, middle ware examine the data [9]. Detailed Introduction of various cloud services is included below.

INFRASTRUCTURE:

Infrastructure studies the data to develop web apps, storage, backup and development, increases scale and performance of IT work loads, optimizes costs enhances business continuity and security disaster recovery, migrates application early to cloud.

IAAS (INFRASTRUCTURE AS A SERVICE):

Today, new billing and metering models allows procurement of hardware and operating system known as IaaS[10]. It is completely IT infrastructure consumed as a service and it is pay as you use basis. But monitoring of data may become more difficult for the user. Different IaaS providers are Microsoft Azure, IBM, VMware, Citrix, Deft, Amazon web service etc of which AWS and Windows Azure cloud services are more popular.

Amazon Web Services(AWS(http://aws.amazon.com): AWS is a Cloud-based IaaS service. It is used to pay-as-a service. The AWS Cloud provides access to the device via an API key.

Windows Azure (https://azure.microsoft.com): Windows Azure is also a Cloud-based IaaS service, used to pay-as-a-service. The Cloud platform provides free services up to 10 API apps, and it is on payment basis.

NaaS (Network as a service): NaaS has recently developed Cloud model that includes services such as Wide area network (WAN) connectivity, data centre connectivity, bandwidth on demand (BOD), security services, and other applications. Different NaaS Cloud providers are AT&T, Verizon, Akamai, Aryaka, Telefonia, of which AT&T is a popular one. AT&T(https://m2x.att.com): AT&T is a Cloud-based NaaS service, on the basis of pay-per-use. AT&T provides multi-level protection of information, data, and data centre environments. The models of security include physical and network security, detection of intrusion, management of firewall, hardening of environment and security of the data.

Different Cloud service providers have used the AT&T service (M2X, Synaptic). M2x and Synaptic Cloud services are allow Restful API key to store and retrieve the real-time data.

PLATFORM:

Paas service is categorized basing on platform level. It runs users existing application over the internet.

PaaS (Platform as a service): The providers of this service include: Microsoft, Google, Sales force of which Google is given below.

Google Cloud: Due to its popularity Google Cloud is a cost-effective PaaS platform. It provides constant data monitoring for exact reproduction. It provides open source Cloud software that can be accessed via API key.

APPLICATION:

IPMaaS, DaaS, SaaS are under the category of application level, which provides the specific application for users. Many software industries and internet services such as IBM, Microsoft, Amazon, Google, etc. are used for development of Cloud services.

IPMaaS (Identity and Policy management as a Service): IPMaaS provided to manage identity and service policy of its customers. It is used to record, capture and manage user identities and

permission to access the services automatically. The IPMaas Cloud providers are Tricipher, Ping Identity and so on. Below is a brief introduction of these Clouds.

Ping Identity: Ping Identity providing secure access that enables and manage user account and to access the things, continuously and securely [11].

DaaS (Data as a Service): It transmits data to consumers over API's. It gives access to desktop visualization, business tethering and provides productivity software. The DaaS Cloud provider is: strike Iron. Here we give a brief introduction about some of these Clouds.

Strike Iron: Using this Cloud the data distribution and consumption can be done through the internet. It also used to control user management and usage reporting for authentication. It uses security and policy mechanism to maintain the user accounts.

SAAS (SOFTWARE AS A SERVICE) :

Users access the cloud based apps from internet through this service. The Saas Cloud providers are IFTTT, Evry Thng, Microsoft, Zoho and so on [12]. Here we give a brief introduction about these Clouds.

EvryThng: It is a centralized SaaS platform used to present the data from the connected things. It allows via RESTful API to store and retrieve the data. It includes MQTT and CoAP protocols.

1.5CC3200 LaunchPad supported Clouds

Different Cloud computing services are available for IoT applications. Among those Clouds, Texas Instrument CC3200 LaunchPad supported Clouds are IBM, Amazon, AT&T M2X, Microsoft, Arrayent, Exosite, Xively, Thing Speak, C2M, CESANTA, Octoblu, PubNub Temboo, CyberVision.

Characteristics of Clouds: The common characteristics of various Clouds are: license type, security/privacy type, standards, payment, user group, standards and agreements. But most of the Clouds are used as open source software and uses HTTP protocol for connecting to the Cloud. In security/privacy, the Cloud services support SSL/TLS encryption and authentication. For standardization, the Cloud services use API Keys. The agreement used in Cloud services are named as SLA[13]. Table 1 shows the characteristics of Clouds that are supported by CC3200.

Table 1. Clouds supported by CC3200 and their characteristics.

S.No	Cloud platform	Service	Licence	User group	Payment	Security/privacy	Standards	Agreements
1.	Xively	Paas	Proprietary	Public	Free for personal use(up to 5 devices)	MQTT	REST API	SLA
2.	ThingSpeak	Server	GPL version 3	Open source	Free for use	FQTT	REST API	No
3.	AT&T	IaaS	Proprietary	Private, public, virtual Cloud	Free or Pay-for-use	FQTT	REST API	SLA
4.	IBM	IaaS, PaaS, SaaS	Proprietary	Private	Pay-as-you-go	MQTT	REST API	SLA
5.	PubNub	IaaS	Proprietary	Private	Free/payment	MQTT/TLS and AES Encryption	REST API	No/SLA
6.	Exosite	PaaS	Libraries only(BSD license)	Open source	Free	HTTP	REST API	No
7.	Temboo	Server	Choreos only	Open source	Payment	MQTT,FQTT,CoAP/TLS encryption	REST API	No
8.	Arrayant	SaaS	Proprietary	Private	Free	HTTP	REST API	No
9.	AmazonWeb Service(AWS)	IaaS	Proprietary	Private	Free up-to 12 months	HTTP	REST API	No
10.	Windows Azure	PaaS, IaaS	Proprietary	Open source	Pay-for-use	HTTP	REST API	SLA
11.	C2M (Cloud contact Management)	SaaS	Proprietary	Private	Free	HTTP, MQTT	REST API	No
12.	Octoblu	SaaS	Proprietary	Open source	Free	HTTP,MQTT,CoAP,XMPP andAMQT	REST API	No

LITERATURE SURVEY :

Several authors carried out different techniques about the practical approach to Cloud computing services. Meriyani et al. has given a survey about Cloud computing services. According to this

survey, the Cloud computing services are used for public and private. Based on the provisions, the services can divide into six types, such as IaaS, NaaS, PaaS, IPMaaS, SaaS, DaaS. [14]. Louay A. Al-Nuaimy et al. has given an explanation about the taxonomy of Cloud computing services. According to the taxonomy of Cloud computing services, the Clouds can be divided in either public or private. The services IaaS and PaaS are the public types and SaaS is a private type. The taxonomy of Cloud gives the characteristics of the Clouds such as license, security, standardization etc[15].Dimitri N has given an analysis of Cloud computing service. The analysis gives the information about broad network access, on-demand self service, resource pooling, sensing and actuating technologies of cloud service.[16]. Sharma et al. have developed smart city monitoring system using ThingSpeak Cloud technology. The sensor data is transmitted to the Cloud using MSP430G2553 MCU. Bluetooth technology is used to upload the data into the Cloud [17]. Elham Fazel has designed implementation of Cloud services for IoT data analysis. The Cloud platforms such as Xively and ThingSpeak are used to save and analyze the measured data. The Arduino board is used to send the values to the Cloud [18]. Following the above literature review, the authors had designed and implemented some of the CC3200 supported Clouds. The authors made successful attempts to connect the sensors and uploads the corresponding data to the different Clouds supported by CC3200 using Wi-Fi technology. The Architecture description of CC3200 launch pad and different clouds are listed below.

ARCHITECTURE OF CC3200 LAUNCH PAD:

In the present work, the implementation of Cloud IoT through on-chip Wi-Fi Texas Instrument's Simple Link CC3200 Launch Pad, by embedding it with specific clouds using Wi-Fi automation. TI is the first company that has released first on-chip Wi-Fi Launch pad CC3200-XL.[19].

On Board Facilities: The board facilities of CC3200 are discussed below.

- CC3200 Launch Pad has onboard Wi-Fi and U.F.L connectors.
- The FTDI and JTAG headers allow connecting, debugging and programming directly from PC USB port.
- Two programmable buttons, one RESET button and three users LED's.
- Thermopile temperature sensor (TMP006) and Tri-axial accelerometer (BMA222).
- 2*20 pin headers, TCP/IP Stack.
- Chip antenna and SOP pins.
- S-Flash 8 Mbit Chip,RTC, 12-Bit ADC
- 802.11 b/g/n protocol and PWM pins
- I2C, SPI, General purpose I/O pins.
- Voltage from 2.1-3.6 V with two AA cells [20].

Figure 2. shows the architecture of the selected microcontroller CC3200-XL Launch Pad. The technical specifications of CC3200 Launch Pad are listed in Table 2. Figure 3. shows the photograph of the CC3200 development board.

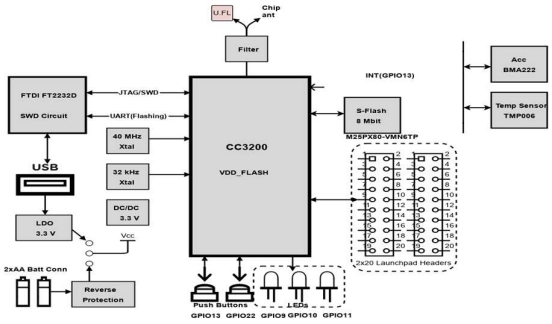

Figure 2: Architecture of CC3200

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Table 2: Specifications of CC3200

Chip	CC3200
Voltage	2.1-3.6V
SRAM	256 Kb
ClockSpeed	80 MHZ
ROM	64 Kb

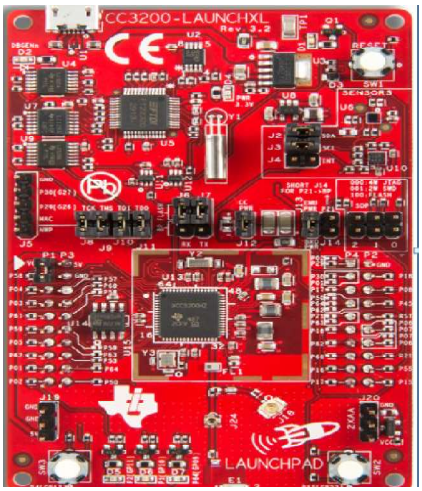

Figure 3: CC3200 Development Board

LAUNCH PAD IN THE CLOUD :

The TI launch pad CC3200-XL supports wide number of clouds but the method of data analyzing and uploading is completely unique for various clouds. The execution of few clouds with CC3200 is listed in the below section.

Temboo:

Temboo Cloud handles IoT applications such as monitoring, controlling, data logging, notifications and more. Temboo software libraries are pre-shipped and integrated into hardware development platforms of Texas Instruments, Samsung, and Android and it supports 10 SDKs. The Cloud supports various M2M protocols such as MQTT, FQTT and CoAP, the developed application code is generated on the Cloud itself automatically [21]. Step by step process to upload and monitor the data using Temboo is listed below.

- Open the website https://www.temboo.com.
- First Create the Temboo account, then Log In to the Temboo. A profile page will be opened. In the profile page select the Texas Instruments and then click the get started now button.
- Click the IoT button file page to ON.
- Select the choreo basing on which type of data to be accessed using Temboo.
- After selecting the choreo, select the LaunchPad and then click the how is connected box window. On this window, select the CC3200 LaunchPad.
- While selecting the CC3200 LaunchPad a pop-up window tell about user connection in which input details are given. On this window, enter the details of security type, SSID name and password and then click Save button.
- Fill the details in 'INPUT' columns, click the 'Run' option.
- After the successful run of choreo, at the bottom of the window with a header file, a code is prompted.
- Now open the Energia and copy the information from the header file and save it as Temboo Account.h.

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- ❖ Compile and upload the code on CC3200 LaunchPad. After uploading the code, the jumper is placed on 'Sop2' position.
- ❖ After uploading the code, Baud rate should be selected as 115200 from the drop down menu.
- ❖ The serial monitor shows the output of temboo data.

Temboo Cloud supports different choreos in which yahoo choreo is explained. In the selected Yahoo choreo, information regarding weather can be captured through its address co-ordinates as shown in the Figure 4.

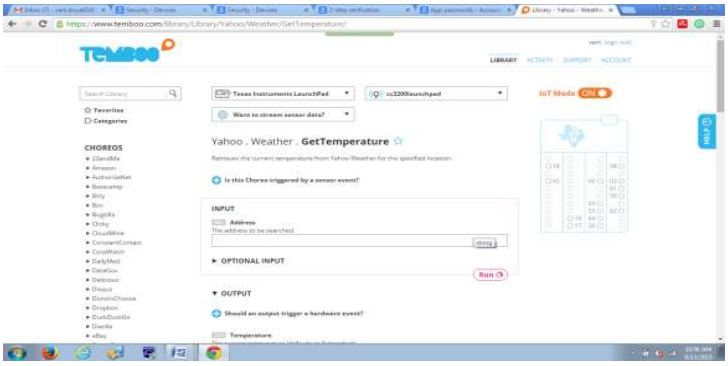

Figure 4: Get temperature window on Temboo main page.

- ♣ Select yahoo→Weather→Get temperature.
- ♣ To obtain the sensed weather data, update the co-ordinates in the main page.
- ♣ Select Run button. After successful run of Yahoo choreo, at the bottom of the header file a code is prompted.
- ♣ Now open the new tab of Energia copy the information from the header file and save it as Temboo Account.h.
- ♣ After the program uploaded on the launch pad, Baud rate should be selected as 115200 from the drop down menu. Now connect the jumper from VCC to P58 pin and click reset pin. The weather parameters displayed on the monitor as shown in the Figure 5. and Figure 6. Shows the development experimental setup.

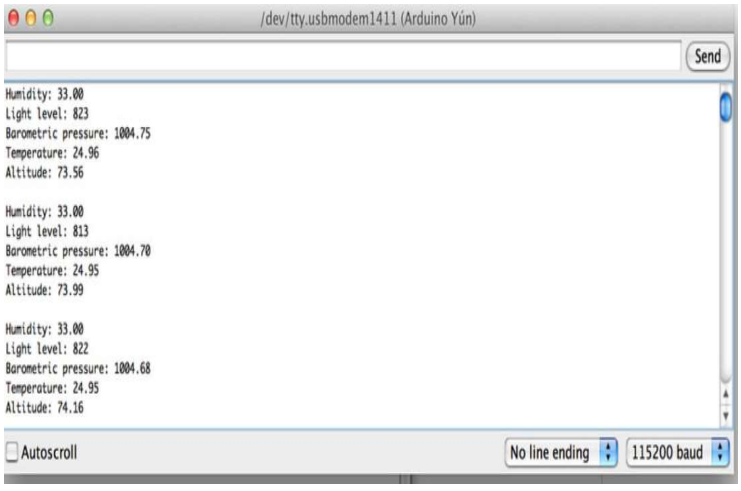

Figure 5: Weather data on the window of serial monitor

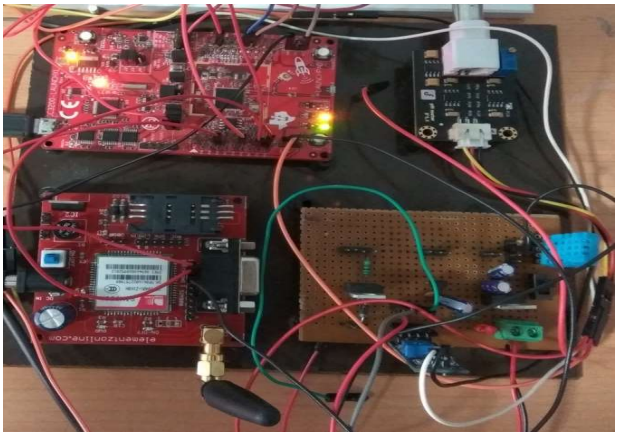

Figure 6: Developed Experimental setup

AT&T's M2X

This cloud is specially designed to collect and store the real time data from inter connected devices and things, the gathered data is shown in the graphical representation on M2X website for further processing[22].

Distinct sensors can easily connect to the M2X Cloud by identifying the device ID, stream name and API key. Energia software has a separate software M2X client library. Launch pad is connected to this cloud through API's libraries. The procedure of Cloud connecting with CC3200 Launch Pad is explained below.

- M2X account is created by signing up in the cloud home page, once the account is created the device can be added to the cloud.
- Click on the left side device button. A new window create a device is opened. On this window enter the device name and select the device as a private or public. If the device is successfully connected, Device Id and API key generated automatically.
- In M2X cloud the sensed data can be viewed through stream name. Enter the full details after clicking ADD STREAM and save button. For M2X cloud data, pressure sensor is interfaced with the CC3200-XL launch pad. Figure 7. shows the sensed data displayed on the cloud. Figure 8. shows the developed experimental setup for pressure measurement.

Code for AT&T'sM2X Cloud:

M2X Cloud supports the libraries for Energia IDE. The values are transmitted using device Id, M2X key, stream name can be obtained from the M2X website. Software is developed using the following algorithm:

- Start and Initialize the suitable libraries.
- Initialize the I2C protocol.
- Enter the AT&T's M2X API key, Stream name.
- Enter the Wi-Fi SSID name and Password.
- Connect to the Wi-Fi.
- Initialize the I2C for weather parameter measurement.
- Read the values of Pressure and Temperature.
- Print the values on Serial monitor.
- Connect the AT&T's M2X Cloud.
- Upload the values to the Cloud via the internet.
- Displayed the Pressure Vs time, Temperature Vs Time On M2X website.
- Disconnected.

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Figure 7: Pressure Values displayed on the window of selected M2X cloud

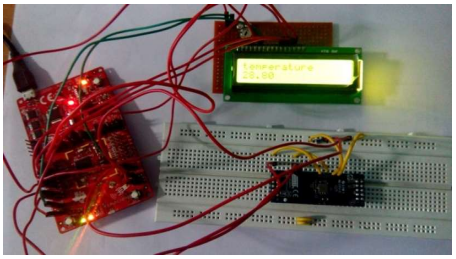

Figure 8: The photograph of the pressure measurement in the laboratory

THING SPEAK:

Thing Speak is a free of cost service as it provides API data platform for IoT. Thing Speak access the sensors and actuators data in real time and to visualize it in terms of charts and Bar graphs. This cloud visualizes the collected data using Software MATLAB along with plug-in creations [23].The main advantage is to review the collected data on Andriod/IoS with ThingView.

Following are the steps to access this cloud.

- Sign up and create an account in the homepage of the cloud.
- After that, log into the newly created account to compose a New channel and unique channel ID will be generated.
- Every channel includes eight data fields to display the data, declare the channel as public or private along with new channel. Once the channel is created, API keys will be generated to read and write the data.

Code for Thing Speak Cloud: The code is written using Energia IDE. HTTP protocol is used to upload the data to the Thing speak cloud.

- Initialize the suitable libraries.
- Enter the Thing Speak Channel Name, API Keys. Enter the Wi-Fi SSID name and Password.
- Connect to the Wi-Fi. To hold the soil moisture analog values, ADC channel-1 should be initialized. Read the Soil moisture values.
- Print the values on Serial monitor along with Wi-Fi IP address and status code.
- Connect the Thing Speak Cloud.
- Disconnected.

In the current work, Soil moisture sensor is interfaced with CC3200-XL launch pad to access the data in the Thing Speak Cloud [24]. Figure 9. Shows the photograph of soil measurement.

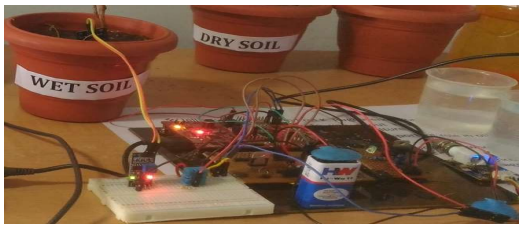

Figure 9: Photograph of the hardware of the soil moisture measurement system

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Sensor values were read by the Thing Speak Cloud via internet connectivity and graphically displayed on the cloud page along with location identification at the institute campus where the experiment is conducted as shown in the Figure 10. The user can import/export data easily from the cloud and the chart view of soil moisture data in the Thing view mobile application [25] as shown in the Figure 11.

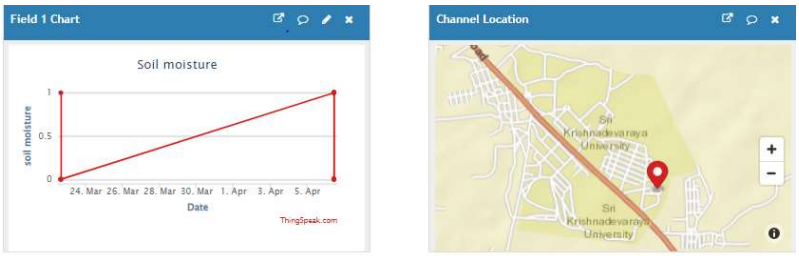

Figure 10: Screenshot of the sensed data over the cloud in the form of graphs along with location

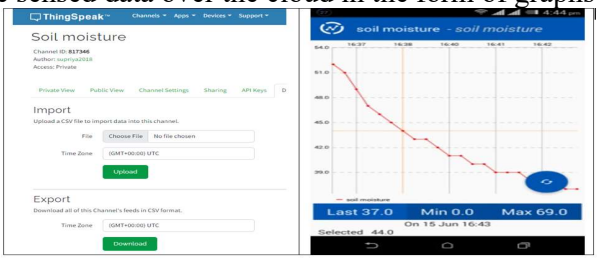

Figure 11: Screenshot of the import/export data window and Thing View application on mobile

CONCLUSION :

The selected Texas instrument's CC3200-XL Launch Pad completely supports wide number of IoT based clouds as listed in the Section 4. For the present work, the chosen clouds are M2X, Temboo and Thing Speak. Among the chosen clouds only Temboo and Thing Speak clouds sends alert to android ios mobile/laptops/PCs where as M2X cloud is unable to send real time alerts. The temperature humidity, pressure and soil moisture are displayed in the cloud and send alerts to trigger and to take appropriate action by the observer.

REFERENCES :

1. Kinza Shafique.; Bilal, A.; Khawaja.; Farah Sabir.; Sameer Qazi.; Muhammad Mustaqim. Internet of Things (IoT) for Next-Generation Smart Systems: A Review of Current Challenges, Future Trends and Prospects for Emerging 5G-IoT Scenarios. IEEE Access 2020, 8, 23022 – 23040.
2. Bahar Farahani.; Farshad Firouzi.; Markus Luecking. The convergence of IoT and distributed ledger technologies (DLT): Opportunities, challenges, and solutions. Journal of Network and Computer Applications. 2021, 177, 1-23.
3. Nasiba, M.; Abdulkareem.; Subhi, R.; Zeebaree.; Mohammed.; Sadeeq.; Dindar Ahmed, Ahmed SAIFULLAH Sami.; Rizgar R.; Zebari. IoT and Cloud Computing Issues, Challenges and Opportunities: A Review. Qubahan Academic Journal. 2021, 1, 1-7.
4. Alhaidari, F.; Rahman, A.;. & Zagrouba, R. Cloud of Things: architecture, applications and challenges. Journal of Ambient Intelligence Humanized computing. 2023, 14, 5957–5975.
5. Mehedi Masud.; Ghulam Muhammad.; Hesham Alhumyani.; SultanS Alshamrani.; OmarChe ikhrouho.; Saleh Ibrahim.; Shamim Hossain. Deep learning-based intelligent face recognitionin IoT-cloud environment. Computer Communications. 2020, 152, 215-222(2020).

6. Sung Won Kim.; Andrea Marin.; Mohsen Guizani. Deep learning for intelligent IoT: Opportunities, challenges and solutions. Computer Communications. 2020, 164, 50-53.
7. K, Sowmya.; Deepika.; J, Naren.; Layers of Cloud – IaaS, PaaS and SaaS: A Survey. International Journal of Computer Science and Information Technologies. 2014, 5, 4477-4480.
8. Motahareh Nazari Jahantigh.; Amir Masoud Rahmani.; Nima Jafari Navimirour.; Ali Rezaee. Integration of Internet of Things and cloud computing: a systematic survey. IET Communications. 2019, 14, 165-176.
9. Neha Thakur.; Avtar Singh.; A.L. Sangal.; Cloud services selection: A systematic review and future research directions. Computer Science Review. 2022, 46, 514-520.
10. Sunilkumar, S.; Manvi.; Gopal Krishna Shyam. Resource management for Infrastructure as a Service (IaaS) in cloud computing:A survey. Journal of Network and Computer Applications. 2014, 41, 424-440.
11. Bader Alouffi.; Muhammad Hasnain.; Abdullah Alharbi.; Wael Alosaimi.; Hashem Alyami.; Muhammad Ayaz. A Systematic Literature Review on Cloud Computing Security: Threats and Mitigation Strategies. IEEE Access. 2021, 9, 57792 – 57807.
12. Alessio Botta.; Walter de Donato.; Valerio Persico.; Antonio Pescapé.; Integration of Cloud computing and Internet of Things:A survey. Future Generation Computer Systems. 2016, 56, 684-700.
13. http://www.ti.com/ww/en/internet_of_things/iot-cloudsolution.html.
14. Meiryani.; Jasmine Mochamm ad Fahlevi.; Agung Purnomo. The Integration of Internet of Things (IoT) And Cloud Computing in Finance and Accounting: Systematic Literature Review. In Proceedings of the 2023 8th International Conference on Business and Industrial Research (ICBIR), Thailand, Bangkok, 18-19 May 2023; pp.525-529.
15. Louay, A.; Al-Nuaimy.; G, Jai Arul Jose.; Mohammed Mastan.; Mohammed, A.; Al-Sharafi.: Cloud computing services and its Effect on tertiary education: Using Google Classroom. In Proceedings of the 2020 7th IEEE International conference on ICT & Accessibility (ICTA), Tunisia, 13-15 December 2019; pp.1-3. Tunisia, pp.1-3.
16. Dimitri, N.; Pricing cloud IaaS computing services. Journal of cloud computing: Advances, Systems and Applications. 2020, 9, 1-11.
17. Sharma.; N, Kumar.; and J, Park. Block chain-based distributed framework for automotive industry in a smart city. IEEE Transactions on Industrial Informatics. 2019, 15, 4197–4205.
18. Elham Fazel, Mahmoud.;Zahedian Nezhad, Javad Rezazadeh.; Marjan Moradi.; John Ayoade . IoT convergence with machine learning & blockchain: A review. Internet of Things Elsevier. 2024, 26, 101187-197.
19. CC3200 Launchpad Datasheet, https://www.ti.com/lit/ds/symlink/cc3200.pdf
20. CC3200 Launchpad specifications. http://www.ti.com/general/docs/lit/getliterature.tsp?genericPartNumber=cc3200&fileType=pdf.
21. Temboo cloud home page, https://temboo.com.
22. M2X home page, https://m2x.att.com/develop/documentation/v2/overview.
23. Thing Speak cloud home page, https://thingspeak.com
24. Palle, V.; Kanchi, RR. Cloud-Based monitoring and measurement of pressure and temperature using CC3200. In Proceedings of the 2017 11th IEEE International Conference on Intelligent Systems and Control (ISCO), Coimbatore, India, 05-06 January 2017,; pp.393-397.
25. Divyavani, P.; Raghavendra Rao, K.; Measurement and Monitoring of Soil Moisture using Cloud IoT and Android System. Indian Journal of Science and Technology. 2016, 9, 1-8.