DESIGN AND IMPLEMENTATION IOT²ALK CLOUD COMPUTING PLATFORM FOR IOT APPLICATIONS

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Abstract. An integration between the Internet of Things (IoT) and cloud computing can potentially leverage the utilization of both sides. As the IoT-based system is mostly composed of the interconnection of pervasive and constrained devices, it can take advantage of the virtually unlimited resources of cloud entities, i.e., storage and computation services, to store and process its sensed data. In this study, we examine the design and implementation of IoT and cloud computing platforms. The proposed system consists of two main components: hardware and software. Many experiments are used to gather data and upload it to the framework. The software is an IoT2ALK platform that is designed and implementation using front- and back-end techniques that can connect any IoT applications to it. Several experiments are implemented to ensure the effectiveness of the platform. The platform depends on connecting the IoT devices to it and using communication protocols like HTTP to transfer the data from the IoT devices to the platform. Another way to gather data is by uploading a CSV file to the platform after filling it with the required data. The system can collect, store, analyze, and process the data in an efficient manner

1 Introduction

The cloud is an expansive and highly interconnected system of powerful servers that provide various services to individuals as well as corporations. The Internet of Things (IoT) is a system that consists of interconnected computing devices, digital machines, objects, or people who are given the ability to transfer data over a network without the need for human-to-human or human-to-computer interaction. This is accomplished through the use of unique identifiers that are assigned to each component of the system. The Internet of Things has progressed alongside the expansion of data generation. Cloud services for the Internet of Things generate an excessive amount of communication between the IoT's very affordable sensors, which results in an even higher level of connectedness. In the near future, billions of connected machines and devices will join human users. The Internet of Things produces a large amount of data, and cloud computing creates the opportunity for this data to move around [1]. The Internet - of - things platform provides
hardware and software support for building on the system. The platform adheres to some basic framework implementation guidelines and enables best application functionalities for the assigned purpose. There are several IoT platforms on the market, and it is nearly impossible to identify any of the optimal solution among all accessible platforms. Because these platforms are private, they keep their communication model and data secret [2]. The system's user must be well-versed in the interconnection of many platforms. Cross-platform APIs are frequently used for data integration across platforms. When the framework is not open source and doesn't let any API to reach its data without private benefits, it becomes problematic. When data is transmitted or merged via a cross-platform or cross-domain application, compatibility is accomplished.

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Famous IoT platforms include Kaa and EclipseIoT; the remaining platforms have proprietary rights and are not accessible as open-source platforms [3].

2 Related Works

In 2018 Ref. [4], Researchers highlight the Cloud-based IoT platform's connectivity, computing, and storage. This framework may employ Cloud services to gather, transmit, analyze, process, and store device data. They're also Cloud-based IoT deployments. In 2019 Ref. [5], in this study the proposed IoT platform is plug-and-play. The IoT platform varies from IoT marketplaces, where users may create apps using virtual objects. CoT virtual products power IoT platform and marketplace experiments. Safe and user-friendly IoT platform suggested. Case study and household IoT testbed use virtual marketplace products. Share virtual items. Comparing IoT to FIWARE The proposal outperforms FIWARE. In 2019 Ref. [6], Researchers present smart parking framework model integrates sensor data and data processing. These systems use parking lot sensors and equipment to provide real-time data to cloud servers via edge computers. Real-time data from city parking server creates mobile apps. Fuzzification can simulate urban parking challenges. City parking challenges are addressed through analyzing fuzzy logic systems. This study uses the Mamdani Fuzzy Inference System to build a smart parking system. These conclusions are verified using MATLAB. In 2019 Ref. [7], this study creates a simple, cost-effective health monitoring and fall surveillance system using off-the-shelf electrical components. A microcontroller, sensors, and transmitter relay patient data to the cloud. This article describes a wearable fall detection device. This speech-recognition technology determines if a patient needs aid following a fall, reducing false alerts and enhancing system efficiency.

In 2020 Ref. [8], in this article, researchers explain creating a smart home system utilizing IOT and cloud computing to estimate energy use and pricing. The proposed system captures power usage, indoor temperature, humidity, and meteorological data, and uses cloud computing for data storage and energy consumption prediction using time series forecasting techniques. Users can track energy usage, expenses, and expected usage in real time using a cloud-based dashboard. To measure indoor temperature, researchers used DHT11 and Arduino ESP8266. Have created Google Cloud Platform (GCP) apps and tools to gather, store, and anticipate sensor energy data.

In 2021 Ref. [9], this paper offered a wearable technology and cloud computing platform for smart maternal healthcare. We explore its use, tracking, and management in obstetric departments. The IoT-based Smart Maternal platform can reduce medical staff workload, increase work efficiency, and improve obstetrical care. In 2022 Ref. [10], in this research, authors describe a novel way to improving real-time data in IoT sensor networks. A look into IoT-enabled cloud platform components On top of it, an IoT-enabled sensor network framework is introduced. Optimizing data in IoT-enhanced sensor networks is also proposed. In this paper, authors proposed MIDDO for IoT-assisted sensor networks.

3 Proposed Platform

This section focuses on the design and implementation of the IoT cloud platform component. Fig. 1 depicts a building block for the proposed platform. The suggested platform is divided into two parts: the front end and the back end. The front end is the interfaces between the IoT devices and the cloud. The back end provided software services such as cloud interface, communication, and data management.

3.1 The Proposed Platform Frontend

The "front end" refers to the user interface. The server receives a request from the user, verifies it, and sends it to the client after retrieving the necessary information from the database. The prime interface includes the proposed platform's name as well as several menus. The platform proposal team created the frontend design and implemented the system's user experimentation aspects. At this point, it displays the most essential methods, such as (platform design and web server), as well as the programming languages that were used in the act of designing and developing the proposed platform [11].

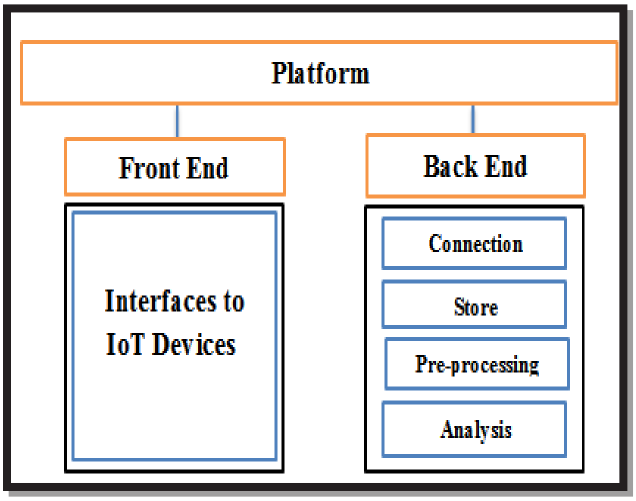

Fig. 1 Proposed Platform

3.1.1 PHP Hypertext Preprocessor

It is a programming language that was created to facilitate the generation of dynamic content. Additionally, PHP permits this dynamic content to interact with databases. PHP is a server-side language of programming, which means PHP documents reside on a remote or local server rather than being uploaded onto a client-side computer's browser [12].

3.1.2 Asynchronous JavaScript and XML (Ajax)

Is a term that refers to a group of related web technologies. is also known as asynchronous JavaScript and XML. These technologies enable web developers to create web applications that can interact with users dynamically and work in the background with web servers to recover application data [13].

3.1.3 HTML (Hyper Text Markup Language)

Is the most widely used programming language for creating Web pages. Additionally, it is a necessity for JavaScript and CSS. HTML documents, the basis for all content on the World Wide Web (WWW), consist of two basic components: information content and a set of instructions that instruct your computer on how to display that information [14].

3.1.4 JS (JavaScript)

It is a computer language designed for developing network-centric applications. JavaScript is automatically combined with Java. This programming language actually complements Java. In addition, for JavaScript to be executed, the code must be combined into an HTML file. The primary characteristics of this programming language are its cross-platform nature and its open source availability. JavaScript is an object-oriented programming language that is interpreted (rather than compiled) and designed to work in tandem with other web technologies. JavaScript is not a standalone programming language [15].

3.1.5 CSS (Cascading Style Sheets)

Specifies how HTML elements should appear on screen, paper, or in other medium. CSS saves a significant amount of time. It has the ability to control the layout of numerous web pages at the same time. CSS can be used to control the color of the text, font style, paragraph spacing, how columns are scaled and laid out, what background pictures or colors are used, layout designs, and differences in display for various screen sizes and devices among other things [16].

3.1.6 A web server

Is what makes it possible to access material such as web pages and other data from anywhere with an internet connection. The hardware stores the content, while the software provides internet access to the content. Web servers are most commonly used to host websites, but they can also be used to store data or operate enterprise software. Additionally, there are other methods to get information from a web server. In the proposed solution, the Apache web server is used [17]. Apache is often regarded as the most used Web server on the planet (HTTP server). The Apache Web server was originally developed for UNIX servers but has now been ported to Windows and other network operating systems. The term "patchy" was used by the Apache developers to describe early versions of their software, hence the name "Apache." The Apache Web server offers a comprehensive set of Web server services, such as Computer - generated imagery (CGI), secure sockets layer (SSL), and virtual domains. Also supporting plug-in modules for extensibility is Apache. Apache is dependable, open-source, and straightforward to conFig. Apache is offered as free software by the Apache Software Foundation. The Apache Software Foundation promotes advanced Web technologies that are both free and open-source [18].

3.2 The Proposed Platform Backend

The backend of the IoT2ALK platform is primarily concerned with developing apps that can identify and provide data to the front end. A programming language, communication protocol, databases, and some techniques are used to code IoT2ALK platform's back end as shown in Fig. 1 and is discussed below.

3.2.1 The Communication Protocols

In the proposed system, the stage of communication systems utilized with physical devices to generate, receive, and exchange data effortlessly. IoT applications strive to automate diverse tasks and enable passive physical objects to function autonomously [19]. The Internet of Things (IoT) is a complicated technology that serves as an extension of the current Internet by integrating digital technology into our physical world via Ethernet and WiFi. Protocol-based IoT device-to-device interactions allow Internet-connected devices to transmit information, send and receive orders, and connect with each other in general. A protocol is a standardized, structured method about communication among network. They specify what is to be delivered and reception, as well as the appropriate responses. The most prevalent data transmission and reception protocols are HTTP, MQTT, and CoAP [20]. HTTP was applied in proposed work; HTTP is an application layer protocol for scattered, cooperative hypermedia networks. HTTP is a TCP/IP-based protocol used to send data over the Web, with port 80 as the default. HTTP's connectionless, media independence and statelessness make it a successful protocol. This protocol was created for HTTP-based IoT. Restful Architecture mimics HTTP. Restful Architecture uses GET, POST, PUT, and DELETE to facilitate client-server interactions [21]. Handshake began HTTP communication. Client-server connections are made using handshake protocols. A synchronization packet starts the server connection. This packet secures the client-server connection. The server answers to a SYN message with a SYN-ACK packet. SYN-ACK packets acknowledge synchronization. This packet alerts clients to start sessions. Client sends ACK packet in response to server's SYN-ACK packet. After this packet, the client and server will have a trustworthy session [20].

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3.2.2 Data Storing

Due to the necessity of storing data that must be rapidly retrieved and assessed, numerous IoT data storage strategies have arisen. There are three basic types of Internet of Things data: structured, unstructured, and semi-structured [22]. Database design is a collection of methods and actions that enhance the planning, development, implementation, and maintenance of a commercial data management system. The amount of disk storage capacity has a considerable impact on the cost-effectiveness of a database's design, which saves maintenance costs and increases data consistency [23].

Database systems

That manage the data types are divided into several categories as illustrated in Fig (2), the most prevalent of which are Relational and Non-Relational Databases, Hierarchical Databases, and Cloud Databases. Among the most common database environments is MySQL DB is a freely available database management system. The system comprises a server and a client. After linking a client to a server, users are able to enter Sql queries to the server to build databases, delete databases, save, arrange, and retrieve data from the database. MySQL and PHP have become the backbone of the majority of

websites for data management and e-commerce. The fundamental data types utilized by MySQL, which mostly fall into three categories: numeric, string, and date/time. This database type was used for the proposed method [24].

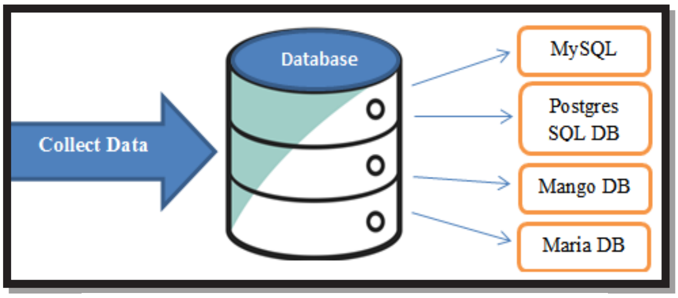

Fig. 2. Store Data

3.2.3 Data Preprocessing

Data pre-processing is the process of converting raw data into a comprehensible format. The preprocess data can then be put through a model after the transformation. Actual data is typically imperfect, i.e. lacking attribute values, lacking certain attributes of interest, or containing only aggregate data, inconsistent, i.e. containing name discrepancies, noisy, i.e. containing errors or outliers and/or lacking in certain behaviors or trends, and is prone to many errors. Data preparation is a tried-and-true way for dealing with such problems [25]. Pre-processing data is a critical stage in data preparation. It is the method of converting raw data into clean data. The raw data is insufficient for analysis. It goes through various iteration procedures. Data pre-processing is primarily required in data science models that require the data to be in a specific format [26].

3.2.4 Data visualization

Data visualization is the mapping from data space to graphic space, i.e., processing and filtering the data, changing it into an expressible visual form, and displaying it for the user. The visual display of information and data using graphical components such as charts, graphs, and maps is data visualization. Invisible trends, outliers, and complicated patterns in data can be viewed and comprehended with the assistance of data visualization tools [27]. Data visualization that transforms abstract data into real insights (such as length, position, shape, and color, etc.) is crucial for enhancing data processing and analysis through the application of human abilities. Data visualization can facilitate the extraction of more complex information [28].

4 Experiments and Results

4.1 First Experiment

The first experiment covers IoT2ALK platform. Building a small system that transmits data of the temperature, humidity, level of the weather. The components involved in this system are:

4.1.1 IoT Devices

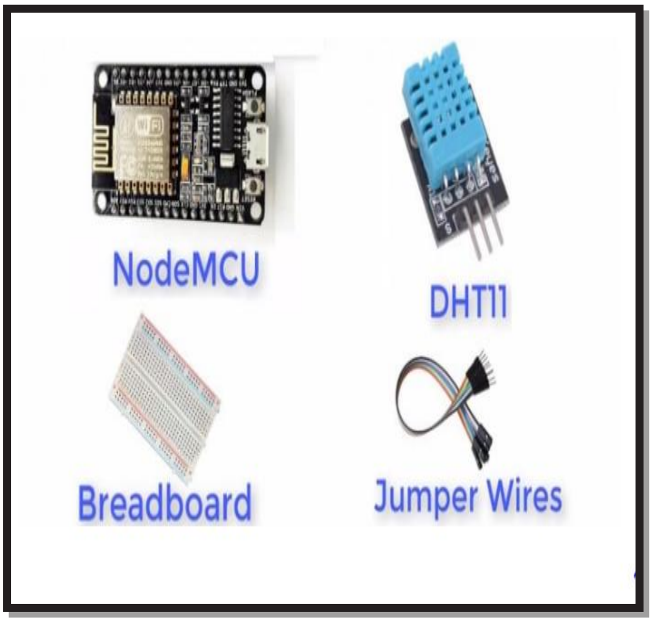

Fig.3. shows a list of all the hardware components needed to construct the temperature/humidity weather station.

- A DHT11 temperature/ humidity sensor.
- A gadget using an Arduino ESP8266 microcontroller node tracks temperature and humidity levels and sends a message to IoT2ALK.
- Breadboard Arduino.
- Jumper wires

4.1.2 Software Required

- Arduino IDE.
- IoT2ALK (hosted)

(http://beitacademy.com/iot/iot/index.php).
Fig. 4 exhibits the complete circuit of the first experiment after all components have been assembled and are now ready to test data transmission from the sensor to the node and then to the (IoT2ALK) platform.

4.1.3 Connecting to Platform

IoT2ALK platform is using HTTP API application to communicates between two systems using the HTTP. The user sends information from IoT devices to the database using the HTTP protocol. HTTP APIs provide endpoints as API gateways, enabling HTTP requests to connect with a server. To establish a connection between IoT devices and the platform and begin exchanging data, there are some step must be following as shown in flowchart Fig. 5

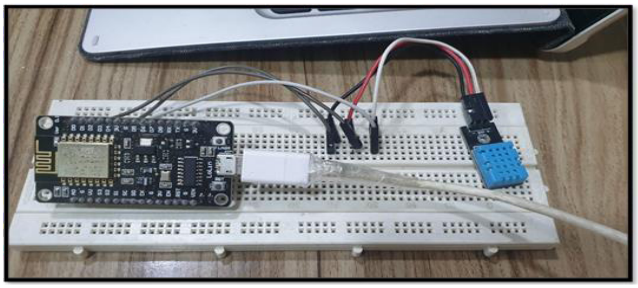

Fig. 4 . The entire Circuit of the First Experiment

- Start.
- Enter the name and password of the Wi-Fi connection in the IoT devices to establish a connection to the cloud platform. Enter the server name.
- If the internet is available
- Yes: go to channel id, and entering the channel id.
- No: return to step 2.
- The sensor will be sensing the data.
- If the HTTP response from server
- Yes: sending data to cloud-No: return to step 2.
- Show the data in platform with visualization techniques.

*4.1.4 **The Results***

The results of the first experiment to measure the temperature and humidity level in the air showed that on the date 12-13-2022 at (4:30 PM) Iraqi time, the temperature (24.8Co) and the humidity level ranged between (32% - 33%). Fig. 6 shows the graph of the results as well as the Excel file for the channel (Weather Station).

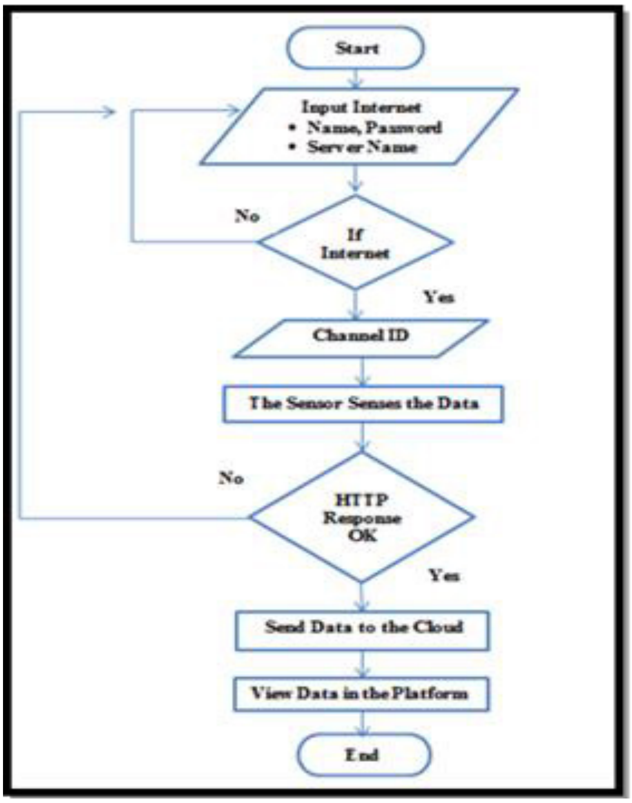

Fig. 5. Flowchart Connec tio Platform

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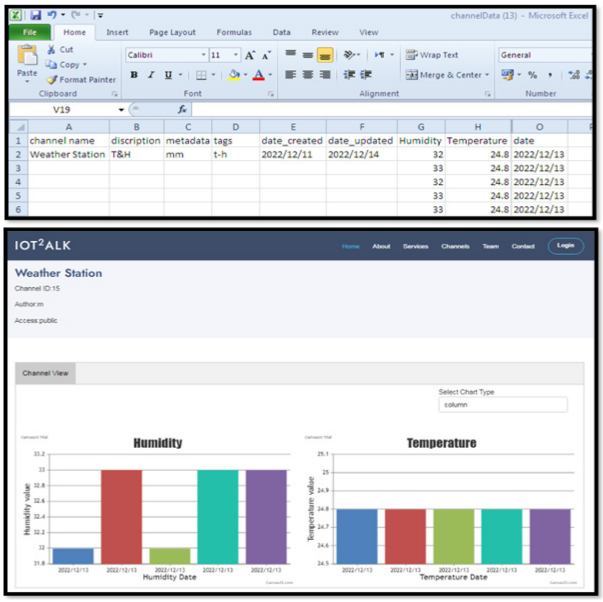


	A	B	C	D	E	F	G	H	O
1	channel name	discription	metadata	tags	date_created	date_updated	Humidity	Temperature	date
2	Weather Station	T&H	mm	t-h	2022/12/11	2022/12/14	32	24.8	2022/12/13
3							33	24.8	2022/12/13
4							32	24.8	2022/12/13
5							33	24.8	2022/12/13
6							33	24.8	2022/12/13

Fig. 6. Results of the First Experiment

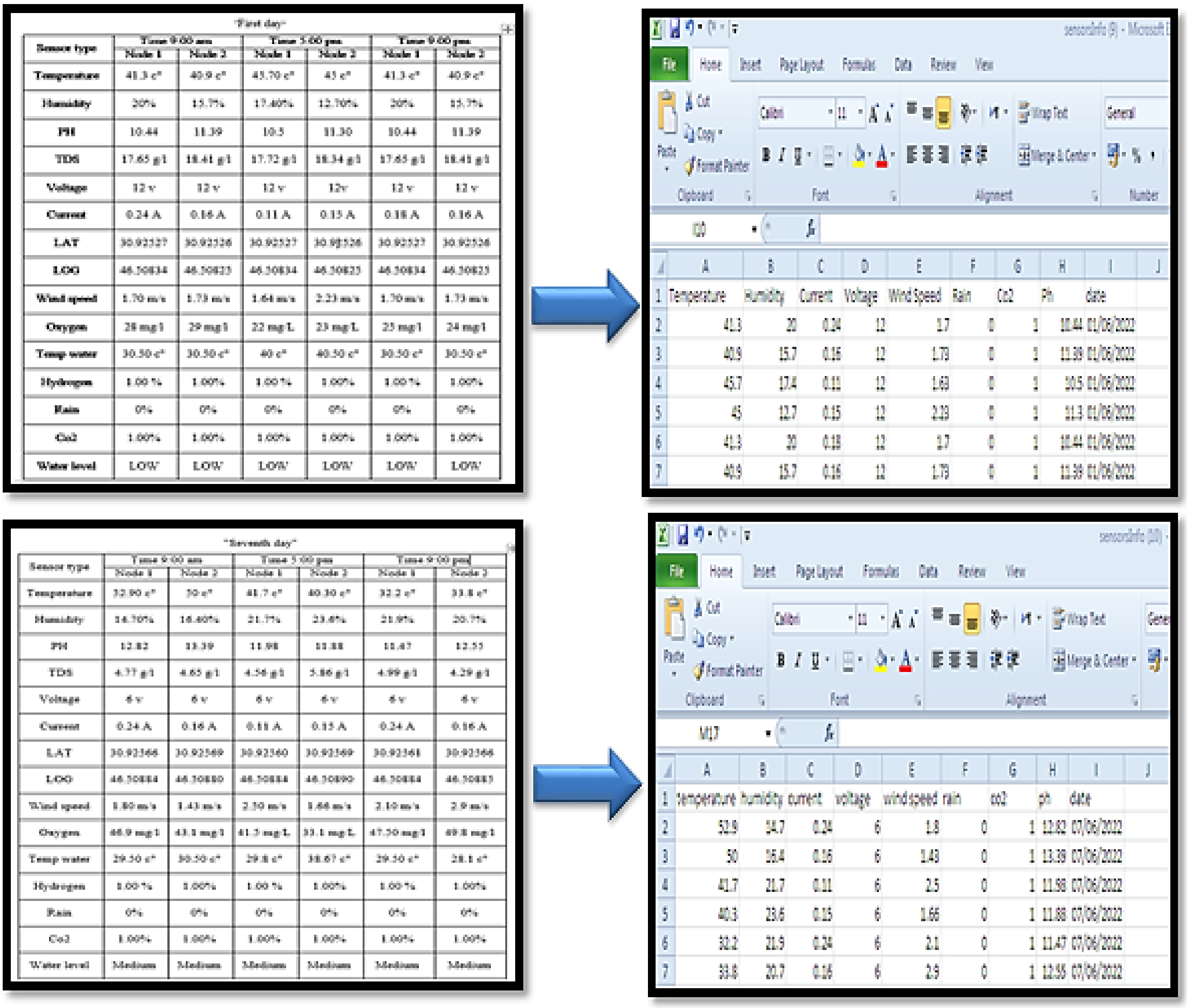
- Sensor Data in an Excel File
- Channel data analysis

4.2 Second Experiment

The second experiment is to use a form of an Excel file available on the platform and fill it with a set of data for the purpose of storing, displaying and analyzing it on the platform.

Two channels under the name (Marshlands 1, Marshlands 2) were created by a user, each channel contains eight sensors and they are (Temperature, Humidity, PH, Voltage, Current, Wind speed, Rain, CO2). This user has a dataset for all these sensors as shown in Fig. 7. To fill in the platform's Excel file, the user did the following:

- The user downloads an Excel file from channel tab, then click on data import/export, then download the Excel file under the name (sensorsInfo).
- All sensor data for the two user channels were filled in an Excel file and uploaded to the platform via the Upload tab of the same page.
- We go to the channel view tab to ensure that the data is stored correctly and then displayed with the analysis tools available on the platform.



"First day"

Sensor type	Time 9:00 am		Time 3:00 pm		Time 9:00 pm	
	Node 1	Node 2	Node 1	Node 2	Node 1	Node 2
Temperature	41.3 c°	40.9 c°	45.70 c°	45 c°	41.3 c°	40.9 c°
Humidity	20%	15.7%	17.40%	12.70%	20%	15.7%
PH	10.44	11.39	10.5	11.30	10.44	11.39
TDS	17.65 g/l	18.41 g/l	17.72 g/l	18.34 g/l	17.65 g/l	18.41 g/l
Voltage	12 v	12 v	12 v	12v	12 v	12 v
Current	0.24 A	0.16 A	0.11 A	0.15 A	0.18 A	0.16 A
LAT	30.92527	30.92526	30.92527	30.92526	30.92527	30.92526
LOG	46.30834	46.30825	46.30834	46.30825	46.30834	46.30825
Wind speed	1.70 m/s	1.73 m/s	1.64 m/s	2.23 m/s	1.70 m/s	1.73 m/s
Oxygen	28 mg/l	29 mg/l	22 mg/L	23 mg/L	25 mg/l	24 mg/l
Temp water	30.50 c°	30.50 c°	40 c°	40.50 c°	30.50 c°	30.50 c°
Hydrogen	1.00 %	1.00%	1.00 %	1.00%	1.00 %	1.00%
Rain	0%	0%	0%	0%	0%	0%
Co2	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%
Water level	LOW	LOW	LOW	LOW	LOW	LOW

	A	B	C	D	E	F	G	H	I
1	Temperature	Humidity	Current	Voltage	Wind Speed	Rain	Co2	Ph	date
2	41.3	20	0.24	12	1.7	0	1	10.44	01/06/2022
3	40.9	15.7	0.16	12	1.73	0	1	11.39	01/06/2022
4	45.7	17.4	0.11	12	1.63	0	1	10.5	01/06/2022
5	45	12.7	0.15	12	2.23	0	1	11.3	01/06/2022
6	41.3	20	0.18	12	1.7	0	1	10.44	01/06/2022
7	40.9	15.7	0.16	12	1.73	0	1	11.39	01/06/2022

"Seventh day"

Sensor type	Time 9:00 am		Time 3:00 pm		Time 9:00 pm	
	Node 1	Node 2	Node 1	Node 2	Node 1	Node 2
Temperature	32.90 c°	30 c°	41.7 c°	40.30 c°	32.2 c°	33.8 c°
Humidity	14.70%	16.40%	21.7%	23.6%	21.9%	20.7%
PH	12.82	13.39	11.98	11.88	11.47	12.55
TDS	4.77 g/l	4.65 g/l	4.56 g/l	5.86 g/l	4.99 g/l	4.29 g/l
Voltage	6 v	6 v	6 v	6 v	6 v	6 v
Current	0.24 A	0.16 A	0.11 A	0.15 A	0.24 A	0.16 A
LAT	30.92568	30.92569	30.92560	30.92569	30.92561	30.92568
LOG	46.30884	46.30880	46.30884	46.30890	46.30884	46.30883
Wind speed	1.80 m/s	1.43 m/s	2.50 m/s	1.66 m/s	2.10 m/s	2.9 m/s
Oxygen	46.9 mg/l	43.1 mg/l	41.3 mg/L	33.1 mg/L	47.30 mg/l	49.8 mg/l
Temp water	29.50 c°	30.50 c°	29.8 c°	38.67 c°	29.50 c°	28.1 c°
Hydrogen	1.00 %	1.00%	1.00 %	1.00%	1.00 %	1.00%
Rain	0%	0%	0%	0%	0%	0%
Co2	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%
Water level	Medium	Medium	Medium	Medium	Medium	Medium

	A	B	C	D	E	F	G	H	I
1	temperature	humidity	current	voltage	wind speed	rain	co2	ph	date
2	32.9	14.7	0.24	6	1.8	0	1	12.82	07/06/2022
3	30	16.4	0.16	6	1.43	0	1	13.39	07/06/2022
4	41.7	21.7	0.11	6	2.5	0	1	11.98	07/06/2022
5	40.3	23.6	0.15	6	1.66	0	1	11.88	07/06/2022
6	32.2	21.9	0.24	6	2.1	0	1	11.47	07/06/2022
7	33.8	20.7	0.16	6	2.9	0	1	12.55	07/06/2022

Fig. 7. Excel File Import to the Platform Part 1 and Part 2

Seq.	Marshes land 1		Marshes land 2	
	Sensor	Value	Sensor	Value
1	Temperature	(40-46) C^0	Temperature	(32.2-52.9) C^0
2	Humidity	(12-20)%	Humidity	(14.7-23.6)%
3	Current	(0.11-0.24)A	Current	(0.1-0.24)A
4	Voltage	12 V	Voltage	6V
5	Wind Speed	(1.6-2.3)Km/H	Wind Speed	(1.43-2.9) Km/H
6	Rain	0	Rain	0
7	Co_2	1 M	Co_2	1M
8	PH	10.4-11.4	PH	11.47-13.39

Fig.8.Marshland Channels Results

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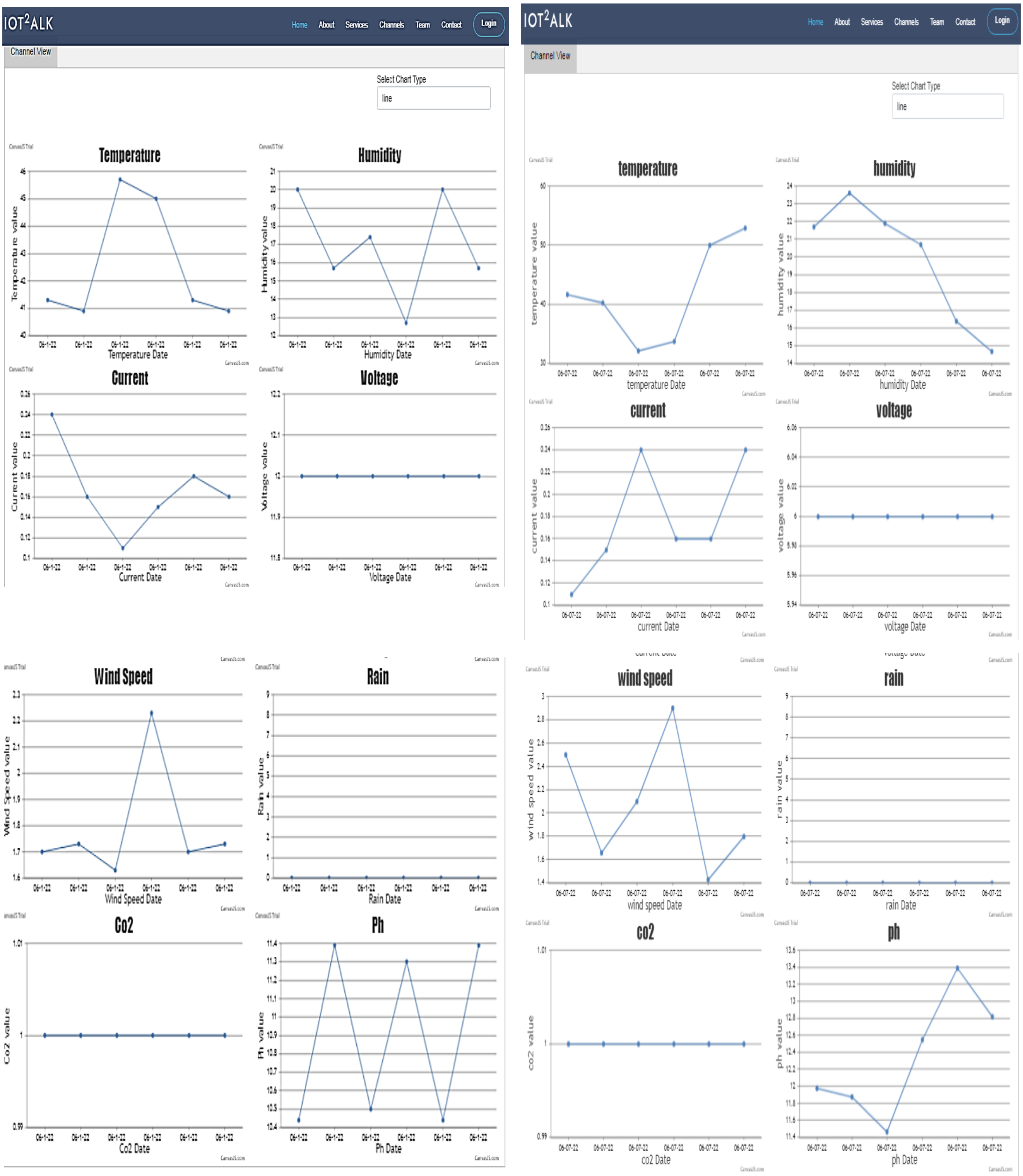
The above results were analyzed in the two channels by the analysis tools in the platform, and as shown in the Figure 9



A B

Fig. 9 A. Marshland1 Analysis b. Marshland2 Analysis

The first, graph represents the temperature sensor in Fig (8,a), (8,b), the first column in the Excel file for both terminals Fig. 9. The highest value (45.7 C0) and lowest value (40.9 C0) for 24 hours were brought by the sensor

	A	B	C	D	E	F	G	H	I
1	Temperature	Humidity	Current	Voltage	Wind Speed	Rain	Co2	Ph	date
2	41.3	20	0.24	12	1.7	0	1	10.44	01/06/2022
3	40.9	15.7	0.16	12	1.73	0	1	11.39	01/06/2022
4	45.7	17.4	0.11	12	1.63	0	1	10.5	01/06/2022
5	45	12.7	0.15	12	2.23	0	1	11.3	01/06/2022
6	41.3	20	0.18	12	1.7	0	1	10.44	01/06/2022
7	40.9	15.7	0.16	12	1.73	0	1	11.39	01/06/2022

	A	B	C	D	E	F	G	H	I
1	temperature	humidity	current	voltage	wind speed	rain	co2	ph	date
2	52.9	14.7	0.24	6	1.8	0	1	12.82	07/06/2022
3	50	16.4	0.16	6	1.43	0	1	13.39	07/06/2022
4	41.7	21.7	0.11	6	2.5	0	1	11.98	07/06/2022
5	40.3	23.6	0.15	6	1.66	0	1	11.88	07/06/2022
6	32.2	21.9	0.24	6	2.1	0	1	11.47	07/06/2022
7	33.8	20.7	0.16	6	2.9	0	1	12.55	07/06/2022

Fig. 10. Sensors values

to the first station. For the highest value (52.9), and lowest value (32.2) brought by the same sensor to the second station for another 24 hours. The wind sp eed which is fifth chart, the highest and lowest values in per (2.23, 1.63) for the first station, while the second station were (2.9, 1.43). We are observing the change in the sensor values from time to time.

Conclusion

The implementation and design of a platform (IoT2ALK) based on the Internet of Things and cloud computing, together with all of its components for data collection, storing, processing, and analysis, were described in this study. The suggested platform has been used for numerous experiments. The first experiment involved measuring the temperature and humidity levels in enclosed and open environments using a weather station made up of a microcontroller (ESP8266) and a sensor (DHT11). This station was connected to the platform in order to retrieve data, store it in the database, and perform graphic analysis on it. For the second experiment, a data set from the Marshes station was used, and it was uploaded to the suggested platform using Excel files (CSV) that were available in the platform. The data was then processed and shown in a similar manner to the first experiment. With the ability to receive data from Internet of Things devices, process it, and show it as graphs in cloud computing, this platform has succeeded in achieving its intended purpose.

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