A Review on Internet of Things-Based Cloud Architecture and Its Application

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Keywords Internet of Things · Cloud computing · IoT cloud · MQTT · Sigfox sensors

1 Introduction

Nowadays emerging technologies are playing a key role in our daily activities. Some of them are Internet of Things, blockchain, artificial intelligence, and robotics. More than 9 billion 'Things' (physical objects) are connected through the Internet. In the future, the number is likely to rise to a whopping 50 billion [1]. Internet of Things consists of four main components. They are low-power embedded systems, cloud computing, big data availability and connecting of networks. In IOT low-power utilization and high performance are contrary factors which play an important role in design of electronic systems. Cloud computing is used because IOT devices are huge and data collected is massive, and so to store the data, we need a storage server. Hence cloud computing is used and plays a vital role. The data is trained to discover flaws like electrical or errors found within the system. Availability of big data where IOT depends on sensors and real-time devices as the electric devices are throughout all fields, usage of these devices cause a huge change in usage of big data. Networking connection is used to communicate and Internet connection

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is necessary where every physical object will be represented by the IP address. IP naming is given to limited devices as growth in devices increased naming procedure is not applicable further. So researchers are proceeding for alternate naming system to signify physical object individually [1, 2]. Here we are going to discuss about Internet of Things along with IOT cloud. Internet of Things makes objects very intelligent and increases their potential for active interaction. We identify the objects and perceive the data around them in IOT. These objects interact with the server and store the information, and if we want to access the data, this can be done using the Internet. In order to store the information which is necessary for these objects, we require a large storage capacity that will become complicated for organizations to provide as it will become expensive to purchase more physical machines and provide space to store them to rectify this problem. We use cloud architecture as it provides large storage capacity. In order to manage and deploy the IOT applications, we use the cloud computing techniques. Earlier before cloud IOT applications are used to run locally using the fog computing and edge computing as they are sufficient, but when large amount of storage capacity is required, then these computing techniques are not useful and cost spent will be more for storage. Hence to sort out this problem cloud computing techniques have come to existence to store IOT applications. Now, we discuss about the architecture and applications of IOT cloud which explains how the data flow happens between different layers and how in each layer data is made more and more efficient for analysis and insights. There are various IOT applications which are using cloud architecture, for example, smart appliances, smart home hub, smart locks, self-driving cars and smart security systems [3].

In IOT standardization we use different techniques like M2M, Contiki, LiteOS, RPMA and Sigfox. Machine-to-machine service layer is embedded both with hardware and software, for example, microwave oven which is hardware embedded with the software. Contiki is an open-source operating system used for the IOT microcontrollers that require low power. LiteOS is also an open-source software that works similar like Linux operating system which is used for wireless sensor networks. RPMA takes the standard ownership to connect the objects of Internet of Things. Sigfox is a low-power technology for both IOT and machine-to-machine communications. The IOT device we done various investigations on Wireless capability, function process, Interoperability, Security providence for storage, Fast boot capacity, Categorization of Devices, System Bandwidth, Control the Cryptograhic, Managing the power [4]. We will discuss about the IOT device architecture which use both the network and the cloud the architecture explained in four stages. The first stage is about the different networks like the actuators we use and the wireless sensor networks. Stage two consists of the sensor data aggregation system and conversion of analog to digital data is. Third stage is the system analytics and processing using edge IT, and final stage, stage four, is where the entire data is stored in the data centre where cloud acts as the data centre and management of the data is done.

1.1 Related Work

There are some existing IOT applications which are using cloud architecture for storing the information. The IOT cloud architecture consists of IOT cloud applications, IOT integrated middleware, databases, security patches and other software algorithms, and analytic engine where the interface of secure communications is developed between the IOT device and the cloud and is done by the MQTT, COAP, AMQP, Websockets, etc. We will connect the IOT device and monitor it continuously with the help of the IOT cloud applications. These will also help the consumers with the issues they face and resolve them, and these applications are loaded with APIs and interface which will pull and push the information/data/commands to and from the applications and sensor nodes/devices. The above services are used in the IOT cloud architecture. The usage of IOT cloud has a great impact on performance of IOT applications. We have several IOT cloud applications which were discussed previously like smart buildings, smart farming, smart parking lot, intelligent transportation, smart homes and many more. In Saber Talari et al. (2017), smart cities based on Internet of Things are proposed. Smart buildings use sensors for power management to continuously monitor the power; these results will give an idea on usage of electricity and water consumption where sensors are used to detect the usage of water and automatically turn on/off of the lights, and here the sensors which we use will gather data and analyse the data and maintain the record of the data which will help us in developing the smart cities. In Chungsan Lee et al. (2016) smart parking system using IOT is proposed where ultrasonic sensors are used and connected to smartphones to find parking space availability and also to detect location of the vehicle. In Lu Hou et al. (2016) intelligent transportation is proposed where GPS is used to locate vehicle and sensors and cameras are used to know the traffic congestion of the vehicles, and the data collected and analysed is stored in IOT cloud and through this technology traffic information will also be available to pedestrians. In Prem Prakash Jayaraman et al. (2016) smart farming is proposed which used phenonet which involved a variety of crop studies that are conducted by means of IOT technologies which include sensors, cameras, smartphones and data analytics.

Abdulsalam Yassine et al. (2018) proposed about IOT smart homes that use sensors, metering services and different appliances that collect and analyse data through big data analytics using fog computing and cloud computing. Alessio Botta et al. (2015) proposed about cloud IOT applications and explained that the data and applications are different drivers which are used for the purpose of communication and the cloud can improve the IOT application's performance.

2 IOT Cloud Architecture

IOT cloud applications consist of interfaces or APIs which are used to send or receive information between the IOT sensors and consumer apps. We use IOT integrated middleware like MTQQ cluster to get data from sensors and transmit the data into cloud services to process it. The MTQQ is used for communication between the IOT devices and the end users as it is a broker protocol used for subscribing transportation of messages and the packets will be published with the help of these broker. For the purpose of publication we will uniquely define a topic and the packets will be published using broker but for subscription we use MTQQ client by using these at a time multiple topics can subscribed and for server implementation we use open source in node that means we use MTQQ connections to improve the performance of MQTT servers. The IOT cloud uses different types of NoSQL databases like MongoDB, Cassandra, CouchDB, Hypertable, Redis, Riak, Neo4j and Hadoop HBase which are used to store the data, and here the data is stored in rows and the columns same as RDBMS (Relational Database Management System). NoSQL databases are used for managing the data based on the modern demands. Rest API endpoints are the points where URL of a service is included, and each endpoint is used to access resources for carrying the functions. API runs by sending the request to server and receiving the response from server. Analytic engine consists of RDBMS, artificial intelligence algorithms, and machine learning algorithms which are used to integrate IOT-based applications or various business apps. There are different types of IOT cloud application services like sensor nodes of IOT and interface of cloud development, user IOT application developments, database management, analytics in sensor nodes of IOT and interface of cloud development which provides secured communication between IOT devices and cloud applications using MQTT, and the continuous monitoring of IOT cloud application is done using IOT device, and IOT device also alerts the users about issues and resolve them. Safe handshake mechanism is implemented for communicating or transferring the data between sensor nodes and services. User IOT applications development here user pays a key role where user access assigned IOT devices after login and end users will be given roles and responsibilities that are maintained by IOTCloud applications. IOT devices are managed and stored to cloud where it is mapped to users so that we can provide security by avoiding non-permitted access and finally end users can also control, monitor and access parameters and processes which are stored inside IOT cloud. In Database Management secure design is maintained which ensure no loss in Data, optimization is used to maintain scalability and managing device data for monitoring of devices which are deployed and the analytic phase is used for developing and integrating machine learning algorithms with IOTcloud for the growth of business. Historical data is processed when we enable IOT cloud which predicts behaviour patterns that in turn benefits the user. In Fig. 1, the process of the IOT cloud application is shown [4, 5].

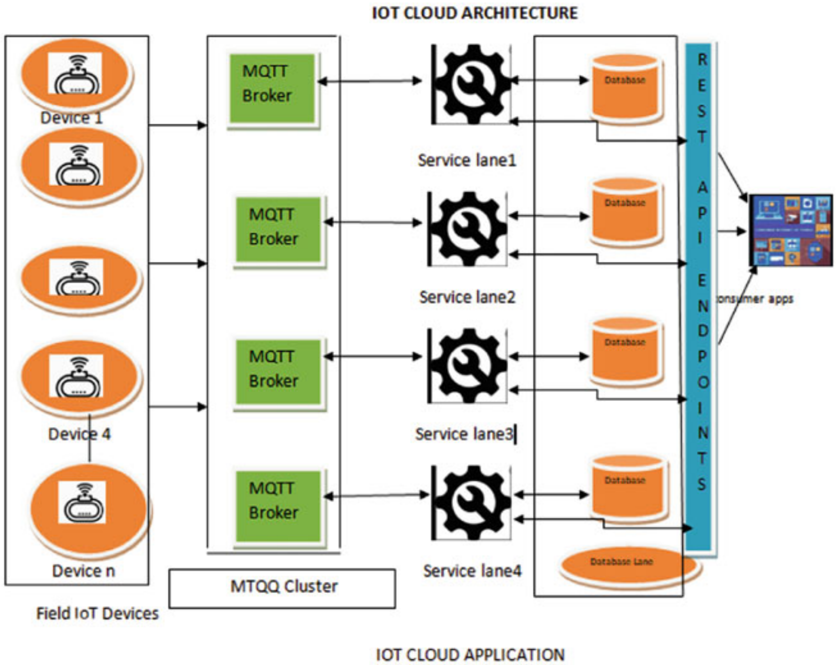

Fig. 1 IOT cloud application

3 IOT Cloud Applications

Before going to discuss about various IOT cloud applications, we will go through the services of the IOT cloud as IOT cloud should fulfil the requirements of all IOT applications using the services that are provided by IOT cloud. Different applications will be offered for the end users, managers and programmers. We can access the services using the browsers and smartphones whenever we require and from anywhere in the world. IOTCloud are classified into three categories [5]. Web applications where IOTCloud provides services by deploying WebPages using HTTP servers and these WebPages are developed with the help of Hyper text Markup Language and CSS is used to develop static pages and JavaScript is used to page where a page is taken to forward for next page [6, 7]. In IOT cloud web applications are developed for managers in order to manage interface, monitor the data of the IOT devices like timing tasks and control IOT devices with owner's permissions for debugging. Mobile apps in smartphone play a crucial role in communication as it helps people in their daily life to access the Internet using different kinds of apps. And for the ease of users, these apps are developed in such a way that they can be accessed both in Android and iOS platforms like Facebook, etc. [8, 9]. To improve the applications and the services provided by Internet of Things, we use a software development kits (SDKs). IOT uses two types of SDKs. One is Android and the other is Azure. We have many different types of IOT applications that use cloud architecture. We are going to discuss these applications in details and how they are using the cloud architecture and the benefits they can get by using this architecture. Here I will explain about the various applications which use IOT cloud architecture, as shown in Fig. 2.

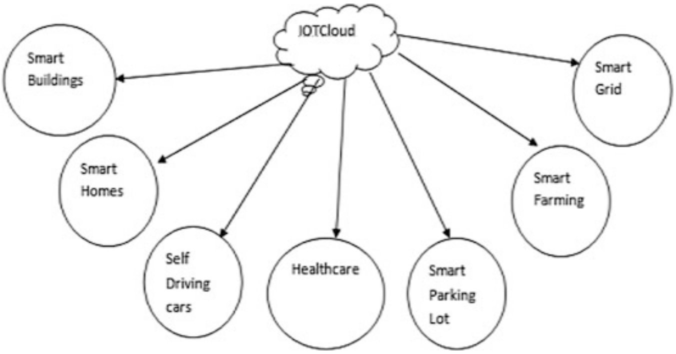

Fig. 2 Application using IOT cloud architecture

3.1 *Smart Buildings*

Smart buildings will adjust to both the inside and outside environmental change to provide comfort to occupants where the automated system infrastructure of a building is cheaper, simpler, autonomous and wireless. Sigfox sensors can be quickly installed all over the building to monitor the HVAC, boilers, light, power, fire and security. These sensors allow us to control and monitor all the operational parameters such as indoor air quality, temperature, occupancy, humidity and door openings. The machinery like lifts and escalators which are heavy in size and weight can also be fitted using sensors to trigger and check the breakdowns and to be proactive to do the required service to overcome the problem when a fault is detected. If there is water leakage, it can also be detected using IoT sensors. The advantage of using these sensors is that they can run on the same battery, thus eliminating the hassle of manual maintenance and control. We will get fire alerts and smoke alerts via fire safety using Internet equipment where time and manpower is wasted by doing continuous checkings. Alerts will be triggered by smoke detectors which will not be heard by people or ignored by them. These detectors will be connected to the Sigfox network which can send real-time alerts to keep status and battery level alive. By these alerts security providers will be alerted and will respond quickly, and they will also set up backup alarms and provide protection which is powered by Sigfox IoT network. Smart security solutions are also used to hold security guards accountable and increase the reliability of alarm system. Instead of competing with traditional systems, smart devices are used to complement existing platforms and provide a cost-effective way to help increase the effectiveness of existing system services. By collecting the consumption data effortlessly we can put an end to time spent and money used on manual on-site metre readings and processing of data. Once activated, metres will transmit data immediately using the Sigfox public network, without pairing or configuring systems [10]. You can monitor infrastructure by detecting leaks and by activating and deactivating the services. Without wasting the time we can call refuse collection service and automatically sent the data to cloud to trigger refuse collection request [11]. A simple temperature sensor and fire alarm can be added and triggered as appropriate. This offers convenience and safety and cuts down on collection requests. Refer to Table 1 for these information [12].

3.2 Smart Parking Lot

Parking is considered as the major problem in cities where population is high compared to towns and villages. So we should provide extra services to solve this problem which will be useful for parkers and also for administrators. We are offering a survey on the relevant technologies and IoT with parking in smart city [13]. From the past decade, cars are manufactured having some advanced features which include radio, automatic door locks, movie player, navigating systems, and so on. Now using IoT we can link them up with smartphone apps to find availability of parking, reservations of parking [14] and online payment mode [15]. We can secure this parking lot information using the emerging technology called blockchain. Techniques like sensor network, positioning system and image detection are also used. Table 2 explains what are the types of sensors used in parking lots in different countries like underground sensors, RFID, etc. [16].

3.3 Smart Farming

Nowadays lots of services are provided by various technologies like IoT, artificial intelligence and other technologies. Some of them are used for farming which will increase growth and reduce manpower as well as increase the quality of product. IoT plays a key role in product growth and provides better measures compared to regular farming, and the technologies offered are sensors, software solutions used for the purpose of connecting IoT platforms, connectivity's used and mobile devices along with GPS locations using robotic tractors along with different processing facilities

Table 1 Usage of IOT cloud by smart buildings

Scenario	Use cases	Device type	People population	Energy consumption	Cost	Throughput	Latency	Mobility	Reliability	Security
Smart buildings	Water metering	Sensors Metres	Large	Low	Low	Low	High	Fixed	Medium	Low
	Residential monitoring	Sensors	Few	Low	Low	Low	Low	Fixed	High	High
	Secure electrical panels	Sigfox	Few	Low	Low	Low	High	Fixed	High	High
	Smoke and fire using the Internet	Detectors	Large	Low	Low	Low	High	Fixed	Medium	Low

Table 2 Smart parking applications and technologies used in various areas

Smart parking application	Country	Sensors/technology used
Park.ME	Austria, Germany	Underground sensors
SmartParking	New Zealand	Underground sensors, RFID
ParkMe	Japan, US, UK, Germany, Brazil	Underground sensors
ParkAssist	US	M4 smart sensors, LPR
SpotHero	US	Underground sensors
EasyPark	Canada	Underground sensors
PaybyPhone	France	Underground sensors
ParkMobile	US	Underground sensors
AppyParking	UK	Magnetometer
EasyPark Group	Sweden, Denmark, etc.	Transactional data and crowdsourcing
Parker	US	Underground sensors, machine vision
ParkiFi	US	Magnetometer
Best Parking	US	Underground sensors
Parkopedia	US, Germany, Sweden, etc.	Predictive analytics, Underground sensors
SFPark	US	Underground sensors
Open Spot	US	Crowdsourcing

and we can also use data streaming for other solutions. By using all these, a farmer can always monitor the field condition and can act according to it and follow using the steps like first observing the problem, then diagnosing the damage and what cause it and taking a decision to make action for that problem. We use two types of farming: One is precision farming and the other is livestock farming . In precision farming the changes in the field are measured and will act according to it, while in livestock farming, we use various smart farming techniques which will make cultivation easy for the farmer [17].

We use different ways to use IoT in farming to make agriculture more efficient. These include using sensors which collect data to improve the quality of soil, growth of the crop and health of the cattle and provide information of climate conditions. It also helps control the risk in production by predicting future problems. We can also reduce the cost as there will be a decrease in manpower and predict losses in harvesting the crop by knowing the weather conditions [18].

The monitoring of weather conditions is done by using some IoT devices like Smart Elements and allMETEO, Greenhouse automation is also done by using the Farmapp and GreenIQ which are used to find the humidity, lighting and soil conditions of the crops. The management of the crops is done by the devices like Arable and Semios, Monitoring the cattle is done by placing sensors to the cattle which will monitor their health condition like the using Cowlar. CropX is used to determine soil condition and finally drones are used to monitor and perform operations like spraying pests (Fig. 3). Table 3 shows the sensors used in smart farming technologies [19].

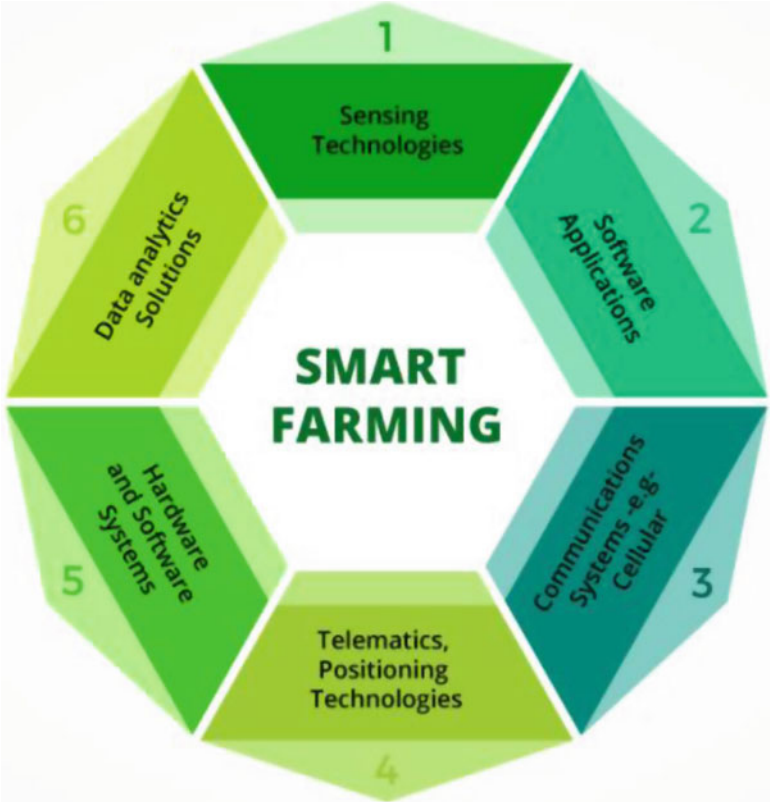

Fig. 3 Smart farming technologies

4 Conclusion

In this review paper, I addressed some of the IoT applications that use cloud architecture. These applications are very useful to the end users. With this new technology, various experiments were conducted with an objective to evaluate the performance of the application servers in the proposed IoT cloud. For example, in smart agriculture we have smarter and efficient farming methods which will increase the growth of the crop. All these aspects are mentioned in this paper briefly and cloud computing implementation is explained thoroughly and other applications are specified where IoT-based architecture is used in all these applications. Based on the following data I can conclude that IoT applications will become efficient to use by using cloud architecture. More research is being conducted to solve challenges which are faced while using IoT cloud.

Table 3 Sensors used in IoT-based agriculture

	Target/placed				Considered purpose/parameters							
Sensor/system	Plant	Equipment	Soil	Weather	Yield	Temp	Moisture	Location/tracking	Wing	Pollution/Co^2	Water	Fruit/stem size
Loup 8000i [138]		✓			✓		✓					
XH-M214 [139]			✓				✓					
Ag Premium Weather [140]		✓		✓		✓		✓	✓			
FI-MM [141]	✓											✓
PYCNO [142]			✓	✓		✓	✓				✓	
MP406 [143]			✓			✓	✓					
DEERE 2630 [144]		✓			✓		✓					
Sol Chip Com (SCC) [145]				✓						✓	✓	
SenseH2TM [146]	✓								✓	✓		
DEX70 [147]	✓											✓
Piccolo ATX [148]		✓						✓				
CI-340 [149]	✓						✓			✓		
Wind Sentry 03002 [150]				✓					✓			
AQM-65 [151]				✓						✓		
POGO Portable [152]			✓			✓	✓				✓	

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