

The Cloud-IoT Paradigm

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Abstract— The Internet of Things (IOT) involves the internet-connected devices we use to perform the processes and services that support our way of life. The on-demand availability of computer system resources, especially data storage and computing power, without direct active management by the user is Cloud computing. There are many issues standing in the way of the successful implementation of both Cloud and IoT discreetly. Basic solution to these issues is integration of IOT and Cloud Computing services. IOT and Cloud Computing are both different fields of study and engineering but they work in sync with each other to create some remarkable applications, products, and devices that ease our daily lives. This paper provides an overview of the integration of the Cloud into the IoT by highlighting the integration benefits and explore the latest developments that have taken place by this combination.

Keywords— *Internet, cloud, engineering, computing, discreetly.*

I. INTRODUCTION

Cloud Computing helps IOT applications and devices to store data online on a cloud server and then access the data anytime from anywhere. They both function together to bring the best utilization of each domain because in combination with cloud computing, the IOT devices and their sensor network get remote access to the data storage from any geographical location with an active internet connection. Most important component of Future Internet for providing a global IT Platform for combining consistent networks and networked things is IOT (Internet of Things). In the future version of world Internet, people will be connected anytime, anyplace, with anything and anyone, and appropriately utilizing any network and any service. In other words, the IoT addresses the content, collections, computations and computer functions, communication, and connectivity between people and things irrespective of any geographical location. Whereas, the story on the other side is different, Cloud Computing is considered as the backend

solution for processing huge chunks of data streams, computations and processing of data while facing the provocation of everything being connected by consistent networks in the future. Cloud technologies can provide a virtual, scalable, efficient, and flexible data centre for context-aware computing and online service to enable IoT. The IoT is moving towards a phase where all items around the world are going to be connected to the Internet and will also be capable enough to perform human tasks. The IoT devices normally consist of a number of objects with limited storage and finite computing capacity. It could well be said that the results arising from the integration of Cloud computing and the IoT will be the future of the world of Internet and next-generation technologies. However, Cloud services are dependent on service providers which are extremely self-sufficient and have the capability of interoperability, and on the contrary IoT technologies are based on diversity rather than interoperability. No wonder 96% of the organizations have adopted cloud in one form or the other for online data storage/modification. And with the emergence of the likes of Amazon Web Services, Google Cloud Platform, Microsoft Azure and IBM Cloud, the growth prospects of IoT appear even brighter.

II. BASIC CONCEPTS

A. Cloud Computing

Cloud computing consists of five type of varied models, three different service models, and five unique characteristics. Cloud computing service models are most commonly classified as belonging to the public Cloud, where resources are made available to consumers over the Internet in an organized and authorized way. Public Clouds are generally owned by a profitable organisation, which can handle a bigger customer base (e.g. Amazon EC2). Conversely, the infrastructure of a private Cloud is commonly provided by a single organisation to serve the particular functioning needs of its primary users. The private Cloud offers a secure running environment and a

higher level of control functions for the data stored on it (Microsoft Private Cloud). Hybrid Clouds are a mixture of private and public Clouds. This choice is provided for consumers as it makes it possible to overcome the limitations that may arise from different models individually. In contrast, a community Cloud is a Cloud infrastructure which is delivered to a community of users by a number of organisations which share the same operational and functioning need. In order to allow consumers to choose the service that suits them as per their individual need, services in Cloud computing are provided at three different calibres of operation, namely: the Software as a Service (SaaS) model, where software is delivered through the Internet to end-users (e.g. Google Apps); the Platform as a Service (PaaS) model, which offers a higher level of integrated environment that can build, test the functioning, and deploy specific software (e.g. Microsoft Azure); and finally, with the Infrastructure as a Service (IaaS) model, infrastructure such as storage, hardware and servers are delivered as a service to the customer. (e.g. Amazon Web Services).

B. Internet of Things (IoT)

The Internet of Things (IoT) represents the latest approach where boundaries between real and digital domains are progressively eliminated by consistently evolving every physical device to a smart alternative ready to provide cutting edge smart services. All things in the IoT (smart devices, sensors, etc.) have their own unique functioning identity and recognition. They are combined to form the communication network and will become actively participating objects that play their role efficiently to run the bigger network. These objects include not only daily usable electronic devices, but also things like supper, clothing, accessories and materials; commodities and luxury items; monuments and landmarks; and various variations of transport modes that we use in our daily lives. In addition, these objects are able to create requests and alter the state of operation of sensors/devices. Thus, all IoT devices can be monitored, tracked and counted, which significantly decreases time, financial loss, and cost.

III. INTEGRATING CLOUD WITH IOT

Based on the principles of expandability and dexterity, the cloud is raised as an uprising technology in the world. Cloud solutions can assemble the large-scale plans of IoT initiatives. Here are some key points why the cloud is essential to the success of IoT:

1) **Computing Power:** We live in a world surrounded by heavy technology, where one corner of the

world can get connected to the other one. With 5G and high internet speed, Cloud technology can help in capturing profits in business to access data anytime anymore, without imposing any load on the system. It also reduces need of having on-premises infrastructure.

- 2) **Security and Privacy:** High end technology never comes without risk, so even if IOT devices allow companies, industries and organizations to automate their tasks, it also compromises security to some extent. But at the same time, cloud services provide proper security measures and that's eases the implementation of system and devices. Identity of users accessing IOT devices can be secured by using top-notch cloud services.
- 3) **Data Integration:** As IoT continues to gain fame, initiations have begun analysing with connected devices to get real-time information on key business aspects. While these devices work towards an optimal solution, they also generate massive data that are too unmanageable to process even for their inquisitive platforms. Cloud-based services have built in robust data integration capabilities to handle massive chunks of data gathered from multiple sources. It helps processing data from both, enterprise systems and connected devices.
- 4) **Low Entry Barrier:** Hosting solutions in Cloud services are quite better than that available in IOT domain. Where in IOT users have to look for struggle free solutions, cloud services work on a 'pay-as-you-go' system where the user is charged only for resources used by him. So, this way, by demand of Cloud services, the entry barrier for IOT business is reducing.
- 5) **Business Continuity:** Cloud computing solutions are known for their dexterity and accuracy. Cloud services are a tree network of servers that are planted in multiple locations. Copies of data are stored by their system in various data centres of the country. As a result, redundancy is caused. IoT-based systems still continue to work even if any of their servers goes offline for some reason or the other.
- 6) **Inter-device Communication:** Other than communication with users, it is also important for IoT devices and services to connect with each other. Here cloud services are useful since they provide absolute communication between IOT devices. They also enable many robust APIs and allow interaction between connected devices and smartphones thereby covering the way for the raise of connected technologies.

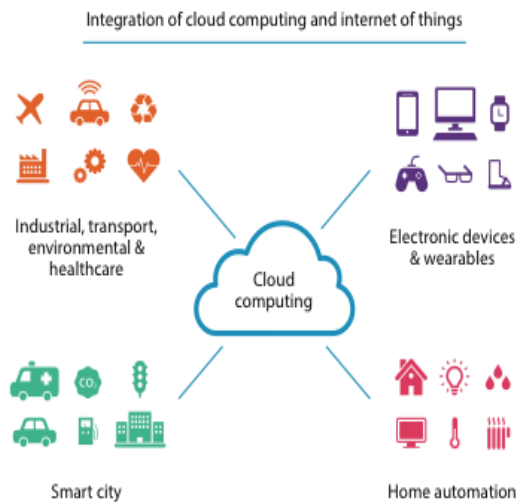


Fig. 1: integrated model of cloud with IoT.

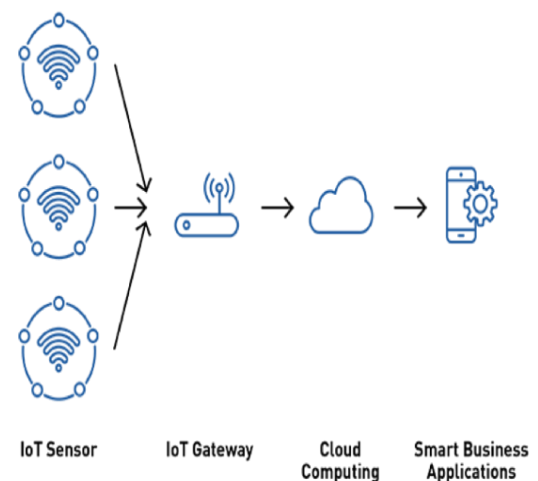
7) *Pairing with Edge Computing*: Computing in which data is being generated near the edge of network, such practice and processing of data is called Edge Computing. Such computing is provided by IOT devices to reduce response time and accelerate data processing. It basically adopts a decentralized structure instead of centralized computing. Only Edge computing doesn't stand alone for optimal solutions, instead of an optimal integration of Edge and Cloud is recommended to drive business to its maximum plans of profits.

IV. PRODUCTS WITH CLOUD-IOT PARADIGM

- 1) *Amazon Alexa*: Alexa was first used in smart speakers and at present it is the most used voice assistant in the world. The Alexa voice assistant has a number of unique and exciting features which include Voice interaction, music playback, making to-do lists, setting alarms, streaming podcasts, playing audiobooks, providing weather, update traffic, sports, and other real-time information. Life is much easier when input/output of the system is in the form of Voice. It needs wake up initiation by words such as "Alexa" to respond and function. Wake words can also be customised according to the user in Alexa. This device implements voice control by integration of Cloud Computing Services.
- 2) *Google Home*: Google Home comprises of some smart Wi-Fi speakers including devices named Google Home, Google Home Mini and Google Home Max. They give us access to the same Google Assistant service. They differ in size, price and quality of sound of the speaker. It needs wake up initiation by words such as "OK Google" or "Hey, Google" to respond

and function. This system allows users to listen to music, control motion of videos, photos, and also receive news updates entirely by voice. Not only the can assistant gives answers to the commands, but it also can automate Home as per the commands, which is an additional feature. These series of IOT speakers use their very own custom designed suite of Cloud Services called Google Cloud to perform, store, modify various functions.

- 3) *Nest Camera*: As the name suggests, this IOT system uses a camera and monitors the surrounding area using it. It is a type of security camera so the user can be alert 24/7 by various functionalities provided various products under Nest Cam are Nest Cam IQ Outdoor, Nest Cam Outdoor, Nest Cam IQ Indoor and Nest Cam Indoor. This system provides features like 24/7 Video recording, Alerts on Phone, 1080p HD quality, 3-hour snapshot history and night vision. Nest Aware service including with it provides event-based recording and more video history. Simply more data calls more storage, so these IOT devices and services provide cloud storage of every footage. Cloud Computing also enhances the quality of data like images in the system.
- 4) *Awair*: In today's time, life is moving so fast that quality of air is really not an issue to worry about for the people, but still the statistics say a different story. Average of 7 million people die because of polluted air and so the IOT system like Awair can be useful. Invisible fine dust and chemicals in your air are tracked by Awair. Along with it, it also gives you



personalized recommendations to help you stay safe and healthy. HiveMQ and MQTT are used by this system for connecting all their devices to the Awair hosted cloud platform.

Fig. 2: Framework of Cloud-IOT Product

- 5) *Mi Band*: Mi Band is a type of wearable IOT device which helps users track daily health data such as heart rate, steps taken, sleep data, etc. It also acts as a Fitness Coach and allows users to set goals, timers, missions, etc and track those data also. Various versions of MI band are 1, 2, HRX Edition, 3, 3i, 4. This smart product uses technologies like AI, big data, cloud computing etc to provide various functions.

V. FUTURE SCOPE

- 1) *Fog Computing, a replacement of Cloud Computing?*
Nowadays, another technology making fame is Fog Computing or Fogging. It is being used to process data received from IOT devices, in place of sending such data to Cloud Computing. It is a model which concentrates at network edge for elements like data, its processing and applications to support. Rather than working completely in Cloud, this focuses on decentralized Edges of Network.
- 2) *Fog V/s Cloud*
As the number of interconnected devices are increasing day by day, along with that production of heavy chunks of data is also done. If various different devices have to access cloud data that is centralized, it is simply going to increase load on the system and working of it. Fog computing works locally and not globally. It is a decentralized model, handling the interpretation of logic to be used by smart IOT devices.
- 3) *A Sensible Shift*
A developmental shift from the cloud to the fog makes complete sense. The cloud services were booming during the start of smartphone usage. But for today's systems, the old technology is lacking. Hence, it makes sense to use a hub-and-spoke cloud architecture which is like a mesh or edge computing data architecture.

VI. CONCLUSION

In this paper, we focused on IOT and Cloud Computing as a discrete technology, their functioning, their integration and the benefits caused to the society when both IOT and Cloud support each other. According to our analysis, both technologies create high end solutions for making real life easier. Both technologies are far from each other in functioning but still when merged, they relevantly add worth to solutions. Along with this, we also explored some high-end Cloud-IOT devices and their usage in real life. We also gave a glimpse of Fogging and analysed Fog Computing to be more booming in future. Overall, each system has its own requirements and suitable

technologies. If more and more IOT devices or products are to be enhanced, integration with Cloud Computing gives better results.

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