Cloud Computing for Internet of Things (IoT)

Abstract - Cloud computing and Internet of Things (IoT) are two very different technologies that are both already part of our life. The Internet of Things (IoT) is becoming the next Internet-related revolution. It allows billions of devices to be connected and communicate with each other to share information that improves the quality of our daily lives. By analyzing the basics of both IoT and Cloud Computing, we discuss their complementarity, detailing what is currently driving to their integration.

*Index terms – Cloud Computing, Internet of Things (IoT)*

I.INTRODUCTION

Cloud computing is a transformative technology that has revolutionized the way individuals and organizations access and use computing resources. Delivering a range of computing services via the internet is the fundamental component of cloud computing. Users can use these services on a pay-as-you-go basis from cloud service providers in place of purchasing and maintaining actual gear and software. Because of its affordability, scalability, and flexibility, this model is well-liked by both people and enterprises.

- *Types of Cloud Computing:*

1. *Software-as-a-service (SaaS)*

2. *Infrastructure-as-a-service (IaaS)*

3. *Platform-as-a-service (PaaS)*

Different Types of Cloud Computing have been described and explained in the figure below.
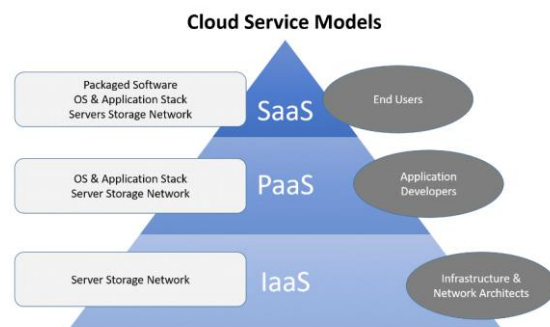
identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. A thing in the internet of things can be a person with a heart monitor implant, a farm animal with a biochip transponder, an automobile that has built-in sensors to alert the driver when tire pressure is low or any other natural or man-made object that can be assigned an IP address and is able to transfer data over a network.

II.LITERATURE REVIEW

As outlined in the National Institute of Standards and Technology (NIST) definition, cloud computing is composed of three service models which encompass the underlying structure of the cloud. These main service /delivery models comprise of Software-as-a-Service (SaaS), Platform-as-a-Service (PaaS) and Infrastructure-as-a-Service (IaaS) and provide an alternative cost-effective solution compared to the traditional Information Technology department. Below Figure outlines the types of responsibilities afforded to either the cloud customer or cloud service provider, in a traditional IT Department and in a SaaS, PaaS and IaaS setting.
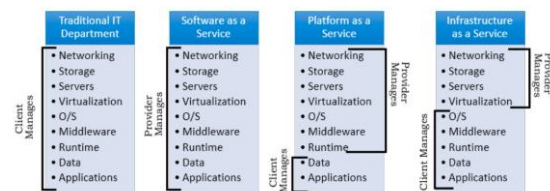
Businesses can employ cloud computing in different ways. Some users maintain all apps and data on the cloud, while others use a hybrid model, keeping certain apps and data on private servers and others on the cloud. When it comes to providing services, the big players in the corporate computing sphere include:

- *Google Cloud*
- *Amazon Web Services (AWS)*
- *Microsoft Azure*
- *IBM Cloud*
- *Aliyun*

Amazon Web Services is 100% public and includes a pay-as-you-go, outsourced model. Once you're on the platform you can sign up for apps and additional services. Microsoft Azure allows clients to keep some data at their own sites. Meanwhile, Aliyun is a subsidiary of the Alibaba Group.
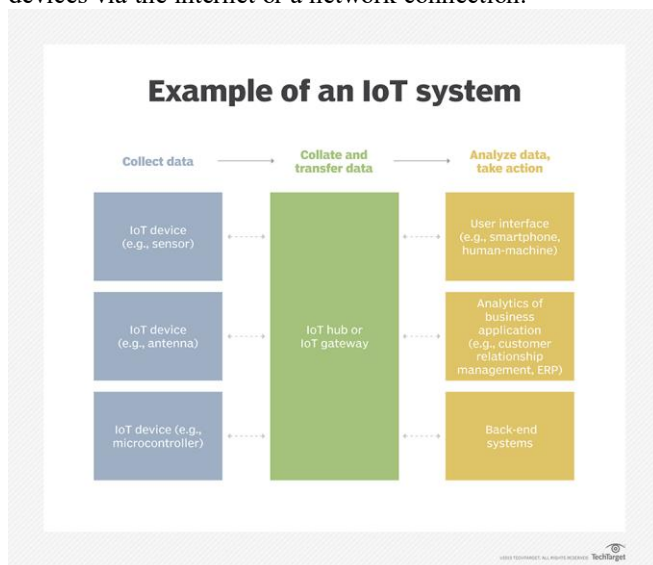
III.INTERNET OF THINGS(IoT)

The internet of things, or IoT, is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique

Increasingly, organizations in a variety of industries are using IoT to operate more efficiently, better understand customers to deliver enhanced customer service, improve decision-making and increase the value of the business.

IV. WORKING MODEL OF IOT SYSTEM

Typically, an Internet of Things system is made up of sensors and other devices that use several connectivity options to communicate with the cloud. After the data is transferred to the cloud, software processes it. Based on the software's findings, the devices or sensors may be automatically adjusted or alarms may be sent, all without requiring human participation. A functioning model for an IoT system can also be created from a variety of IoT project concepts, including air monitoring, health monitoring, smart agriculture, and home automation. Moreover, an Internet of Things device's system model usually consists of a "Sense-Think-Act-Communicate" cycle, in which the device perceives information from its surroundings, interprets it, acts upon it, and then connects to other apps, databases, or devices via the internet or a network connection.

Example of an IoT system

V. BENEFITS OF IOT

The internet of things offers a number of benefits to organizations, enabling them to:

- *Real-time asset/resource visibility*
- *Reduced costs*
- *Improved operational efficiency*
- *Data-driven insights for quick decision-making*
- *End-to-end, remote monitoring and management of assets/resources*
- *Real-time, predictive and prescriptive insights*
- *Improve end-customer experience*

IoT encourages companies to rethink the ways they approach their businesses, industries and markets and gives them the tools to improve their business strategies.

VI. DIFFERENCE BETWEEN CLOUD COMPUTING AND IOT

Cloud computing in simple terms means accessing data and programs from a centralised pool of compute resource that can be ordered and consumed on demand. Typically clouds deployments are described in 3 different models; Public, Private or Hybrid.

- Private Cloud Services is a secure cloud that only the specified organisation can access. The additional security offered by a private cloud model is ideal for any organisation, including enterprise, that needs to store and process private data or carry out sensitive tasks. For example, a private cloud service could be utilised by a financial company that is required by regulation to store sensitive data internally and who will still want to benefit from some of the advantages of cloud computing within their business infrastructure, such as on demand resource allocation.
- Public Cloud Service is like a private cloud although the main differentiator is that resources used to process and store data can be shared with other organisations, and data transferred over a public network such as the internet. Third party providers will deliver cloud services over the internet and are normally charged by CPU cycles, storage or bandwidth that they require.
- Hybrid Cloud is a cloud computing environment which uses a mix of on premise, private cloud and third-party public cloud services. With the hybrid cloud model, IT decision makers have more control over both the private and public components than using a pre-packaged public cloud platform. The internet of Things, meanwhile refers to the connection of devices other than the usual such as computers to the Internet. Cars, kitchen appliances and other sensors can be connected through the IoT. The IoT is an enabler for change. It enables systems and devices to be automated in a cost effective, intelligent manner supporting real-time control and monitoring. Having all the relevant information available (real time along with historical trend data) provides the ability to combine and process this data in an innovative manner resulting in more effective and efficient control or decision making.

Key	IoT	Cloud Computing
Connectivity	The Internet is used as a point of convergence by the IoT.	The delivery of services in cloud computing is accomplished via the use of the Internet.
Features	IoT is present everywhere. These are things that exist in the actual world.	Cloud is omnipresent. These are materials that may be accessed online.
Storage	Limited	Unlimited
Processing	Computational powers are restricted.	It is nearly impossible to reach a limit to computational capability.
Big data	It is a source of massive amounts of data.	It handles the massive amounts of data.

VII. CHALLENGES

1. Handling a large amount of data

Handling a large amount of data can be overwhelming especially when there are millions of devices in the picture. This is because the overall performance of applications is at stake. Hence, following the NoSQL movement could be beneficial, but it is not tried and tested for the long run. Which is why there exists no sound or fool-proof method for the cloud to manage big data.

2. Networking and communication protocols

Cloud and IoT involve machine-to-machine communications among many different types of devices having various protocols. Managing this kind of a variation could be tough since a majority of application areas do not involve mobility. As of now WiFi and Bluetooth are used as a stop-gap solution to facilitate mobility to a certain extent.

3. Sensor networks

Sensor networks have amplified the benefits of IoT. These networks have allowed users to measure, infer and understand delicate indicators from the environment. However, timely processing of a large amount of this sensor data has been a major challenge. Though cloud provides a new opportunity in aggregating sensor data it also hinders the progress because of security and privacy issues.

VIII.CONCLUSION

The next major development in the internet world is the combination of cloud computing and IoT. This combination, known as IoT Cloud, is producing a plethora of new applications that are opening up new business and research opportunities. We can only hope that this combination will reveal a new paradigm for open service platforms for users and multi-networking in the future.

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