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Cloud IoT: A Combination of Cloud Computing and Internet of Things

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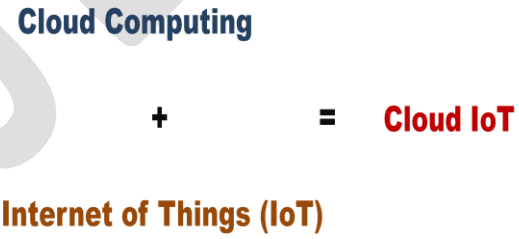
Abstract: Cloud Providers like Amazon Web Services, Google Cloud Platform, IBM Watson, and Microsoft Azure have incorporating of Internet of Things in cloud Computing. Cloud Computing is a remote location technology that has transformed the way of Information Technology. Internet of Things (IoT) is radically changing the way of businesses operate and people interact with the physical world. The combination of Cloud Computing and Internet of Things build a robust, maintainable, end-to-end Internet of Things solution on cloud platform. It creates streams of insight by extending your infrastructure to the physical world.

Keywords: Cloud IoT, Cloud Computing, Internet of Things (IoT), Amazon Web Services IoT, Google Cloud Platform, IBM Watson IoT, Microsoft Azure IoT Suite

I. Introduction

Cloud Computing is a remote location technology that transformed the way of Information Technology. It provides Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS). Internet of Things (IoT) is radically changing the way of businesses operate and people interact with the physical world. Although things, Internet, and connectivity are the three core components of IoT, the value is in closing the gap between the physical and digital world in self-reinforcing and self-improving systems. The combination of Cloud Computing and Internet of Things (IoT) are known as Cloud IoT.



Amazon Web Services IoT, Google Cloud Platform, IBM Watson IoT, Microsoft Azure IoT Suite has provides the combination of Internet of Things (IoT) and Cloud Computing. Cloud IoT is a platform that enables you to connect device to cloud services and other devices, secure data and interactions, process and act upon device data and enable applications to interact with devices even when they are offline and build a robust, maintainable, end-to-end Internet of Things (IoT) solution on cloud platform.

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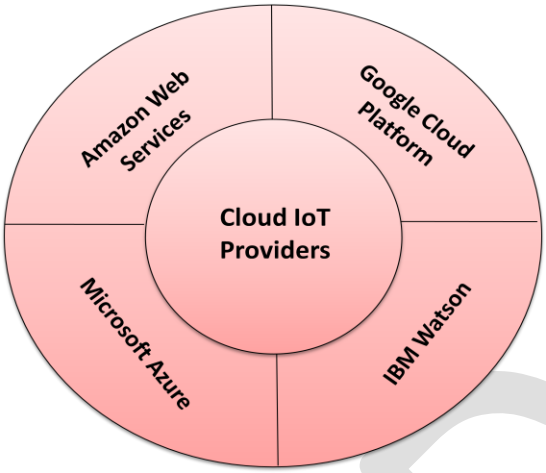

Fig: Cloud IoT Providers

II. Amazon Web Services (AWS) IoT

AWS IoT is a managed cloud platform that let's connected devices easily and securely interacts with cloud applications and other devices. AWS IoT can support billions of devices and trillions of messages, and can process and route those messages to AWS endpoints and to other devices reliably and securely. With AWS IoT, your applications can keep track of and communicate with all your devices, all the time, even when they aren't connected.

AWS IoT makes it easy to use AWS services like AWS Lambda, Amazon Kinesis, Amazon S3, Amazon Machine Learning, Amazon DynamoDB, Amazon CloudWatch, AWS CloudTrail, and Amazon Elasticsearch Service with built-in Kibana integration, to build IoT applications that gather, process, analyze and act on data generated by connected devices, without having to manage any infrastructure.

AWS IoT Features:

AWS IoT is a platform that enables you to connect devices to AWS Services and other devices, secure data and interactions, process and act upon device data and enable applications to interact with devices even when they are offline.

- **AWS IoT Devices SDK:** AWS IoT provides an SDK to help you easily and quickly connect your hardware device or your mobile application. The AWS IoT Device SDK enables your devices to connect, authenticate, and exchange messages with AWS IoT using the MQTT, HTTP, or WebSockets protocols. The Device SDK supports C, JavaScript, and Arduino, and includes the client libraries, the developer guide, and the porting guide for manufacturers.
- **Device Gateway:** The AWS IoT Device Gatway enables devices to securely and efficiently communicate with AWS IoT. The Device Gateway can exchange messages using a publication/subscription model, which enables one-to-one and one-to-many communications. With this one-to-many communication pattern AWS IoT makes it possible for a connected device to broadcast data to multiple subscribers for a given topic. The Device Gateway supports MQTT, WebSockets, and HTTP 1.1 protocols and you can easily implement support for proprietary or legacy protocols. The Device Gateway scales automatically to support over a billion devices without provisioning infrastructure.
- **Authentication and Authorization:** AWS IoT provides mutual authentication and encryption at all points of connection, so that data is never exchanged between devices and AWS IoT without proven identity. AWS IoT

supports the AWS method of authentication (called 'SigV4') as well as X.509 certificate based authentication. Connections using HTTP can use either of these methods, while connections using MQTT use certificate based authentication and connections using WebSockets can use SigV4. With AWS IoT you can use AWS IoT generated certificates, as well as those signed by your preferred Certificate Authority (CA). You can map your choice of role and/or policies to each certificate, so that you can authorize devices or applications to have access, or change your mind and revoke access altogether without ever touching the device. You can create, deploy and manage certificates and policies for the devices from the console or using the API. Those device certificates can be provisioned, activated and associated with the relevant policies that are configured using AWS IAM. This allows you to instantly revoke access for an individual device if you choose to do so. AWS IoT also supports connections from user's mobile apps using Amazon Cognito, which takes care of all the steps necessary to create a unique identifier for your app's users and retrieve temporary, limited-privilege AWS credentials.

- **Registry:** The Registry establishes an identity for devices and tracks metadata such as the devices attributes and capabilities. The Registry assigns a unique identity to each device that is consistently formatted regardless of the type of device or how it connects. It also supports metadata that describes the capabilities of a device, for example whether a sensor reports temperature, and if the data are Fahrenheit or Celsius.
- **Device Shadows:** With AWS IoT you can create a persistent, virtual version, or "shadow" of each device that includes the device's latest state so that applications or other devices can real messages and interacts with the device. The Device Shadows persist the last reported state and desired future state of each device even when the device is offline. You can retrieve the last reported state of a device or set a desired future state through the API or using the rules engine. Device shadows make it easier to build applications that interact with your devices by providing always available REST APIs. In addition, applications can set the desired future state of a device without accounting for the devices current state. AWS IoT will compare the difference between the desired and last reported state, and command the device to make up the difference.
- **Rules Engine:** The Rules Engine makes it possible to build IoT applications that gather, process, analyze and act on data generated by connected devices at global scale without having to manage any infrastructure. The Rules Engine evaluates inbound messages published into AWS IoT and transforms and delivers them to another device or a cloud service, based on business rules you define. A rule can apply to data from one or many devices, and it can take one or many actions in parallel. The Rules Engine can also route messages to AWS endpoints including AWS Lambda, Amazon Kinesis, Amazon S3, Amazon Machine Learning, Amazon DynamoDB, Amazon CloudWatch, and Amazon Elasticsearch Service with built-in Kibana integration. External endpoints can be reached using AWS Lambda, Amazon Kinesis, and Amazon Simple Notification Service (SNS). You can author rules within the management console or write rules using a SQL-like syntax. Rules can be authored to behave differently depending upon the content of the message. For example, if a temperature reading exceeds a certain threshold it could trigger a rule to transmit data to AWS Lambda. Rules can also be authored to take into account other data in the cloud, such as data from other devices. For example you could say take an action if this temperature is more than 15% higher than the average of 5 other devices. The Rules Engine Provides dozens of available functions that can be used to transform your data and it's possible to create infinitely more via AWS Lambda. For example, if you're dealing with a wide range of values you could take the average of incoming numbers. Rules can also trigger the execution of your Java, Node.js or Python code in AWS Lambda, giving you maximum flexibility and power to process device data.

III. Google Cloud Platform

Google Cloud Platform to build a robust, maintainable, end-to-end Internet of Things (IoT) solution on Cloud Platform. It creates streams of insight by extending your infrastructure to the physical world.

Features:

- **Streaming Insights:** Events of interest fire off continuously in the physical world, and data that is material to decision making can't always wait for offline analysis. Internet-equipped sensors on any physical item imaginable make it possible to ingest data continuously into the cloud, directly from the source at massive scale.
- **Tap into the World:** A new type of device technology along with ubiquitous networking makes it easy and economical to mine information from any physical item and place. This untapped pool of data gives organizations visibility into parts of their operations previously considered "offline". Combined with real-time processing and predictive analytics, an IoT capability profoundly changes monitoring and management practices by enabling proactive resolution in response to real-time events, and ultimately, predictive capabilities.
- **From Small to Big (Data):** Each sensor-equipped device may be small and yields only incremental insight. Multiply this by hundreds, thousands, or millions of sensors all ingesting data to the cloud and the collective stream presents as a big data problem. Cloud Pub/Sub makes real-time, reliable processing of IoT data easy, and our storage products persist all your data efficiently and economically. IoT on Cloud Platform lets you make extremely fast queries into your business and operating environment, without managing any infrastructure.
- **Real- Tim, Actionable, Insight:** a ride-sharing car blipping toward a user on her mobile device, to sensors tracking the location of buses and trains, users no longer tolerate stale information. Using Cloud Platform as the base of your IoT capability, the expectation of real time is build-in; stream and transform data as it arrives with Cloud Dataflow, a unified programming model for both batch and streaming data sources. Take immediate action based on complex events, triggers, and thresholds you define, and instantly query vast volumes of real-time and historical data in BigQuery.
- **Google-Grade Security:** Whether device-to-cloud or cloud-to-device, security is a first-class concern as IoT is increasingly used to support business-critical operations. All Cloud Platform APIs are secure by default with full encryption, backed by integrated and pervasive security across by integrated and pervasive security across the entire infrastructure. Cloud IAM can ensure devices have access only to resources you explicitly designate.
- **Global Fiber Network:** Google's operates its own private fiber network that spans the globe with over 70 points of presence across 33 countries, ensuring data to and from your devices gets delivered at ultra-low latency. Reliability and security are enhanced because your IoT data avoids having to travel the public Internet through the majority of its time in transit. Google's global network ensures that millions of devices and sensors distributed worldwide can deliver raw data efficiently so your organization can tap operational insight continuously with no disruption.

IV. IBM Watson IoT

Internet of Things is radically changing the way businesses operate and people interact with the physical world. As virtually everything becomes connected-from cars to crops to conveyor belts-businesses can harness the resulting data to improve virtually every aspect of what they do.

Features:

- **Boost Operational Performance:**
  - Gain a whole new level of visibility across your extended supply chain.
  - Optimize performance, empower employees and lower costs.
  - Monitor assets and equipment to enable predictive maintenance.
  - Increase throughput and optimize resource use.
  - Run more energy and cost-efficient facilities.

- **Enhance the customer experience:**
  - Offer products and services that continuously adapt to the connected customer.
  - Gain valuable insights throughout the product lifecycle that inform product development.

- Achieve a new level of customer engagement to boost loyalty, drive revenue and create differentiation.
- Speed development and accelerate time to market.

➢ **Lead Industry Transformation:**

- Find new ways to monetize value through asset-based online marketplaces.
- Garner new revenue from existing products and services.
- Partner in new ways across industries.
- Disrupt competitors by seizing new IoT opportunities first.

➢ **Scale Institutional Expertise:**

- Work smarter by giving any employee access to the company's collective knowledge.
- Infuse equipment and devices with deep domain knowledge and sensory input such as sound, images, videos and text.
- Give equipment and devices the power to reason and lean, and the ability to interact naturally with people.

➢ **Drive Environmental Leadership:**

- Join the movement to use IoT for green initiatives that benefit the bottom line.
- Reduce energy and water consumption, eliminate waste across the supply chain, and optimize asset utilization.
- Cut costs while reducing CO2 emissions and enhancing your brand image.

V. Microsoft Azure IoT Suite

Azure IoT Suite brings the Internet of your things to life. Connect your devices, analyze previously-untapped data, and integrate business systems and transform your company when you uncover new business models and revenue streams.

Benefits:

- **Get started in minutes:** Use pre-configured solutions. And accelerate your IoT projects to jump ahead of the competition.
- **Connect any device:** Using an open and flexible solution, connect a broad range of existing and device types and operating systems.
- **Predict the future:** Use advanced analytics and machine learning to capture insights from data that were not possible before.
- **Automate to transform:** Integrate with your existing business systems and make the best use of the data and processes you already have.

Features:

- **Connect quickly and scale with efficiency:** Microsoft Azure IoT Suite uses preconfigured solutions and accelerate the development of your Internet of Things (IoT) solution. Add new devices and connect existing ones using device SDKs for multiple platforms, including Linux, Windows and real time operating systems. Easily scale from just a few sensors to millions of simultaneously connected devices and rely on the global availability of Azure, no matter how large or small your project.
- **Analyse and act on untapped data:** Collect previously untapped data from devices and sensors and use built-in capabilities to visualize and act on the data. Set up real time analytics by using SQL based syntax in a scalable, high performance and resilient way, without having to manage complex infrastructure and software. Use a vast algorithm library to extend predictive analytics solutions. And extend real time analytics and

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machine learning solutions by integrating code from languages such a Python and R directly into your workspace.

- **Integrate and transform your business:** Easily integrate Azure IoT Suite with your systems and applications, including Salesforce, SAP, Oracle Database and Microsoft Dynamics, making it simple to access your data and keep your disparate systems up to date. Send millions of messages to heterogeneous devices through a mobile push notification engine with less development effort. Build mobile and we applications which integrate with Microsoft and third party web APIs and use OAuth 2.0 to build your own secure web APIs.
- **Enhance Security of your IoT solutions with per-device authentication:** Set up individual identities and credentials for each of your connected devices and help retain the confidentiality of both cloud to device and device to cloud messages. Also, selectively revoke the access rights of specific devices to maintain the integrity of your system.

VI. Conclusion

Amazon Web Services IoT, Google Cloud Platform, IBM Watson IoT, Microsoft Azure IoT Suite has provides the combination of Cloud Computing and Internet of Things (IoT). Cloud IoT Connect your devices, analyze previously-untapped data, and integrate business systems and transform your company when you uncover new business models and revenue streams. The combination of Cloud Computing and Internet of Things is a platform that enables you to connect device to cloud services and other devices, secure data and interactions, process and act upon device data and enable applications to interact with devices even when they are offline. It creates streams of insight by extending your infrastructure to the physical world.

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BIOGRAPHY

Mandeep Kumar, pursuing MCA from Central University of Haryana, India. He is MCA First Rank Holder till now and BCA Gold Medalist. He has presented two research papers in different National Conferences and attended various Workshops and Seminars. He has published one paper in National Conference and six papers in International Journals. His research interests are Cloud Computing, Cloud Security, Internet of Things, Artificial Intelligence, DevOps and Web Design & Development.