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Recent Trends in Cloud Computing and IoT Platforms for IT Management and Development: A Review

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Abstract- **Cloud computing has transformed the delivery and management of IT services, and with the advent of the Internet of Things (IoT), cloud platforms have become even more crucial for developing and managing IT solutions. This critical review article presents the latest research on cloud computing platforms with IoT capability and their impact on IT management and development. The review covers the advantages of cloud computing platforms, including their cost-effectiveness, scalability, and flexibility. It also provides an in-depth analysis of six leading cloud platforms with IoT capability: ThingSpeak, Ubidots Platform, AWS IoT, IBM Watson, ThingWorx, and Salesforce Platform. The review focuses on their features, capabilities, and limitations. The article concludes by emphasizing the crucial role of cloud computing platforms with IoT capability in IT management and development and their potential for future growth and development. The insights provided by this review are essential for researchers and practitioners who seek to comprehend the emerging trends in cloud computing platforms and their impact on IT management and development.**

Index Terms— **Cloud computing, IoT, IT services, management, development, cost, scalability, flexibility, ThingSpeak, Ubidots, AWS IoT, IBM Watson, ThingWorx, Salesforce, features, limitations, growth, trends, review.**

I. INTRODUCTION

Cloud computing is a revolutionary model transforming how organizations and individuals access and use computing resources. By leveraging the power of the internet, cloud computing allows users to access servers, storage, and applications on-demand without the need to invest in and manage their own physical infrastructure [1]. This saves time and money and provides benefits such as increased reliability, security, and data management. To help organizations and individuals choose the best cloud computing platform for their needs

An Evaluation of Cloud Computing Performance: AWS, AZURE and Google Cloud is a comprehensive study that compares and evaluates the three major cloud computing platforms - Amazon Web Services (AWS), Microsoft Azure, and Google Cloud [2]. These platforms are among the world's most widely used cloud computing services and are known for their reliability, scalability, and wide range of services and capabilities. The study examines key performance metrics, such as speed, reliability, and scalability, to provide a comprehensive overview of each platform's strengths and weaknesses [3]. It also examines other important factors such as cost, security, and ease of use to help organizations decide which platform best suits their needs, with its impartial and up-to-date information. An Evaluation of Cloud Computing Performance: AWS, AZURE and Google Cloud" is an essential resource for anyone looking to understand the differences between the three major cloud computing platforms (see Fig. 1) and make informed decisions about which platform to choose. Do not miss this opportunity to gain valuable insights into cloud computing and choose the platform that best meets your needs [4].

The COVID-19 pandemic has ushered in a new era of work and a remarkable surge in demand for cloud computing services. This shift to remote work has been a game-changer, and businesses have scrambled to keep up by migrating their IT infrastructure to the cloud and setting up remote work systems [5].In response to this demand, major cloud providers have doubled their offerings, focusing on providing cutting-edge cloud security, advanced AI and machine learning services, and multi-cloud and hybrid cloud solutions [6]. This means businesses now have access to unparalleled tools and services to support their cloud computing needs.

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The rise of edge computing and the Internet of Things has also created exciting new opportunities for cloud providers to offer real-time data processing and analytic solutions at the network's edge [7]. This is a game-changer for businesses that need to process large volumes of data quickly and accurately. So if you want to take advantage of the latest cloud computing technologies, now is the time to act. With a wealth of powerful tools (see Table I) and services at your fingertips, there's never been a better time to harness the power of the cloud and take your business to the next level [8].

Table 1: Clouds Metrics 2020

Metric	AWS	Azure	GCP
Revenue Growth	33%	61%	45%
User Adoption	67%	48%	32%
Market Share	31%	24%	8%

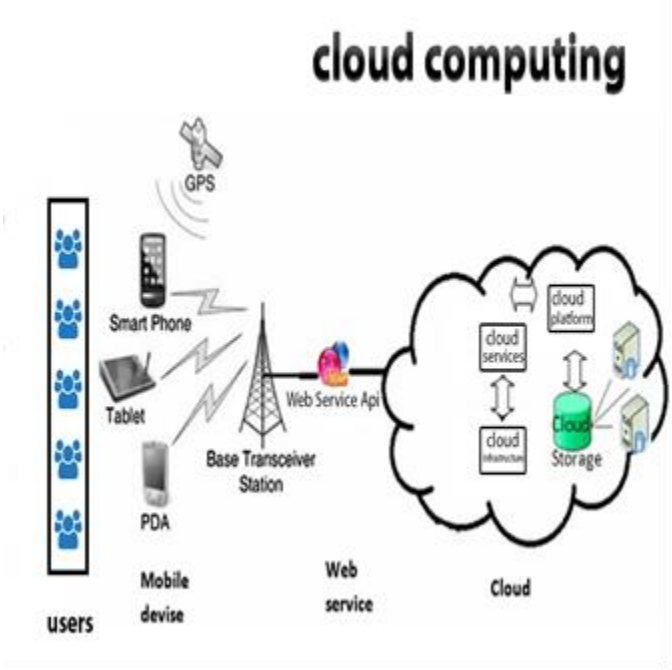

FIGURE 1: Cloud Computing

Cloud computing has been essential in responding to the COVID-19 pandemic, enabling businesses to stay connected and productive with remote collaboration, communication, and data management tools. Cloud services have proved to be a game-changer, providing reliable and secure solutions that have kept businesses up and running even during these challenging times. But that's not all. Cloud providers have continued to push the boundaries of innovation with cutting-edge AI and machine learning technologies that are transforming businesses across various industries. As these technologies become increasingly critical to success, businesses that embrace them stand to gain a significant competitive advantage, And that's not all [9]. The cloud has also become a leading force for sustainability, with many providers investing heavily in renewable energy and carbon offset programs. By harnessing the power of the cloud, businesses can reduce their carbon footprint and contribute to a more sustainable future for us all. In short, the cloud is not just a game-changer as shown in Fig. 2. It is a game-saver. By embracing cloud technologies and working with providers committed to innovation and sustainability, businesses can thrive in even the most challenging times given in Table II. So why wait? Now is the time to take advantage of the cloud and improve your business [10].

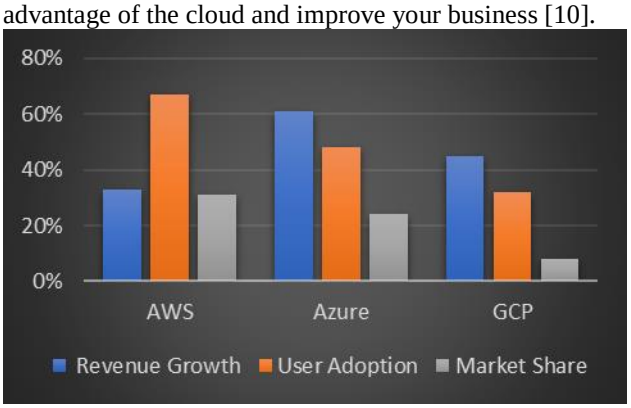

FIGURE 1: Clouds Metrics Chart 2020

Table II: Clouds Metrics 2021

Metric	AWS	Azure	GCP
Revenue Growth	32%	24%	45%
User Adoption	38.9%	51.3%	63.7%
Market Share	33%	24%	9%

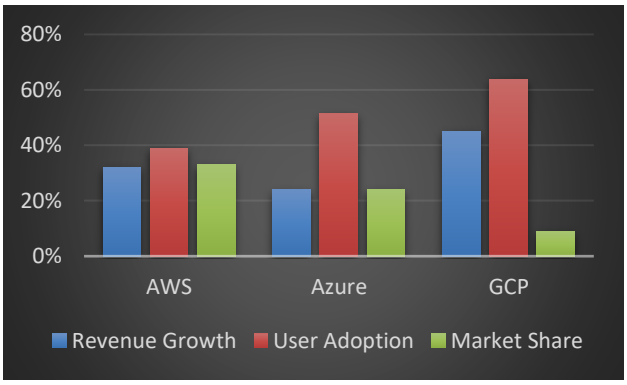

FIGURE 3: Clouds Metrics Chart 2021

Businesses today face a dizzying array of cloud computing options, each with its own strengths and weaknesses shown in Fig. 3. But with multi-cloud and hybrid cloud solutions,

businesses can have the best of both worlds, leveraging the unique strengths of different cloud providers and optimizing their IT infrastructure for specific use cases [11]. As if that weren't enough, the rise of 5G networks has opened up a whole new world of possibilities for cloud computing. With their increased bandwidth and low latency, 5G networks make it possible to run even more demanding applications and services in the cloud, unlocking new levels of productivity and performance for businesses across industries. But with great power comes great responsibility, and that's why cloud providers have redoubled their focus on security. With cyber threats and data breaches becoming increasingly sophisticated and frequent, cloud providers are investing heavily in cutting-edge security technologies to keep their customers safe and secure. So whether you are looking to harness the power of the cloud for your business or stay current on the latest cloud computing trends as given in Table III and Fig. 4, there's never been a better time to get involved [12].

Table III: Clouds Metrics 2022

Metric	AWS	Azure	GCP
Revenue Growth	37%	63%	9.2%
User Adoption	34%	21%	10%
Market Share	34%	22%	8%

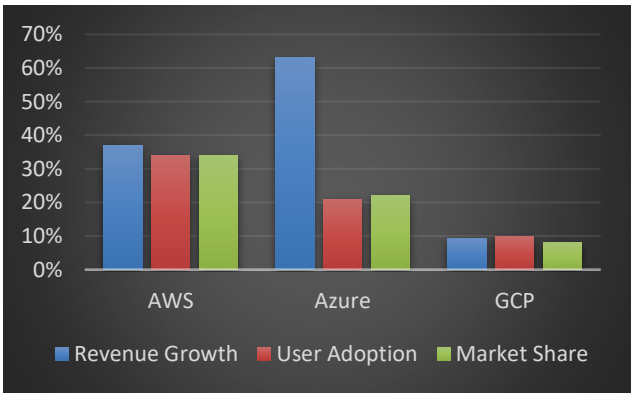

FIGURE 4: Cloud Metrics Chart 2022

II. ADVANTAGES OF CLOUD COMPUTING

In today's fast-paced business world, organizations seek every possible advantage to stay ahead of the competition. That's where cloud computing comes in, offering a host of benefits that can help organizations thrive and grow.

1. Cost saving:

The pay-as-you-go model allows cost savings by only paying for the resources used. Eliminates the need for upfront capital expenditures for hardware and infrastructure. Reduces costs associated with managing and maintaining hardware, such as cooling and power consumption.

2. Reliability:

Cloud providers offer redundant systems and backup options, which increases system reliability. Cloud providers have experienced teams managing the infrastructure, which reduces the likelihood of errors or downtime. Cloud providers also offer Service Level Agreements (SLAs) that ensure a minimum level of uptime, further enhancing reliability.

3. Scalability:

Cloud providers allow for easy scaling up or down of resources as needed, which can help businesses save costs by only paying for what they use. Scaling can be done quickly and easily, allowing businesses to respond to changing demands or unexpected spikes in traffic. Scalability also enables businesses to test and deploy new applications and services quickly.

4. Flexibility:

Cloud services offer a range of tools and services that can be customized to meet the specific needs of a business .Depending on their requirements, businesses can choose from different cloud models, including public, private, or hybrid clouds.Cloud services can be accessed from anywhere, allowing employees to work remotely or from different locations.

5. Performance:

Cloud providers offer high-performance computing resources that can handle complex workloads and applications .Cloud providers also use advanced hardware and software to ensure fast processing and response times .Cloud providers can offer low-latency connections that are ideal for real-time applications and services.

6. Availability:

Cloud providers offer 24/7 availability and support, ensuring that businesses can access their resources at anytime .Cloud providers also have multiple data centers and backup systems, ensuring that data and services are available even in the event of a hardware failure or disaster. Cloud providers also offer data replication and backup services, ensuring that data is always available and protected.

III. CLOUD SERVICES MODELS

Cloud service models refer to the different ways cloud services are provided and managed. The main categories are IaaS, PaaS, SaaS, FaaS, and STaaS, each with unique features and provider examples, as shown in Fig. 5.

IV. CLOUD PLATFORMS WITH IOT CAPABILITY

A. ThingSpeak

ThingSpeak is an Internet of things platform that allows users to analyze and visualize data from IoT devices. It provides an easy-to-use cloud-based infrastructure for building IoT applications and projects [18]–[20]. The platform lets you connect your IoT devices to the internet and securely send data to the cloud shown in Fig. 6. Once the data is in the cloud, it can be stored, analyzed, and visualized in real-time using built-in tools.

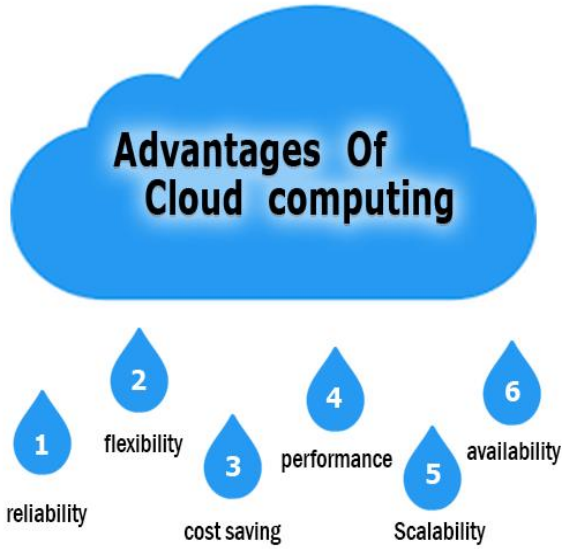

FIGURE 5: Clouds Advantages

Table IV: Cloud Services Models

Cloud Service Model	Description	Examples
Infrastructure as a Service (IaaS)	Provides visualized computing resources over the internet. Customers rent virtual machines], storage, and other resources and are responsible for managing the operating system, middleware, and application software.	Amazon Web Services (AWS), Microsoft Azure, Google Cloud Platform (GCP)
Platform as a Service (PaaS)	Provides a platform and environment for customers to develop, run, and manage applications and services without having to worry about infrastructure. Customers are responsible for managing their applications, while the provider manages the underlying infrastructure.	Heroku, AWS Elastic Beanstalk, Google App Engine
Software as a Service (SaaS)	Provides customers with access to software applications over the internet. Customers use the applications provided by the provider, who is responsible for managing both the applications and the underlying infrastructure.	Salesforce, Google G Suite, Microsoft 365
Function as a Service (Faas)	Allows customers to run small, single-purpose functions in the cloud, triggered by events and automatically managed by the provider. This eliminates the need to manage the underlying infrastructure and resources, making it a cost-effective option for running and scaling small applications and micro services.	AWS Lambda, Google Cloud Functions, Microsoft Azure Functions
Storage as a Service (STaaS)	Provides customers with access to calculable and highly available storage over the internet, without having to worry about the underlying infrastructure. The provider manages the storage infrastructure and provides various features such as backup, recovery, and data protection.	Amazon S3, Microsoft Azure Blob Storage, Google Cloud Storage

FIGURE 6: Clouds Services

The platform supports a variety of data sources, including sensors, web services, and social media feeds [21]. One of the key features of ThingSpeak is its ability to create custom IoT applications using MATLAB [22], [23], a programming language commonly used in scientific computing and engineering. This feature allows users to perform advanced data analysis and modelling on their IoT data, and to integrate it with other MATLAB-based applications. ThingSpeak also includes a public API, which allows developers to build custom applications and integrate with other systems. This makes it easy to create custom dashboards, alert systems, and other IoT applications that can be used in various industries and applications [24].
In summary, ThingSpeak is an IoT platform that provides a simple and flexible infrastructure for collecting, analyzing, and visualizing data from IoT devices. It is ideal for building custom IoT applications and projects and supports a wide range of data sources and integration options.

B. Ubidots Platform

Ubidots is an IoT platform that provides a cloud-based infrastructure for collecting, storing, and analyzing data from connected devices. The platform allows users to build IoT applications and projects easily and quickly without extensive programming knowledge [25]. Ubidots provides a user-friendly interface for setting up and managing IoT devices and data streams. It supports many devices, sensors, and protocols, allowing users to easily integrate their existing hardware into the platform. The platform also provides tools for creating custom dashboards, charts, and alerts, allowing users to visualize their data in real-time and take action based on insights. One of the key features of Ubidots is its flexibility and scalability. The platform can handle large volumes of data and easily integrate with other systems and applications. Ubidots also provides APIs for developers to build custom applications and integrations, enabling users to extend the platform's functionality to meet their specific needs. Ubidots also provides advanced features for data analysis and machine learning. The platform includes built-in algorithms for anomaly detection, predictive maintenance, and other use cases, allowing users to extract insights from their data quickly and easily [26].
Ubidots is an IoT platform that provides a flexible and scalable infrastructure for collecting, storing, and analyzing data from connected devices. It is ideal for building custom IoT applications and projects and supports many devices and protocols. With its user-friendly interface and advanced features, Ubidots makes it easy for users to gain insights from their IoT data and take action based on those insights.

C. AWS IOT

AWS IoT is a cloud-based platform offered by Amazon Web Services (AWS) that allows users to securely connect and manage IoT devices at scale. It provides comprehensive services and tools for building, deploying, and managing IoT applications and projects. AWS IoT provides a scalable and reliable infrastructure for connecting IoT devices to the cloud. The platform supports a wide range of devices and protocols, allowing users to easily integrate their existing hardware into the platform. It also provides tools for securely managing device identities, credentials, and data, ensuring data is protected throughout its lifecycle. One of the key features of AWS IoT is its flexibility and scalability. The platform can handle large volumes of data. It can be easily integrated with other AWS services, such as Amazon S3, Amazon DynamoDB, and Amazon Kinesis, for advanced data processing and analysis. AWS IoT also provides APIs and SDKs for developers to build custom applications and integrations, enabling users to extend the platform's functionality to meet their specific needs.AWS IoT provides a range of features for device management, such as over-the-air (OTA) updates, remote device monitoring and control, and device shadowing. It also includes advanced analytics and machine learning services, such as Amazon SageMaker and Amazon QuickSight, for analyzing and visualizing IoT data and generating actionable insights [27].
In summary, AWS IoT is a cloud-based platform offered by Amazon Web Services (AWS) that provides a scalable and reliable infrastructure for connecting and managing IoT devices at scale. It is ideal for building custom IoT applications and projects and supports a wide range of devices and protocols. With its flexible and scalable infrastructure, advanced analytics and machine learning services, and robust device management features, AWS IoT is a powerful platform for building and managing IoT applications and projects.

D. IBM WATSON

IBM Watson IoT is a cloud-based platform that provides tools and services for building and managing Internet of Things (IoT) applications and projects. It offers a scalable and secure infrastructure for connecting and managing IoT devices, collecting and analyzing data, and generating insights to improve business operations. The platform allows users to connect and manage IoT devices securely, enabling them to collect and analyze data from sensors and other sources. IBM Watson IoT supports a wide range of devices and protocols, making it easy for users to integrate their existing hardware into the platform. The platform also provides tools for managing device data, such as data filtering and normalization, and supports real-time data streaming for faster analysis and processing. One of the key features of IBM Watson IoT is its advanced analytics and machine learning capabilities. The platform includes powerful data analytics tools that enable users to derive insights from their IoT data and identify trends and patterns. It also supports machine learning models, which can automate and optimize business processes based on IoT data.IBM Watson IoT also provides various tools for building custom IoT applications and integrations. It includes an open API, which allows developers to build custom applications and integrations that leverage the platform's data and analytics capabilities. The platform also includes tools for building custom dashboards and visualizations, making it easy for users to monitor and analyze their IoT data in real-time [28].

In summary, IBM Watson IoT is a cloud-based platform that provides a comprehensive set of tools and services for building and managing IoT applications and projects. With its secure and scalable infrastructure, advanced analytics and machine learning capabilities, and tools for building custom applications and integrations, IBM Watson IoT is a powerful platform for businesses leveraging IoT data to improve their operations and drive growth.

E. THING WORX

ThingWorx is a cloud-based platform offered by PTC that provides a comprehensive set of tools and services for building and managing Internet of Things (IoT) applications and projects. It offers a scalable and secure infrastructure for connecting and managing IoT devices, collecting and analyzing data, and generating insights to improve business operations.

The platform allows users to connect and manage IoT devices securely, enabling them to collect and analyze data from sensors and other sources. ThingWorx supports a wide range of devices and protocols, making it easy for users to integrate their existing hardware into the platform. The platform also provides tools for managing device data, such as data filtering and normalization, and supports real-time data streaming for faster analysis and processing [29].

One of the key features of ThingWorx is its drag-and-drop development environment, which allows users to quickly and easily build custom IoT applications and integrations without extensive programming knowledge. The platform includes a comprehensive set of development tools, including customizable widgets, drag-and-drop data modelling, and reusable components, enabling users to create applications and integrations that meet their needs.

ThingWorx also includes powerful analytics and machine learning tools that enable users to derive insights from their IoT data and identify trends and patterns. The platform supports machine learning models, which can automate and optimize business processes based on IoT data. In addition, ThingWorx provides a range of tools for building custom dashboards and visualizations, making it easy for users to monitor and analyze their IoT data in real-time. The platform also includes an open API, which allows developers to build custom applications and integrations that leverage the platform's data and analytics capabilities.

In summary, ThingWorx is a cloud-based platform providing comprehensive tools and services for building and managing IoT applications and projects. With its secure and scalable infrastructure, drag-and-drop development environment, powerful analytics and machine learning capabilities, and tools for building custom dashboards and visualizations, ThingWorx is an ideal platform for businesses looking to leverage IoT data to improve their operations and drive growth

F. Salesforce platform

Salesforce IoT Cloud is a cloud-based platform that allows businesses to connect, monitor, and interact with their Internet of Things (IoT) devices and data. It provides a scalable and secure infrastructure for collecting and analyzing IoT data, and leveraging it to improve business processes and customer experiences. The platform enables users to securely connect and manage IoT devices, collect and process data in real-time, and generate insights using powerful analytics tools. It supports many devices and protocols, making it easy for businesses to integrate their existing hardware and IoT data into the platform. Salesforce IoT Cloud includes powerful analytics and machine learning tools that allow businesses to derive insights from their IoT data and make data-driven decisions. It enables users to create customizable dashboards and visualizations, monitor their IoT data in real-time, and trigger alerts and actions based on specific events or data patterns. One of the key features of Salesforce IoT Cloud is its ability to integrate with other Salesforce products and services, such as Salesforce CRM, Service Cloud, and Marketing Cloud. This integration allows businesses to leverage their IoT data to enhance customer experiences, improve marketing campaigns, and streamline customer service processes.

Salesforce IoT Cloud also includes tools for building custom IoT applications and integrations, such as APIs and SDKs, making it easy for developers to create custom IoT solutions that meet their specific needs. The platform's drag-and-drop interface and low-code development environment also enable

users to build IoT applications and integrations without extensive programming knowledge [30].

In summary, Salesforce IoT Cloud is a cloud-based platform that provides a comprehensive set of tools and services for connecting, monitoring, and interacting with IoT devices and data. With its scalable and secure infrastructure, powerful analytics and machine learning tools, and seamless integration with other Salesforce products and services, Salesforce IoT Cloud is an ideal platform for businesses looking to leverage IoT data to improve their operations and customer experiences.

V. CONCLUSION

In conclusion, cloud computing platforms with IoT capability are rapidly evolving and transforming the IT industry. The advantages of these platforms, such as cost-effectiveness, scalability, and flexibility, make them increasingly popular among organizations for managing and developing IT solutions. The critical review article has analyzed six leading cloud platforms with IoT capability, including ThingSpeak, Ubidots Platform, AWS IoT, IBM Watson, ThingWorx, and Salesforce Platform, providing insights into their features, capabilities, and limitations. The review highlights the importance of these platforms for IT management and development and their potential for future growth and development. Researchers and practitioners in the IT industry can benefit significantly from this review by understanding the emerging trends in cloud computing platforms with IoT capability and their impact on IT management and development. Overall, the integration of cloud computing with IoT has opened up new possibilities for developing innovative solutions and improving IT services, making it an exciting area for future research and development.

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The authors declare they have no conflicts of interest to report regarding the present study.

CONFLICT OF INTEREST

The Authors declare that they have no conflicts of interest to report regarding the present study.

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