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CLOUD COMPUTING FOR INTERNET OF THINGS

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Abstract: Cloud computing has transformed the Internet of Things (IoT) as it offers easily scalable, flexible, and affordable solutions for storage and processing data. From our study, we found that the integration of cloud computing and IoT, its advantages and disadvantages evolution in future was discussed. Finally, this paper tried to cover up the literature involving these areas retroactively through their past to present studies up to 2021 and a conducive material has been developed for obtaining new insights from researchers who are going further work on some other or extended versions. Through discussing these and conducting a broad literature review as well as comparing current implementations, in this paper we explore the way in which cloud-based platforms can augment capability offered by IoT and facilitate prominence of data management, security and interoperability issues. Our discovery indicates that although cloud computing still advances IoT capabilities, it also adds extra challenges which require more future research and efforts to be settled.

Keywords: Cloud Computing, Internet of Things, Cloud based IoT, Integration.

I. INTRODUCTION

Today, IoT is changing this pace by connecting billions of devices across the globe, enabling them to collect and exchange data. This interconnected system, which spans everything from smart home gadgets to industrial sensors, produces massive volumes of data that need to be managed and processed. Thanks to this scalable and on-demand resources cloud computing is an optimal solution that can manage such large datasets as IoT-generated ones.

This paper explores the combination of IoT with cloud computing, intending to determine how much cloud platforms assist in improving and dealing the difficulties underlying IoT. This is followed by a detailed and in-depth literature review that will help throw light on the trend lines and changes that are happening in this area. Subsequently, we review numerous methodologies and implementation approaches; evaluate the outcomes of previous case studies, and their consequences from our findings [2].

We are moving toward an era of internet, in which everything around us will get connected to the Internet and they can communicate with each other with little or no human intervention. The IoT, if you will pardon my use of a buzzword, consists primarily of things (objects) that have little or no storage and compute resources. So, it is right to say that Cloud computing, IoT (Internet of Things) in combination will be the future of Internet and Next Generation Technologies Cloud services are built upon service providers that are highly interoperable, while IoT is designed to be diverse rather than being an inter-operable.

Fig 1: Integration of cloud computing and IOT

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Face detection is the medium of all facial analysis, e.g., face localization, facial feature detection, face recognition, face verification and facial expression recognition. Moreover, it is a foundational technique for other applications such as content-based image retrieval, video conferencing, and intelligent human-computer interaction (HCI).

The goal of face detection is to find out whether or not there are any faces in the picture, if present, return the location and the extent of each face [1]. While face detection is a trivial task for human vision, but it is a challenge for computer vision due to the variations in scale, area, orientation, pose, facial expression, light condition, and various appearance features.

II. BASIC CONCEPTS

This section reviews the basic concepts of Cloud Computing, the IoT, and Cloud-based IoT.

1. Cloud Computing

Cloud computing is the delivery of various services through the Internet. These resources include tools and applications like data storage, servers, databases, networking, analytics and much more Enterprises can now avoid investing in and managing the physical infrastructure by hiring these services from cloud service providers, which leads to huge capital savings as well as operational efficiency.

Cloud Computing has been defined by the National Institute of Standards and Technology in NIST Special Publication 800–145 as "a model for enabling ubiquitous, convenient, on demand network access to a shared pool of configurable computing resources that can be rapidly provisioned and released with minimal management effort or service provider interaction". The model has several characteristics: on-demand self-service where users can unilaterally access computing capabilities as needed without human interaction. Broad network access must be provided including having the ability to make these services available on the network and accessed through a number of client platforms. Providers use a multi-tenant model which lets multiple consumers share the same resource thereby allowing provider's resources to be dynamically assigned, reassigned, or released based on consumer demand [3]. There is also rapid elasticity that allows for resources to rapidly scale up or down based demands placed upon them.

Cloud computing has particular service models, which are the Infrastructure as a Service (IaaS), offering virtualized computer services; Platform as a Service providing the framework for application development and deployment by developers; Software as a Service delivering software applications over the internet under subscription. Deployment model: whether public (shared across organizations), private (dedicated to one organization), or hybrid (public and private). Thanks to the flexibility, scalability and cost effectiveness that is built into cloud computing, it has become one of the most important components in controlling all the data from IOT (internet-of-things) which are generated by organizations today.

2. Internet Of Things

The new approach is the Internet of Things, where real and digital-world borders are fading away more and more because every physical object can be changed into the smart version that provides smarter services in true potential. Every 'thing' in the IoT (smart devices, sensors, etc.) has a unique identity of its own. The communication network is created by connecting them, which subsequently become active participants. Objects – not just the items within human reach in daily use, but everything from essentials like food, and clothing through to things such as materials, parts and or sub-assemblies; general consumables or luxury goods as well as buildings large or small have stood for thousands of years. Commerce and culture all are ways that anything tangible is known to occupy space at any one time. Moreover, these objects can make requests and change their state. In this way every IoT can be monitored, located and quantity accounted mean wasteful on loss of cost features are highly minimized.

The origins of IoT can be traced back to the early 1980s, at Carnegie Mellon University. This is when a team of researchers modified a Coca-Cola vending machine in their building to report on its inventory and whether newly loaded drinks were cold fan sites Although the name "Internet of Things" didn't come about until a bit later. It was first introduced in 1999 by British technologist Kevin Ashton while working at Procter & Gamble Ashton's term described a system in which the Internet was connected to objects that were linked through ubiquitous sensors to the physical world [4]. Since then, IoT has continued to grow and evolve, with dramatic improvements in the

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availability of wi-fi and cellular networks as well as more affordable sensor technology we have seen an exponential growth in IOT devices and use cases throughout this century.

3. Cloud-Based Internet of Things

The IoT and Cloud computing are two rapidly growing services, yet they both present unique properties. One such model as per which the IoT is grounded the process of using smart devices that connects through world wide web (WWW) network and an extensible infrastructure. This makes everywhere computing possible. Key things to note about the edge layer are that its devices are widely distributed and have minimal processing power/emergence of storage. Performance, reliability, privacy and security issues on those devices So what type of network offers unlimited storage and computation power? As said earlier, cloud computing consists of a huge network Moreover, it offers flexible and resilient surroundings that enable your dynamic data integration from multiple data sources. Almost all of these issues have been mitigated with the help of cloud computing. (In most…) Of course, the IoT and Cloud are two more advanced technologies. They always intertwine to change the current and future environment of internetworking services.

Combining cloud computing and the Internet of Things (IoT) yields an even more powerful synergy: Cloud based IoT. This approach takes advantage of the scalable, flexible cloud computing infrastructure to manage and analyze the enormous volumes of data produced by IoHT devices. Cloud platforms enable organizations to store, process and retrieve data in real-time for more informed decision-making and operational efficiency. Cloud-based IoT, characterized by the ease of device management, higher and smarter analytics in big data processing pipelines, and interoperability across different IoT systems, allows scalable implementations while ensuring data security and minimizing latency [5].

III. ADVANTAGES OF IOT WITH CLOUD

In addition to its limited resources on processing and storage, the IoT has to deal with other problems like performance, security, privacy, reliability. Definitely, the integration of the IoT into the Cloud is by far one of those best methods to mitigate these concerns. By means of providing new services for billions of things in diverse real life contexts, at the same time being more dynamic and distributed in nature, The Cloud can benefit even further from IoT (Date, Time). The cloud makes it simple to use, and cuts down the expenses of applications used by an individual [6]. The Cloud makes it easy to manage the flow of the data collected and processed as well as enables rapid, inexpensive deployment and integration for larger complex data processing and deployment. Benefits are:

- Scalability:

The cloud provides almost unlimited scalability, enabling IoT systems to ‘grow’ and safely support an increasing number of devices and larger data volumes. As IoT deployments continue to grow, cloud platforms will be able to automatically ramp resources up or down according to demand and deliver the best performance levels with little need for heavy upfront investment in infrastructure requirements [7].

- Cost effective:

The organization can reduce the cost of capital in hardware, maintenance, and up-gradation by seizing services of cloud-based. Pay only for what you use: Cloud providers offer the pay-as-you-go subscription model which enables businesses to pay only for what their teams consume, reducing overall IT expenses and promoting cost predictability.

- Flexibility and Agility:

With an unprecedented level of flexibility and agility, cloud-based IoT solutions support fast deployment millions of time-sensitive equipment in the fields to experiment with new emerging applications and services.

- Data Management and Analytics:

The cloud delivers powerful data management, processing, and analytic capabilities that allow companies to gain actionable insights from the explosion of IoT data.

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- Remote Monitoring and Management:

With cloud-based IoT platforms, you can easily monitor and manage your connected devices wherever there is an internet connection. This feature is especially useful for organizations whose business model relies on distributed operations or assets spread out geographically. By enable remote monitoring of device performance, diagnostics and over-the-air (OTA) updates it helps them to be more efficient operationally while minimizing downtime.

- Interoperability and Integration:

Cloud computing helps seamless integration and interoperability between varied IoT devices, protocols, systems.

- Reliability & High Availability:

Cloud based IoT Platform provides high reliability and availability functionality along with a redundancy/security model.

- Ecosystem and Community:

Cloud ecosystems encourage developers, partners, customers by promoting the idea of collaboration between them. It also shares the ideas, best practices and prebuilt solution to develop or deploy IoT products.

IV. CLOUD BASED IOT ARCHITECTURE

As shown in several previous studies, the famous IoT architecture is divided generally into three main layers which are Application Layer, Perception Layer as well as Network Layer.

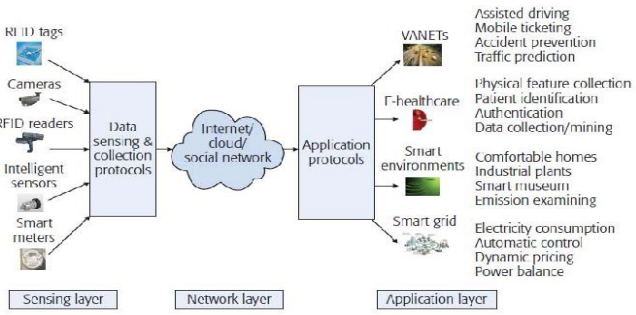

Fig 2: IOT Architecture on the basis of cloud

The perception layer can sense things in the environment and collect data about what happens around it. On the contrary, the only aim of network layer is to transfer all the data collected to internet/cloud. Finally, Application layer acts as interface to the different services it could be any given application built on them.

V. CLOUD BASED IOT APPLICATIONS

- Healthcare:

Cloud-based IoT applications in healthcare provide real-time remote monitoring of patients through wearable health devices that track heart rate and other vital information, allowing later to analyze this data on cloud servers. This results in preemptive healthcare and individualized treatment [8]. While telemedicine platforms use the data from Internet of Things to conduct virtual consultations, smart hospitals leverage it for asset tracking & environment control along with patient management for comfortable patients and fast material throughput.

- Home Automation & Smart Cities:

Senses data like traffic, public safety and environmental conditions into the cloud using IoT sensors. For example, traffic management control systems optimize signal timings by reducing congestion. And surveillance systems that

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benefit public safety via live monitoring and emergency alert system. Smart lighting systems that adjust streetlight brightness to real-time conditions are reducing energy consumption and improving safety.

- Smart Homes:

Smart home application employ cloud connected devices to enable automation of the homes, including energy consumption and security maintenance Controlled remotely by homeowners, smart meters, and cloud analytics can optimize energy consumption by turning lights on and off. Control the thermostat or turn off appliances when they're not in use! Additionally, security systems using IoT cameras and sensors also allow for real-time monitoring as well as alerts which can make it both safer and more convenient.

- Automotive and Smart Mobility:

Automotive using the cloud-based IoT applications can keep performance of the vehicle in record. These applications are telematics systems that records all data related to vehicle which helps in manufacturing improvement also keeps track on real-time navigation updates [10]. The cloud handling the sensor information and traditional production on SD maps are used by autonomous generating technologies with fleet management systems leveraging IoT for tracking, route optimization and monitoring of driver behavior, super-efficiency is assured as well as safety.

- Smart logistics:

Smart logistics IoT application allows real-time tracking of goods and assets leading to increased visibility and efficiency in the supply chain. Temperature sensors for monitoring perishable goods while on the move, thereby maintaining quality and compliance. Avail to cloud-based analytics which help optimize inventory levels and warehouse operations, lowering costs while boosting productivity. Asset- Proper as well as tracking and fleets increased usage of logistics assets or timely maintenance scheduling for an optimized lifespan [9].

VI. CHALLENGES FACED

- Security and Privacy Issues:

Securing IoT systems from cyber-attacks and protecting user data privacy is a top concern. IoT devices and cloud infrastructure may get vulnerable, which sometimes can be the cause for data breach, unauthorized access or privacy issues.

- Managing data:

It is difficult to efficiently manage the massive volume of data produced by IoT devices. We have processes to collect, store and process data and to analyses this data while keeping the integrity of it and also ensuring that the same is available whenever it is needed.

- Interoperability:

IoT devices use different communication protocols and standards in most cases it will be hard to make connected devices with each other or cloud platforms to get transportation data seamlessly. As this capability matrix mentions, the lack of interoperability can limit its scalability and flexibility.

- Reliability and Availability:

IoT systems are so much dependent on network connectivity and cloud services. Any disturbances in network connectivity or cloud service failures (outages) can be detrimental, and they bring with them a negative impact on the functions of IoT applications.

- Cost Management:

Setting up and maintaining IOT systems based on the cloud can be very costly such as costs related to your cloud infrastructure, data storing and processing charges and investments on your IoT devices along with security measurements. These costs are hard to control while the always need to assure that quality is maintained at its best!

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- Complexity in actual implementation:

Due to the existing and cloud-based platforms, IoT implementations required a great deal of expertise and knowledge. That's because complexity comes not just from having to configure devices but also develop applications, secure all the virtual devices and juggle updating and maintaining each of them.

- Regulatory and Compliance:

IoT systems must comply with data protection regulations, industry standards, legal requirements of a particular location. Ensuring that IoT deployments conform to the regulations and standards associated with them is complicated, always evolving, and never done.

- Energy Consumption:

IoT devices and cloud infrastructure uses a substantial amount of energy. Whereas optimizing the use of energy and embracing more energy-efficient technologies are critical components that ensure minimal environmental footprint as well as operational costs.

VII. CONCLUSION

To conclude, this research paper has explored the profound implications and difficulties of combining cloud computing with the Internet of Things. Considerable potential is to be gained from cloud computing, improving functionality, scalability and efficiency of these systems by enabling access to virtually unlimited computational resources, storage and additional services. Cloud infrastructure help IoT applications to break limitations of data storage, processing power and device managing; exploration new solutions in different areas like healthcare, smart cities, automotive or supply chain.

To sum it up, through this paper, we have examined how cloud-based IoT integration brings in major benefits such as better data management, scalability, flexibility and cost savings. We have, however, also called out the substantial challenges that need to be overcome if we are going to truly make this integration as beneficial as it can be. As the number of connected devices grow, worries about security and privacy also takes precedence as it leads to new attack vectors and protection of data. On top of that, there are critical or some other important factors such as interoperability problems and reliability and availability Problems. Cost management problems implementation difficulty, regulatory compliance, energy consumption etc. all these must be carefully considered and addressed.
In the future, more research and innovation is needed to find effective ways of addressing these challenges. This requires collaboration among industry, academia, policy makers and standards bodies to create best practices, standards and frameworks that can be used for developing secure as well as interoperable cloud based IoT systems. “Moreover, continuous developments in data analytics, cybersecurity and edge computing along with energy efficient technologies will further help in steering the future of cloud computing for IoT” Arora adds.

In an era when we continue to observe explosive growth in the number and type of IoT devices, as well a surge towards cloud-based offerings driven by both consumers and tech companies alike, It becomes critical that we adopt a comprehensive view while tackling Cloud-based IoT integration — beyond technology alone, but also considering ethical, legal & societal perspectives.

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