Towards the Integration between IoT and Cloud Computing for Smart Applications

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Abstract: The Internet of Things (IoT) is an emerging paradigm that enables the communication between electronic devices and sensors through the internet in order to facilitate our lives. IOT use smart devices and internet to provide innovative solutions to various challenges and issues related to various business, governmental and public/private industries across the world. IoT is committed to provide the best possible solutions to deal with security issues of data and information. In the traditional version, the internet is an infrastructure which provides theterminals for end users, while within the Internet of Things it provides the inter connection of smart objects within a ubiquitous computing environment.

Internet of Things (IoT) is the next step evolution of Internet, where any physical object/thing having/equipped with computation and communication capabilities could be seamlessly integrated, at different levels, into the Internet. The exploitation of Cloud computing technologies is challenging to support the development of IoT systems, because it guarantees high scalability and reliability of the available services. Thus, IoT and Cloud computing offer new possibilities for sharing data and services through the Internet, by introducing a dynamic global network system with self-configuring capabilities based on standard and interoperable communication protocols.

The chapter begins with the history of IOT followed by integration with cloud computing for smart applications for the new trend that provides flexible computing and storage services that are used to support a massive amount of data processing is cloud computing technology. Thus, the analysis of data produced by sensors and IoT devices can be applied to cloud computing. Platform-neutral technologies are needed to resolve key issues such as communication bottlenecks, data interchange formats, protection and interoperability to maximize the market potential for the future. For any technical services offered via the Internet, Cloud Computing is a general term. For multiple computing tools such as networks, systems, software, and facilities, cloud computing offers compliant and on-demand network access.

1. INTRODUCTION

It is important to explore the common features of the technologies involved in the field of computing. Indeed, this is certainly the case with Cloud Computing and the Internet of Things (IoT) – two paradigms which share many common features. The integration of these numerous concepts may facilitate and improve these technologies. Cloud computing has altered the way in which technologies can be accessed, managed and delivered. It is widely agreed that Cloud computing can be used for utility services in the future [1]. Although many consider Cloud computing to be a new technology, it has, in actual fact, been involved in and encompassed various technologies such as grid, utility computing virtualisation, networking and software services [2], [3]. Cloud computing provides services which make it possible to share computing resources across the Internet. As such, it is not surprising that the origins of Cloud technologies lie in grid, utility computing virtualization, networking and software services, as well as distributed computing, and parallel computing [4]. On the other hand, the IoT can be considered both a dynamic and global networked infrastructure that manages self- configuring objects in a highly intelligent way. The IoT is moving towards a phase where all items around us will be connected to the Internet and will have the ability to interact with minimum human effort [5]. The IoT normally includesa number of objects with limited storage and computing capacity [6]. It could well be said that Cloud computing and the IoT will be the future of the Internet and next-generation technologies. However, Cloud services are dependent on service providers which are extremely interoperable, while IoT technologies are based on diversity rather than interoperability [6].

2. INTERNET OF THINGS (IOT)

The IoT represents a modern approach that is ready to gradually break the boundaries between physical and digital domains, consistently transform each physical device into an intelligent alternative, and deliver intelligent services. Everything in the IoT (smart devices, sensors, etc.) has its own identity. They are combined with objects that are actively participating in the communication network [6]. These objects include food, clothing, materials, parts, assemblies, aswell as the electronics we use every day. Durable consumer goods; monuments and landmarks; various forms of trade and culture [7]. In addition, these objects can make requests and change their status. Therefore, all IoT devices can be monitored, tracked, and counted, significantly reducing waste, loss, and cost [8]. The concept of the IoT was first mentioned by Kevin Ashton [9], [10] in 1999, that "The Internet of Things has the potential to change the world, just as the Internet did. Maybe even more so". Was officially announced by the International Telecommunications Union (ITU) in 2005 [11]. The various definitions of the IoT have been established by many organizations and researchers. According to the ITU (2012), the IoT is a global information society infrastructure that enables advanced services by connecting things (physical and virtual) based on existing and emerging interoperable information and communication technologies. "[12]. The IoT offers a variety of possibilities and applications. However, it faces many challenges that can hinder successful implementation, including: data storage, heterogeneous resource constrained, scalability, Things, variable geospatial deployment,and energy efficiency [13].

3. CLOUD COMPUTING

Several definitions of cloud computing have been proposed, but the most widely acceptedone seems to be the National Institute of Standards and Technology (NIST) definition. In fact, NIST enables cloud computing to provide ubiquitous and convenient on-demand network access to shared pools of rapidly provisioned configurable computing resources (networks, servers, storage, applications, services, etc.). It is defined as "a model to be used". "Release with minimal administrative effort or service provider interaction" [7]. As shown in this definition, cloud computing includes four delivery models, three different service models, and five key characteristics. Cloud computing delivery models are most commonly categorized as: Belonging to the public cloud, it makes resources available to consumers over the Internet. Public clouds are typically owned by profitable organizations (such as Amazon EC2) [8]. Conversely, private cloud infrastructure is typically provided by a single organization to serve a particular purpose of the user [7]. Private clouds provide a secure environment and a higher level of control (Microsoft Private Cloud). Hybrid clouds are a mixture of private and public clouds. This choice is offered to consumers as it can overcome some of the limitations of each model [9]. In contrast, the community cloud is a cloud infrastructure provided to groups of users from different organizations who share the same needs [10]. To help consumers choose the service that suits them, cloud computing services are offered at three different levels: Software as a Service (SaaS) model (eg, software as a service) in which software is delivered to users over the Internet.

4. ROLE OF CLOUD COMPUTING IN IOT:

a) Enable the remote computing feature:

With high storage capacity, the IoT eliminates reliance on on-premises infrastructure. Cloud technology has become mainstream due to continuous advances in the Internet and devices that support advanced cloud solutions and the development of Internet-based technologies. A cloud solution full of IoT allows businesses to access remote computing services with a single click or command.

b) Security and Privacy:

The tasks can be automated with cloud technology and IoT, allowing organizations to significantly reduce security threats. The IoT Engineering Cloud is a solution that provides control for prevention, detection, and remediation. Effective authentication and encryption protocols also provide users with strong security measures. Protocols such as biometrics for IoT products help manage and protect user identities along with data.

c) Data integration:

Recent technological developments not only facilitate the smooth integration of IoT and the cloud, but also provide real-time connectivity and communication. This makes it easy to extract real-time information about key business processes and perform onsite data integration with 24/7 connectivity. With powerful data integration capabilities, cloud-based solutions can handle large amounts of data generated from multiple sources, along with centralized storage, processing, and analytics.

d) Minimal hardware dependency:

Currently, some IoT solutions offer Plug and Play hosting services made possible by integrating the cloud with IoT. With cloud support, IoT hosting providers do not have to rely on any kind of hardware or equipment to support the agility required by IoT devices. It has become easier for enterprises to seamlessly implement large-scale IoT strategies across platforms and move to omni-channel communications.

e) Business Continuity:

Cloud computing solutions are known for their agility and reliability, as well as their ability to provide business continuity in the event of an emergency, data loss, or disaster. Cloud services run on a network of data servers in multiple geographic locations that store multiple copies of backup data.Even in an emergency, IoT-based operations will continue to work and data recoverywill be easier.

f) Communication between multiple devices and touch points:

IoT devices and services need to connect and communicate with each other to perform the tasks achieved by cloud solutions. Supporting multiple robust APIs allows the cloud and IoT to interactand connect devices. Communication supported in the cloud helps ensure smooth dialogue.

g) Response time and data processing:

Combining edge computing with IoT solutions typically results in faster response times and fasterdata processing capabilities. To get the most out of it, you need to use the IoT in your
cloud and edge computing solutions.

Cloud computing services can accelerate the growth of the IoT, but there are certain challengesto successfully delivering these services. The combination of IoT and the cloud presents many hurdles that need to be overcome in advance.

5. Challenges Bringing Clouds and IoT Together

The following are the challenges that bring together IOT and Cloud Computing are as follows:

a) Big Data:

Processing large amounts of data can be tiring and overwhelming, especially with the myriad of devices operating at multiple touch points. This can jeopardize the overall performance of the application. Therefore, it is advisable to constantly monitor system and data backups.

b) Network and Communication Protocols:

Cloud and IoT devices include communication at multiple touch points using multiple protocols. Because it is an internet-dependent service, it can be difficult to manage changes. Internet access over WiFi and mobile internet helps solve all the challenges that arise in this situation due to connectivity issues.

c) Sensor networks:

The sensor networks allow users to process and understand the IoT environment and enhance the usefulness of the IoT. However, processing large amounts of data on a regular basis is a major challenge for these networks.

6. Cloud-based IoT applications

The cloud-based IoT approach has introduced many applications and intelligent services that have impacted the daily lives of end users: [4] [24] [25] [26] [27]

a) **Healthcare** :

Cloud-based IoT has brought many benefits and opportunities to the healthcare sector. You can significantly develop and improve healthcare services and keep your field innovative (intelligent drug / drug control, hospital management, etc.).

b) Smart Cities :

By retrieving data from sensor infrastructure, IoT technology and consistently deploying information, IoT can provide middleware for future smart cities. This will generate services that can communicate with the environment (smart streetlights, Bigbelly, ShotSpotte, etc.).

c) Smart Home :

Many cloud-based IoT applications enable automation of home activities, and with the introduction of various embedded devices and cloud computing, internal activities(home security control, smart metering, energy, etc.) can now be automated.

d) Video surveillance :

By embracing Cloud based IoT, intelligent video surveillance will make it possible tomanage, store and process video content from video sensors easily and efficiently; this will also make it possible to extract information from scenes automatically. It hasbecome one of the supreme tools for many security related applications (e.g. WirelessCCTV Cameras, Movement detection system).

e) Automotive and Smart Mobility :

The integration of Cloud computing into The Global Positioning System (GPS) and other transportation technologies represents a promising opportunity to solve many ofthe existing challenges (e.g. traffic state prediction & notification, remote vehicles).

f) Smart energy and smart grid:

Cloud computing and the IoT can work together effectively to provide consumers with smart management of energy consumption (e.g. smart meters, smart appliances, renewable energy resources).

g) Smart logistics :

It allows for, and eases, the automated management of goods flow between producersand consumers, while simultaneously enabling the tracking of goods in transit (e.g. logistics industry, tracking shipments).

e) Surrounding monitoring :

By combining the cloud with the IoT, we can provide a high-speed information system that combines a wide range of well-deployed environments with entities that monitor sensors (e.g. pollution source monitoring, water quality monitoring, air quality monitoring).

7. THE FUTURE OF SMART DEVICES [28][29]:

The Internet of Things has become a world-leading technology. It has gained a lot of popularityin a short period of time. Advances in artificial intelligence and machine learning have also made it easier to automate IoT devices. Basically, AI and ML programs are combined with IoT devices to achieve proper automation. As a result, the IoT is expanding its application fields in various industries. This section describes IoT applications and future scope in the healthcare, automotive, and agricultural industries.

a) Healthcare:

IoT has proven to be one of the best tools for the healthcare industry. It helps to provide advancedmedical facilities to patients, doctors and researchers. These features include smart diagnostics, wearable health tracking devices, patient management, and more. In addition, IoT devices place an unnecessary burden on healthcare systems.

Fig 1: IoT in Healthcare[28]

Medical devices can send patient health data directly to doctors over a secure network. This allows doctors to diagnose patients remotely.

b) Agriculture:

One of the three basic human needs is food. We are farming to meet our food needs. But as the world's population grows, the agricultural industry faces many challenges. Changes in weather conditions and climate also have a major impact on agriculture. That's why the industry is adopting productivity-enhancing technologies to meet the growing demand for food. This includes the use of precision agriculture, agricultural drones and smart agricultural applications.

Fig 2: IoT in Agriculture[28]

All of these are based on Internet of Things applications. Now let's talk about how precision agriculture, smart agricultural applications, and agricultural drones are helping to improve the country's productivity.

i) Precision Agriculture:

In agriculture, information and communication technology is a tool for intelligent agriculture. Crop fields are monitored using IoT-based devices. This technique uses sensors to calculate soil moisture, humidity, and temperature. It also uses an automatic irrigation system to use water efficiently. Precision agriculture helps farmers monitor their fields and increase their productivity.

ii) Agricultural Unmanned Aerial Vehicles:

Agricultural Unmanned Aerial Vehicles and Agricultural Unmanned Aerial Vehicles are one of the best applications of the Internet of Things. They are used to improve the agricultural process. We use agricultural drones to plant crops, irrigate fields, spray pesticides, and monitor fields. With the help of drones, it will be easier to assessthe health of the plant. All this is possible with the help of smart IoT-based devices used in the manufacture of agricultural drones.

iii) Smart Greenhouses:

Farmers use greenhouse cultivation to increase crop productivity. In greenhousecultivation, the environmental factors that affect plant growth are controlled by manual intervention. However, manual control of the plant's growth mechanism is less productive. With the advent of IoT and technological advances, IoT-based greenhouses consisting of various devices such as sensors and climate controllers have been created.

These IoT devices help measure different environmental conditions depending on the needs of the plant. All sensors and devices are connected via an internet server, providing accurate information about environmental conditions. The device then activates actuators to adjust heaters, fans, windows and greenhouse lighting accordingto the environment. The scale of IoT improves the productivity of the agricultural industry.

c) Automotive industry:

In the 21st century, the use of IoT is revolutionizing the automotive industry. One of the main uses is the development of self-driving cars, which has changed the trend of the automotive industry. Engineers have designed self-driving cars to reduce manual errors and ensure safe driving. Various companies around the world are developing self-driving cars, including Google, Tesla, Mercedes Benz, Volvo and Audi. These self-driving cars use a variety of technologies such as data science, artificial intelligence, deep learning, and IoT. IoT devices are programmed to help buildautomated systems for self-driving cars.

Fig 3: IoT in Automotive industry[28]

These IoT devices consist of HD cameras, heat sensors, smart navigation devices, cruise control, rain sensors, wireless connections, and proximity sensors. While using these cars, you have to enter your location and destination. The navigator then tries to find the destination and find the shortest route. IoT-based HD cameras then help capture the environment and send data to AI-based systems. These systems analyze and visualize data from the environment and modify the reaction of self-driving cars accordingly. There are alsoIoT-based speed controllers that can help you adjust the speed of these cars in response to traffic and traffic. Here's how the scope of the IoT is changing trends in the automotive industry.[28]

8. BENEFITS OF INTEGRATION CLOUD COMPUTING AND IOT FOR SMARTAPPLICATION IN UPCOMMING FUTURE.

As the IoT suffers from limited capabilities in terms of processing power and storage, issues such as performance, security, privacy, and reliability must also be addressed. The best way to overcome most problems is to integrate the IoT with cloud computing. [6], [14].

a) Communication:

Applying and sharing data is two key features of the cloud-based IoT paradigm. You can push popular applications to the IoT and leverage automation to facilitate cost-effective data distribution and collection. The cloud is an effective and economical solution that allows you to connect, manage and track everything using built-in apps and custom portals. [7], [16].

b) Storage:

IoT can be used on billions of devices and covers a huge number of sources of information that produce huge amounts of semi-structured or unstructured data. Cloud storage is considered one of the most cost-effective and appropriate solutions for processing the vast amounts of data generated by the IoT. [17] [4] [18]

c) Processing capabilities:

IoT devices feature limited processing capabilities that prevent complex onsite data processing. Instead, the collected data is sent to the sophisticated node. In fact, this is where the aggregation and processing takes place. The cloud offers unlimited virtual processing capabilities and on-demand usage modes. [18] [6]

d) New Features:

IoT is characterized by the heterogeneity of its devices, protocols and technologies. As a result, reliability, scalability, interoperability, security, availability, and efficiency can be very difficult to achieve. It also offers other features such as ease of use and easy access at low installation costs. [6] [19] [22]

e) New model:

Cloud-based IoT integration enables new scenarios for intelligent objects, applications, and services. Some of the new models are [11], [20]:

- **SaaS (Sensing as a Service)** [11] provides access to sensor data.
- **EaaS (Ethernet as a Service)** [23] provides a ubiquitous connection for controllingremote devices.
- **SAaaS (Sensing and Actuation as a Service)** [11] automatically deploys control logic.
- **IPMaaS (Identity and Policy Management as a Service)** [23] provides access topolicy and identity management.
- **DBaaS (Database as a Service)** [23] provides ubiquitous database management.
- **SenaaS (Sensor as a Service)** [23] provides management of remote sensors.
- **DaaS (Data as a Service)** [23] provides ubiquitous access to all types of data.

9. CONCLUSION

The integration of IoT and cloud computing solutions is the future of the Internet, solvingsome business obstacles and opening new avenues for business and research. At each step, new applications and services are developed to solve existing challenges. The cloud and IoT still have a long way to go to reach their true potential in the future. The IoT is becoming an increasingly ubiquitous computing service that requires vast amounts of data storage and processing power. IoT has limited processing power and storage capabilities, but it also has consequential issues such as security, privacy, performance, and reliability. Therefore, cloud and IoT integration is very beneficial in overcoming these challenges.

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