

Benefits of Integrating Cloud Computing with Internet of Things

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Abstract: This paper is a theoretical approach on the mentioned topic. In this research we mainly focus on the benefits of integration and challenges associated with the same. The main goal of the interaction and cooperation between objects over the wireless networks is to fulfill the objective set for them as a combined entity. This paper mainly focuses on the integration of cloud and IoT which is called Cloud IoT paradigm and what are their usage scenarios. However, the research work lacks detailed analysis of the new CloudIoT paradigm, which involves completely new applications, benefits, challenges and research issues. The challenges or the issues include security concern and the compatibility check between the respective systems. There are many issues standing in the successful implementation of both Cloud and IoT. The integration of Cloud Computing with the IoT is the most effective way on which to overcome these issues.

Keywords: cloud computing, IoT

1. Introduction

As technology progresses, connectivity of devices with the internet has become easy and information gathering and processing has become more manageable. Cloud computing and Internet of Things (IoT) are the technologies which benefited us separately and now their integration provide us several advantages. Although these two are different technologies but when merged together will emerge as a vital component for the near Future. Cloud computing allow users to access software and the applications from wherever they can; computer programs are hosted by an outside party and reside in the cloud. And the connection of everyday physical objects to the internet and being able to identify themselves to other devices. This vision is based on Internet of Things (IoT) [1]. Business applications have always been very complicated and expensive and the hardware and software requirements are massive to run them. We need a whole team of experts to install, configure, test, run, secure, and update them. When these efforts are multiplied across dozens or hundreds of apps, it's easy to see why the biggest companies with the best IT departments aren't getting the apps they needed. With the emergence of cloud computing, it eliminates the headaches that come on storing the data. Cloud computing provides a simple way to access servers, storage, databases and a broad set of application services over the Internet.

2. Basic concepts

Basics of IoT and Cloud and over viewing the characteristics essential for their integration.

A. Internet of things

In the era of computing a new wave is predicted that is realm of traditional computer named IoT. IoT is short form for Internet of Things. Internet of Things (IoT) is an ecosystem of connected physical objects that can be accessed through the internet. The IoT consists of objects that have been assigned an IP address and perform data collection and transfer amongst them without any manual intervention. The thing or object in IoT includes entities like heart monitor, home automation system, automobile with sensors etc. The embedded technology in the objects helps them to interact with internal states or the external environment, which in turn affects the decisions taken. IoT Scan help companies improve performance through IoT analytic and IoT Security to deliver better results. IoT has remarkable effects both in home and work scenarios, where it can play leading role in near future that is E-health, smart transportation etc. [2].

B. Cloud computing

Cloud computing aims for providing information technology services such as cloud storage, cloud data processing, cloud gaming etc. which were earlier restricted to one's local machine only. Cloud computing has blurred the boundary between traditional and cloud applications along with providing high fault tolerance owing to its distributed nature. As long as an electronic device has access to the web, it has access to the data and the software programs to run it. Cloud computing eliminates the headaches of storing the data, because managing hardware and software becomes the responsibility of an experienced vendor like Salesforce. 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 [3][4].

3. Usage scenarios of the two

A. IoT

IoT is applied in many application fields, such as in buildings

construction, car traffic monitoring, environments analysis, health-care assistance, weather forecast, and video surveillance. IoT will also offer new services for making cities “Smarter” and it will improve the interaction of people and IoT devices/services with the surrounding environments, increasing the Citizens’ quality of life [5].

According to requirements, IoT is used in

- 1) IoT-Based Pest Control
- 2) Optimizing the Power Grid
- 3) Saving the Bees
- 4) Making Trash Collection More Efficient
- 5) Thwarting Illegal Fishing
- 6) Doing Away With Dangerous Police Chases
- 7) Using Drones to Help Save the Rainforest
- 8) Redefining Field-Based Intel for the Oil and Gas Industry
- 9) Using Sensors to Make Driving Safer
- 10) Better road traffic management

B. Cloud Computing

According to the requirements,

- 1) Cloud Computing used as an operational technology and as a service provider for businessman, health-care, data centers, education, and CRM.
- 2) You can access the pre-installed application and system software from anywhere on any device. Cloud hosted apps and websites are readily accessible from anywhere.
- 3) The SAAS, IAAS and PAAS business models are producing software as a service such as CRM, Platform as Services such as for application development and Infrastructure (server) as service for data management and analysis.
- 4) Now businesses of all sizes looking for cloud computing to maximize the success opportunities. Amazon, Microsoft, Google, IBM and many other big IT companies are providing and developing cloud-based IT infrastructure and applications for small businesses, healthcare, data centers, education, and CRM [6].

4. Benefits

Since the IoT suffers from limited capabilities in terms of processing power and storage, it must also contend with issues such as performance, security, privacy and reliability. The best way to overcome most of the issues is to integrate IoT with the Cloud Computing.

- *Communication*: Application and data sharing are two significant features of the Cloud-based IoT paradigm. Ubiquitous applications can be transmitted through the IoT, whilst automation can be utilized to facilitate low-cost data distribution and collection. The Cloud is an effective and economical solution which can be used

to connect, manage, and track anything by using built-in apps and customized portals.

- *Storage*: IoT can be used on billions of devices, it comprises a huge number of information sources, which generate an enormous amount of semi-structured or non-structured data. The Cloud storage is considered to be one of the most cost-effective and suitable solutions when it comes to dealing with the enormous amount of data created by the IoT.
- *Processing capabilities*: IoT devices are characterized by limited processing capabilities which prevent on-site and complex data processing. Instead, gathered data is transferred to nodes that have high capabilities; indeed, it is here that aggregation and processing are accomplished. Cloud provides unlimited virtual processing capabilities and an on-demand usage mode.
- *New abilities*: The IoT is characterized by the heterogeneity of its devices, protocols, and technologies. Hence, reliability, scalability, interoperability, security, availability and efficiency can be very hard to achieve. It also provides other features like ease-of-use and ease-of-access, with low deployment costs.
- *New Models*: Cloud-based IoT integration empowers new scenarios for smart objects, applications, and services Some of the new models are as follows:
 - ✓ SaaS (Sensing as a Service) - allows access to sensor data;
 - ✓ EaaS (Ethernet as a Service) - provides ubiquitous connectivity to control remote devices
 - ✓ SAaaS (Sensing and Actuation as a Service) - provides control logic's automatically;
 - ✓ IPaaS (Identity and Policy Management as a Service) - provides access to policy and identity management;
 - ✓ DBaaS (Database as a Service) - provides ubiquitous database management;
 - ✓ SenaaS (Sensor as a Service) - provides management for remote sensors;
 - ✓ DaaS (Data as a Service) - provides ubiquitous access to any type of data [7].

5. Challenges

Cloud Computing can be set as a base technology in the use of IoT. There is a rapid and independent evolution regarding the two words of IoT and Cloud Computing [8]. The IoT technology extends its scope to deal with real world things in a more distributed and dynamic manner and by delivering new services in a large number of real life scenarios, might be beneficial for the use of Cloud Computing technology. The challenges that are faced by us is to have globally competing Cloud infrastructure for Internet of Services that are interconnected with Things distributed over remote areas. In these scenarios, security is one of major factors that is

hampering the rapid and large scale adoption and deployment of IoT and Cloud computing.

A. Security issues

Integration of IoT and Cloud Computing can be observed that Cloud Computing can fill some gaps of IoT such the limited storage and applications over internet. IoT can fill the gaps of Cloud Computing such as the issue of limited scope. IoT applications move towards the Cloud Computing technology, concerns arise due to the lack of trust in the service provider or the knowledge about service level agreements (SLAs) and knowledge about the physical location of data. Some challenges about the security issue in the integration of two technologies are listed [9].

- a) *Heterogeneity*: A big challenge in CloudIoT paradigm is related to the wide heterogeneity of devices, operating systems, platforms, and services available and possibly used for new or improved applications [10].
- b) *Performance*: Often CloudIoT paradigm applications introduce specific performance and QoS requirements at several levels (i.e. for communication, computation, and storage aspects) and in some particular scenarios meeting requirements may not be easily achievable [11].
- c) *Reliability*: When Cloud IoT paradigm is adopted for mission-critical applications, reliability concerns typically arise e.g., in the context of smart mobility, vehicles are often on the move and the vehicular networking and communication is often intermittent or unreliable [12].
- d) *Monitoring*: As largely documented in the literature, monitoring is an essential activity in Cloud environments for capacity planning, for managing resources, SLAs, performance, security and for troubleshooting.

B. Compatibility

Both systems fundamentally complement each other yet they follow different approach to address the same problem and compatibility plays a vital role in the integration of cloud and IoT. The first challenge we have to overcome is of inter-process communication i.e, instead of using heterogeneous protocols and layered stacks. We will have to consider protocols specifically targeting cloud IoT as a system in itself. Cloud IoT based systems can only be successful considering social & economic point of view. International standardization of the concerned technology and its related protocols will ensure cumulative efforts towards its further development. Other compatibility issues stem from non-unified cloud services, lack of standardized M2M protocols and diversities in firmware and operating systems among IoT devices.

6. Applications

A wide set of applications are made possible or significantly

improved with the help of Cloud IoT paradigm [13-16].

- *Healthcare*: Cloud-based IoT has brought many benefits and opportunities to the field of healthcare. It can clearly develop and improve healthcare services and keep the field innovative (e.g. intelligent drug/medicine control, hospital management).
- *Smart Home and Smart Metering*: A large number of Cloud-based IoT applications have enabled the automation of home activities, where the adoption of various embedded devices and Cloud computing has empowered the automation of in-house activities (e.g. home security control, smart metering, energy saving).
- *Video Surveillance*: By embracing Cloud-based IoT, intelligent video surveillance will make it possible to manage, store and process video content from video sensors easily and efficiently; this will also make it possible to extract information from scenes automatically. It has become one of the supreme tools for many security-related applications (e.g. Wireless CCTV Cameras, Movement detection system).
- *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 of the existing challenges (e.g. traffic state prediction & notification, remote vehicles).
- *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).
- *Smart Logistic*: It allows for, and eases, the automated management of goods flow between producers and consumers, while simultaneously enabling the tracking of goods in transit (e.g. logistics industry, tracking shipments).
- *Environmental monitoring*: By combining the Cloud with the IoT, a high-speed information system can be provided which will link the entity that monitors wide-area environments and sensors that have been properly deployed in the area (e.g. pollution source monitoring, water quality monitoring, air quality monitoring)

7. Conclusion

Cloud Computing offers many possibilities, but also with several limitations as well. The main goal of the interaction and cooperation between things and objects over the wireless networks is to fulfill the objective set for them as a combined entity. As the integration of the Cloud into the IoT is very beneficial in terms of overcoming the challenges. In future work, a number of case studies will be carried out to test the effectiveness of the Cloud-based IoT approach for many applications. The benefits and challenges are going hand in hand with this new innovative technology however to better

serve the community all the challenges are to be addressed. *Future Aspects:* Undoubtedly, this research can be the basis for the researchers to address the challenges while these two widely accepted technologies are merged.

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