JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

A Survey on Integration of Cloud Computing and Internet of Things

[1]Majoju Kiran Kumar, [2]Dr.Arathi Chitla
[1]Assitant Professor(C), [2]Professor
[1]Department of Computer Science, [2]Department of CSE
[1]Satavahana University, Karimnagar, Telangana, India

Abstract : Cloud computing is a revolutionary paradigm that involves delivering computing services, such as storage, processing, and networking, over the internet. It provides on-demand access to a shared pool of configurable computing resources, allowing organizations to scale resources up or down based on their needs. Integration is the process of connecting different systems and applications to work together seamlessly, enhancing overall efficiency and productivity. The Internet of Things (IoT) refers to the network of interconnected devices that communicate and share data, ranging from smart sensors to everyday appliances. Cloud computing and IoT integration enable the seamless exchange of data between devices and cloud-based services, fostering a connected and intelligent ecosystem. This integration allows for real-time data processing, analysis, and storage in the cloud, enabling quicker and more informed decision-making. Cloud platforms serve as a centralized hub for managing and processing the massive amounts of data generated by IoT devices. The scalability of cloud computing accommodates the diverse and growing number of IoT devices, ensuring a flexible and adaptive infrastructure. Integration between cloud computing and IoT enhances data security by centralizing management and implementing robust authentication and encryption protocols. Integration allows for the creation of comprehensive solutions where IoT devices can seamlessly interact with other enterprise applications and services hosted in the cloud. Integration facilitates the creation of end-to-end solutions, connecting IoT devices, cloud services, and enterprise applications to deliver a cohesive user experience. This survey paper will focus on the architecture of Cloud-based IoT paradigm and major areas where the IoT applications are widely used, and the various technologies that help in integrating Cloud with IoT. Finally, limitations and future research directions are also suggested.

***IndexTerms* - Cloud Computing, Internet of Things, Cloud basedIoT Applications, Edge Computing, Fogg Computing.**

I.INTRODUCTION

Cloud computing and the Internet of Things (IoT) are two transformative technologies that, when combined, create a powerful and interconnected ecosystem. Cloud computing, as a paradigm, involves delivering computing services such as storage, processing, and networking over the internet on a scalable and on-demand basis. On the other hand, IoT refers to the network of interconnected devices that communicate and share data. The role of the Cloud computing is significant in the day to day lives of the human being[1]. The Cloud Computing encompasses many technologies in order produce efficient service to the users [2], [3]. The cloud computing facilitates the sharing of computing resources over the internet. The origins of cloud technologies can be traced back to various foundational concepts, including grid computing, utility computing, virtualization, networking, software services, distributed computing, and parallel computing. [4]. On the other hand, he IoT as a continuously evolving, globally connected infrastructure with the ability to autonomously manage and interact with objects in an intelligent manner, ultimately moving towards a future where ubiquitous connectivity is achieved with minimal human intervention [5]. The IoT is described as a network that interconnects a variety of devices. This emphasizes the inclusivity and diversity of connected devices within the IoT ecosystem, ranging from everyday objects to advanced technologies. [6].

This paper provides an overview of the integration of Cloud Computing and IoT; this also involves the technologies used in the cloud based IoT and advantages and challenges associated with the integration. Open issues and research directions are also discussed. The remainder of the paper is organised as follows: Section II provides the basic concepts of Cloud computing, IoT, and Cloud-based IoT; Cloud based IoT architecture and Edge computing and Fogg computing technologies are discussed in Section III . Section IV illustrates different Cloud-based IoT applications scenarios. The challenges facing Cloud-based IoT integration are discussed in Section V, limitations in the cloud and IoT integration are discussed in Section VI, open research directions are discussed in Section VII. Section VIII concludes the paper.

II.BASIC CONCEPTS

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

A. Cloud Computing

There are many proposed definitions exist Cloud Computing, although the most widely agreed definition is given by the National Institute of Standards and Technology (NIST). Indeed, the NIST has defined Cloud computing as "a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction" [7].

From the definition given by NIST [7], The Cloud Computing is comprised into the following five deployment models[31].

The public Cloud: where resources are made available to consumers over the Internet. Public Clouds are generally owned by a profitable organisation (e.g. Amazon EC2) [8].

The private Cloud: It is commonly provided by a single organisation to serve the particular purposes of its users [7]. The private Cloud offers a secure environment and a higher level of control (Microsoft Private Cloud).

Hybrid Clouds: This is mixed architecture of private and public Clouds. This choice is provided for consumers to overcome some of the limitations of each model [9]. community Cloud: This type of Cloud infrastructure which is delivered to a group of users by a number of organisations which share the same need [10].

The Cloud Computing provides the following different levels of services to the customers to fulfil their needs.

the Software as a Service (SaaS) model, where software is delivered through the Internet to users (e.g. GoogleApps) [2]; the Platform as a Service (PaaS) model, which offers a higher level of integrated environment that can build, test, and deploy specific software (e.g. Microsoft Azure); and finally, with the Infrastructure as a Service (IaaS) model, infrastructure such as storage, hardware and servers are delivered as a service (e.g. Amazon Web Services) [11]

B. Internet of Things

The concept of the Internet of Things (IoT) was initially introduced by Kevin Ashton in 1999 [9],[10], highlighting its potential to revolutionize the world similar to the impact of the Internet. The formal presentation of IoT came in 2005[11] by the International Telecommunication Union (ITU). Various organizations and researchers have proposed numerous definitions of IoT. According to the ITU in 2012, IoT is described as a global infrastructure for the Information Society. It facilitates advanced services by connecting physical and virtual things through interoperable information and communication technologies, both existing and evolving[12]. In essence, IoT creates a network where various objects can communicate and share data, enabling advanced and interconnected services.

In the [6], the author described The Internet of Things (IoT) as a contemporary approach that blurs the lines between the physical and digital realms by transforming every physical device into a smart alternative capable of delivering intelligent services. In the IoT, all entities, including smart devices and sensors, possess unique identities and actively participate in a communication network. These objects extend beyond typical electronic devices to encompass everyday items like food, clothing, materials, and cultural elements such as monuments[7]. The IoT introduces a variety of opportunities and applications. The IoT also faces several challenges in implementation, such as data storage, heterogeneous resource- constrained, scalability, Things, variable geospatial deployment, and energy efficiency [13].

C. Cloud-Based Internet of Things

In [14], the author elaborated about Cloud-Based IoT as both the technologies together providing rapidly developing services, and have their own unique characteristics. The Internet of Things (IoT) is like a big network of smart devices that talk to each other around the world. This creates a dynamic setup for computers to be everywhere. In the IoT, these smart devices are spread out and don't have a lot of computing power or storage space. They face challenges in terms of how well they work, how reliable they are, and how to keep things private and secure.

According to the author in [30], The Cloud-based Internet of Things (IoT) is a platform that enables the efficient use of applications, information, and infrastructure at a reasonable cost. Although IoT and Cloud computing are distinct concepts, they complement each other well, as illustrated in Table 1. This synergy is a key driver for researchers advocating their integration. [14].

Table 1 Comparison of IoT with Cloud Computing [30]

Items	IoT	Cloud Computing
Characteristics	IoT is pervasive (things are everywhere). These are real world objects.	Cloud is ubiquitous (resources are available from everywhere). These are virtual resources.
Processing capabilities	Limited computational capabilities.	Virtually unlimited computational capabilities.
Storage capabilities	Limited storage or no storage capabilities.	Unlimited storage capabilities.
Connectivity	It uses the Internet as a point of convergence.	It uses the Internet for service delivery.
Big data	It is a source of big data.	It is a means by which to manage big data.

D. Benefits Of Integrating Cloud and IoT

The IoT faces challenges due to limited processing power and storage, along with issues like performance, security, privacy, and reliability. Integrating IoT into the Cloud emerges as the optimal solution to address these challenges. This integration not only overcomes IoT limitations but also allows the Cloud to leverage real-world objects in a more dynamic and distributed manner, enabling the provision of new services for numerous devices across various scenarios [6], [14]. Moreover, the Cloud enhances simplicity, reduces costs for end-users, streamlines IoT data gathering and processing, and facilitates quick, cost-effective installation and integration for complex data processing and deployment [15]. In [30], the author outlined the following benefits of integrating IoT into the Cloud.

- ***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 utilised 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 applications.

- ***Storage:*** The Internet of Things (IoT) operates on billions of devices, generating a massive amount of diverse, rapidly generated, and large-scale data known as Big Data. This data exhibits characteristics such as variety, velocity, and volume. The Cloud is recognized as a cost-effective and fitting solution for managing this vast IoT-generated data. Additionally, it opens up opportunities for integrating, aggregating, and sharing data with third parties [17].
- ***Processing capabilities:*** IoT devices have limited processing power, so they can't handle complex data processing on-site. Instead, the data they collect is sent to more powerful nodes for aggregation and processing. The challenge lies in making this process scalable without the right infrastructure. The Cloud comes to the rescue by providing unlimited virtual processing power and a flexible on-demand usage model [17]. According to the author in [6], some predictive algorithms and data-driven decisions making can be integrated into the IoT in order to increase the productivity and reduce risks at a lower cost.
- ***Scope**:* The world is rapidly transitioning into the Internet of Everything (IoE), where billions of users communicate, and diverse information is collected. This IoE realm forms a network of networks with countless interconnected things, bringing both opportunities and risks . The Cloud-based IoT approach introduces new applications and services by expanding the Cloud through IoT objects. This expansion enables the Cloud to adapt to various real-world scenarios, giving rise to innovative services and possibilities[19],[21].
- ***New abilities**:* The IoT is diverse with varying devices, protocols, and technologies, making achieving reliability, scalability, interoperability, security, availability, and efficiency challenging. Integrating IoT into the Cloud effectively addresses these issues [6]. This integration offers additional benefits such as user-friendly and accessible features with low deployment costs [18], [21].

E. NEW MODELS:

Cloud-based IoT integration empowers new scenarios for smart objects, applications, and services [11], [19][31]. Some of the new models are listed as follows:

- SaaS (Sensing as a Service) [11], which allows access to sensor data;
- EaaS (Ethernet as a Service) [22], the main role of which is to provide ubiquitous connectivity to control remote devices;
- SAaaS (Sensing and Actuation as a Service) [11], which provides control logics automatically.
- IPMaaS (Identity and Policy Management as a Service) [22], which provides access to policy and identity management.
- DBaaS (Database as a Service) [22], which provides ubiquitous database management;
- SEaaS (Sensor Event as a Service) [11], whichdispatches messaging services that are generated bysensor events;
- SenaaS (Sensor as a Service) [22], which provides management for remote sensors;

III. CLOUD-BASED IOT ARCHITECTURE

According to a number of previous studies, the well-known IoT architecture is typically divided into three different layers: application, perception and network layer. Most assume that the network layer is the Cloud layer, which realises the Cloud- based IoT architecture, as depicted in Fig. 1[1].

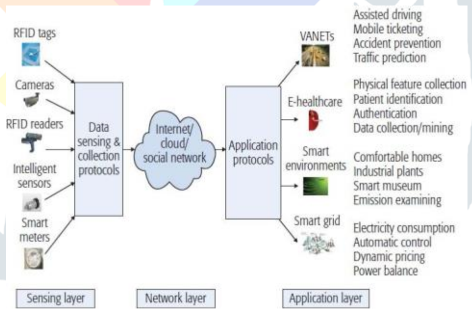


Figure 1 Cloud-Based architecture [1]

The perception layer is used to identify objects and gather data, which is collected from the surrounding environment. In contrast, the main objective of the network layer is to transfer the collected data to the Internet/Cloud. Finally, the application layer provides the interface to different services [19].

IV. CLOUD-BASED IOT APPLICATIONS

- *Healthcare:* Cloud-based IoT greatly benefits healthcare by enhancing services and promoting innovation, such as intelligent drug control and efficient hospital management.
- *Smart Cities:* IoT acts as a middleware for future smart cities, gathering data from sensors and IoT technologies to create consistent information. This leads to the development of services like smart streetlights and surveillance systems.
- *Smart Homes:* Cloud-based IoT applications automate home activities, using embedded devices and Cloud computing for tasks like home security, smart metering, and energy conservation.
- *Video Surveillance:* Cloud-based IoT enables intelligent video surveillance, simplifying the management, storage, and processing of video content from sensors. This is crucial for security applications like wireless CCTV cameras and movement detection systems.
- *Automotive and Smart Mobility:* Integrating Cloud computing into GPS and transportation technologies helps address challenges like traffic prediction and notification, as well as remote vehicle management.

- *Smart Energy and Smart Grid:* Cloud computing and IoT collaborate for smart energy management, incorporating features like smart meters, smart appliances, and renewable energy resources for consumers.
- *Smart Logistics:* Cloud-based IoT facilitates automated management of goods flow between producers and consumers, enabling real-time tracking of goods in transit within industries like logistics.
- *Environmental Monitoring:* Combining Cloud and IoT creates a high-speed information system for monitoring wide-area environments, addressing concerns like pollution, water quality, and air quality through properly deployed sensors.

V. LIMITATIONS IN THE CLOUD-BASED IOT INTEGRATION

There are many limitations which could potentially prevent the successful integration of the Cloud-based IoT paradigm. These include :

1. ***Security and privacy related.***

In [31], the author discussed about the various Security and privacy related issues that may come across in the integration of Cloud and IoT. Some of them are, *Conditional Identity Privacy*, which protects real identities of mobile IoT users from the public but allows tracing by authorities in emergencies using periodically updated pseudonyms, posing computational challenges for resource-constrained nodes. *Location Privacy* Essential in IoTs, concealing frequently exposed location information through pseudonyms. The *Node Compromise Attack* involves extracting private information from resource- constrained IoT devices, including secret and private keys, allowing the adversary to replace devices with malicious ones, potentially compromising a significant amount of sensitive data. In *Layer Removing/Adding Attack*, any Selfish IoT users may remove forwarding layers to maximize rewards, while colluding users might add layers to manipulate packet paths for increased credits, impacting the fairness and efficiency of the network. The *Forward and Backward Security*, which is Essential for dynamic IoT groups, forward security ensures newly joined users can only decipher messages received after joining, while backward security restricts revoked users to decrypting messages received before leaving the cluster, enhancing overall security and privacy.

2. ***Heterogeneous data related***

The major challenge for Cloud-based IoT is the diverse mix of devices, platforms, operating systems, and services. Cloud platforms face issues because services often have unique interfaces tied to specific providers, making it difficult to integrate resources seamlessly. This challenge intensifies when users use multiple Cloud services, relying on various providers for better application performance and resilience. In simpler terms, dealing with the wide variety of devices and services in the Cloud poses a significant hurdle for the Internet of Things[17]

3. ***Big Data related***

According to the author in [4], As of 2020, Big Data from around 50 billion IoT devices has become a crucial focus. Managing the transportation, access, storage, and processing of this massive data is vital. The Internet of Things (IoT) is recognized as a major contributor to Big Data, and the Cloud plays a key role in storing and analyzing this data for extended periods. Dealing with such vast data is a challenge, impacting overall application performance. Finding an ideal data management solution for the Cloud to handle this large-scale data remains a significant issue. Additionally, ensuring data integrity is crucial, not only for service quality but also to address security and privacy concerns, particularly with outsourced data[31].

4. ***Performance related***

Transferring large amounts of data from IoT devices to the Cloud demands high bandwidth. The main challenge is ensuring sufficient network performance for data transfer, as broadband growth lags behind storage and computation advancements. In many cases, services and data need to be delivered with high reactivity to address time-sensitive issues and meet the demands of real-time applications. In summary, the critical issue lies in maintaining effective and timely data transfer between IoT devices and the Cloud, given the constraints in broadband expansion compared to storage and computation progress[28],[17]

5. ***Legal aspects related***

In recent research, legal aspects play a crucial role, especially in applications where service providers need to comply with international regulations. Additionally, users may be required to make donations to contribute to data collection efforts. Simply put, navigating legal requirements is essential for service providers, and user contributions through donations are part of supporting data collection [31].

6. ***Scalability related***

The Cloud-based IoT model enables the creation of applications that analyze real-world data from IoT devices. Interacting with billions of distributed devices poses challenges. Meeting computational and storage needs becomes challenging at this large scale. Additionally, monitoring IoT devices is complicated due to connectivity issues and varying delays. In simpler terms, connecting and analyzing data from a vast number of IoT devices in the Cloud introduces challenges related to computing power, storage, and effective device monitoring[27].

VI. EDGE COMPUTING AND FOG COMPUTING MODELS

As discussed in the previous section, there are several challenges, the Cloud-based IoT applications facing. To over come those limitations, the edge computing shows a new way to reduce computing overhead and it can be done at the edge of the Cloud network thereby improving the performance of the Cloud.

A. Edge Computing Model

Edge computing refers to a distributed computing paradigm where data processing is performed near the source of data generation, rather than relying solely on centralized cloud servers. In edge computing, computing resources, such as processing power and storage, are placed closer to the "edge" of the network, typically at or near the data source or device.

Cloud computing is a model for delivering and consuming computing resources over the internet. Instead of relying on local servers or personal devices to handle applications and store data, cloud computing enables users to access and utilize a shared pool of computing resources hosted on remote servers. These resources can include computing power, storage, databases, networking, software, and analytics as shown in fig.2[34].

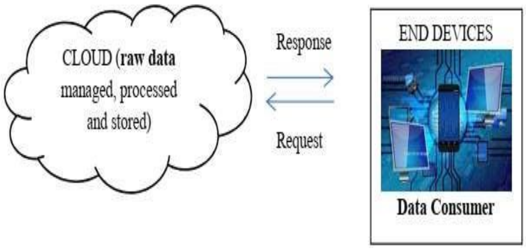
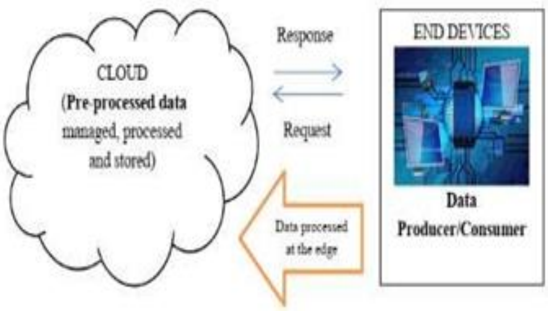


Figure 2 Cloud Computing Model[35]

Edge computing, in contrast to traditional cloud computing, where data is sent to a central server for processing. Edge computing is utilized in various industries and applications, including the Internet of Things (IoT), smart cities, industrial automation, healthcare, and more. The data generated by sensor devices is processed at the edge devices, then the processed data is sent to the cloud, stored and managed. Whenever the sensor devices or end devices request the data, the Edge collect the data from the Cloud and send that required data to end devices. The data flow in the Edge computing and basic model of the Edge computing is shown in the fig.3 [33].



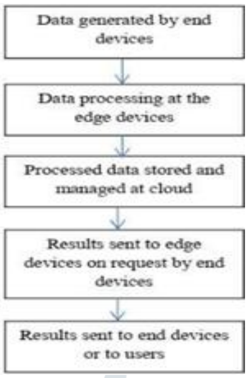


Figure 3 Edge Computing model and Data flow in the Edge Computing Model [34].

B. Fog Computing Model

Fog Computing is like a bridge between local networks and the cloud. It brings computing resources closer to where data is generated, extending the reach of traditional Cloud Computing. This approach enhances the development of more advanced and efficient applications or services. In simple terms, Fog Computing is a highly virtualized platform that offers computing, storage, and networking services between devices in the Internet of Things (IoT) and the conventional Cloud, creating a more responsive and capable network[34],[35].

Fog computing enhances mobile node experiences, particularly in dynamic scenarios like moving vehicles, by strategically placing proxies and access points along highways. It is well-suited for applications requiring low latency, such as video streaming, gaming, and augmented reality. Fog's role in smart communication is crucial, complementing gateways by efficiently handling tasks like virtual sensor nodes, temporary storage, preprocessing, and data security. The localized nature of Fog provides low- latency communication, increased context awareness, and real-time data delivery, making it especially valuable for time-sensitive services like healthcare[34].

VII. KEY ISSUES AND FUTURE RESEARCH DIRECTIONS

In this section, Some of the key issues and future research directions in the Cloud-Based IoT are addressed. These include:

1. Standardisation

The Cloud-based Internet of Things (IoT) faces a critical challenge due to the absence of standardized practices. While there have been various suggested standards, the scientific community acknowledges the necessity of common architectures, standard protocols, and APIs. These are essential for connecting diverse smart devices and creating new services within the Cloud-based IoT framework[4][6][8].

2. Cloud Security

In the Cloud-based Internet of Things (IoT), security is a major concern due to increased vulnerability to attacks on both IoT and Cloud sides. While encryption helps ensure data integrity, confidentiality, and authenticity in the IoT, it doesn't address insider attacks. Additionally, using IoT on devices with limited capabilities poses challenges for security measures[17].

3. Fog Computing

Fog computing is like an extended version of cloud services, bringing them closer to the network's edge. It serves applications similarly to the cloud but focuses on handling tasks that need quick responses. Think of Fog as a middleman between the network's edge and the Cloud, especially useful for applications sensitive to delays. Both Fog and the Cloud use storage, computing, and networking, but Fog stands out with features like knowing its location and being positioned at the edge. This allows it to distribute services geographically with low delays and a large number of nodes. In contrast, the Cloud is better suited for real-time interactions and mobility support [4],[6].

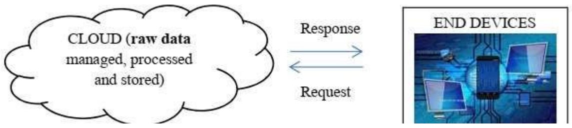


Figure 2 Conventional model for Cloud Computing paradigm[35]

4. *Big Data*

In the previous section, we discussed about Big Data as a significant challenge linked with the Cloud-based IoT paradigm. Despite various proposed solutions, Big Data remains a critical issue requiring further research [17]. The Cloud-based IoT approach deals with handling and processing vast amounts of data from diverse locations and sources. In this framework, many applications demand complex tasks to be carried out in real-time [27].

5. *SLA Enforcement*

The author in [17] addressed about several Service Level Enforcement issues. These include, relying on a single cloud provider to guarantee a certain Quality of Service (QoS) level for cloud resources can be problematic. To avoid potential violations of Service Level Agreements (SLAs), users may need to engage with multiple cloud providers. However, the dynamic selection of the best combination of cloud providers remains a challenge due to factors like time, costs, and the diverse nature of QoS management.

6. *Security and Privacy*

The author in [30][18], discussed about several security and privacy issues which must be resolved for better integration of Cloud and IoT system. Security and privacy are important research areas that have received much attention, yet they remain open challenges requiring further efforts. Adapting to diverse hacker threats is an ongoing issue. Additionally, establishing effective authorization rules and policies to ensure only authorized users access sensitive data is crucial for preserving user privacy, especially when maintaining data integrity is a priority.

7. *Energy Efficiency*

Recent Cloud-based IoT applications involve frequent data transmission from IoT objects to the Cloud, rapidly draining the energy of the nodes. Efficient energy generation for data processing and transmission is a major unresolved issue. Various suggested approaches to address this include using compression technologies, optimizing data transmission, and employing data caching techniques to reuse collected data for applications with less time sensitivity [17][30].

VIII. CONCLUSION

The Internet of Things (IoT) is increasingly pervasive, demanding substantial data storage and processing capabilities. However, the IoT faces limitations in processing power and storage, along with significant challenges in security, privacy, performance, and reliability. Integrating the Cloud into the IoT proves highly advantageous in addressing these issues. This paper emphasizes the necessity of adopting a Cloud-based IoT approach, discussing its architecture, various application scenarios, challenges in integration, and areas for further research. Future work will involve conducting case studies to assess the effectiveness of the Cloud-based IoT approach, particularly in healthcare, smart cities, smart home applications.

REFERENCES

[1] R. Buyya, C. Shin, S. Venugopal, J. Broberg, and I. Brandic, “Cloud computing and emerging IT platforms : Vision , hype , and reality for delivering computing as the 5th utility,” Futur. Gener. Comput. Syst., 2009, pp. 599–616.
[2] M. Armbrust, A. Fox, R. Griffith, A. D. Joseph, R. Katz, A. Konwinski, G. Lee, D. Patterson, A. Rabkin, and I. Stoica, “A View of Cloud Computing,” Commun. ACM, vol. 53, no. 4, 2010, pp. 50–58.
[3] K. Gai, “Towards Cloud Computing : A Literature Review on Cloud Computing and its Development Trends,” 2012 Fourth Int. Conf. Multimed. Inf. Netw. Secur., 2012, pp. 142–146.
[4] A. Botta, W. de Donato, V. Persico and A. Pescapé, "On the Integration of Cloud Computing and Internet of Things," 2014 International Conference on Future Internet of Things and Cloud, Barcelona, 2014, pp. 23-30.
[5] R. Shanbhag and R. Shankarmani, “Architecture for Internet of Things to minimize human intervention,” 2015 Int. Conf. Adv. Comput. Commun. Informatics, 2015, pp. 2348–2353.
[6] S. M. Babu, A. J. Lakshmi and B. T. Rao, "A study on cloud based Internet of Things: CloudIoT," 2015 Global Conference on Communication Technologies (GCCT), 2015, pp. 60-65.
[7] B. B. P. Rao, P. Saluia, N. Sharma, A. Mittal and S. V. Sharma, "Cloud computing for Internet of Things & sensing based applications," 2012 Sixth International Conference on Sensing Technology (ICST), Kolkata, 2012, pp. 374-380.
[8] J. Zhou et al., "CloudThings: A common architecture for integrating the Internet of Things with Cloud Computing," Proceedings of the 2013 IEEE 17th International Conference on Computer Supported Cooperative Work in Design (CSCWD), 2013, pp. 651-657.
[9] K. Ashton, “That ‘Internet of Things’ Thing,” RFiD J., 2009, pp. 49–86.
[10] G. Joshi and S. Kim, “Survey, Nomenclature and Comparison of Reader Anti-Collision Protocols in RFID,” IETE Tech. Rev., vol. 25, no. 5, 2013, pp. 285–292.
[11] ITU, “The Internet of Things,” Itu Internet Rep., 2005, pp. 114–137.
[12] ITU, “Overview of the Internet of things”, 2012, pp. 22–40.F. Kawsar, G. Kortuem, and B. Altakrouri, “Supporting Interaction with the Internet of Things across Objects , Time and Space,” 2010.
[13] A. Botta, W. De Donato, V. Persico, and A. Pescapé, “Integration of Cloud computing and Internet of Things : A survey,” Futur. Gener. Comput. Syst., vol. 56, 2016, pp. 684–700.
[14] Dash, Sanjit Kumar, Subasish Mohapatra, and Prasant Kumar Pattnaik. "A survey on applications of wireless sensor network using cloud computing." International Journal of Computer science & Engineering Technologies, 2010, pp. 50-55.
[15] G. C. Fox, S. Kamburugamuve and R. D. Hartman, "Architecture and measured characteristics of a cloud based internet of things," 2012 International Conference on Collaboration Technologies and Systems (CTS), 2012, pp. 6-12.

[16] S. Aguzzi D. Bradshaw M. Canning M. Cansfield P. Carter G. Cattaneo S. Gusmeroli G. Micheletti D. Rotondi R. Stevens "Definition of a Research and Innovation Policy Leveraging Cloud Computing and IoT Combination. Final Report" European Commission SMART, 2013.
[17] G. Suciu A. Vulpe S. Halunga O. Fratu G. Todoran V. Suciu "Smart Cities Built on Resilient Cloud Computing and Secure Internet of Things" 19th Int. Conf. Control Systems and Computer Science (CSCS) 2013, pp. 513-518.
[18] A. Zaslavsky, C. Perera, and D. Georgakopoulos, “Sensing as a Service and Big Data,” arXiv Prepr., 2013.
[19] M. Wu, T. Lu, F. Ling, and H. Du, “Research on the architecture of Internet of things,” 2010 3rd Int. Conf. Adv. Comput. Theory Eng., vol. 5, 2010, pp. 484–487.
[20] I. Lee and K. Lee, “The Internet of Things (IoT): Applications , investments , and challenges for enterprises,” Bus. Horiz., vol. 58, no. 4, 2015, pp. 431–440.
[21] S. Chen, S. Member, H. Xu, D. Liu, S. Member, B. Hu, and H. Wang, “A Vision of IoT : Applications , Challenges , and Opportunities With China Perspective,” IEEE INTERNET THINGS J., vol. 1, no. 4, 2014,pp. 349–359.
[22] P. Parweker, “From Internet of things toward Cloud of Things,” Int. Conf. Comput. Commun. Technol., 2011, pp. 329–333.
[23] S. M. Babu, A. J. Lakshmi, and B. T. Rao, “A study on cloud based Internet of Things: CloudIoT,” 2015 Glob. Conf. Commun. Technol., no. Gcct, 2015, pp. 60–65.
[24] A. Alenezi, N. H. N. Zulkipli, H. F. Atlam, R. J. Walters, and G. B. Wills, “The Impact of Cloud Forensic Readiness on Security,” in 7st International Conference on Cloud Computing and Services Science, 2017, pp. 1–8.
[25] J. Zhou, Z. Cao, X. Dong, and A. V Vasilakos, “Security and Privacy for Cloud-Based IoT : Challenges , Countermeasures , and Future Directions,” no. January, 2017, pp. 26–33.
[26] K. S. Dar, A. Taherkordi and F. Eliassen, "Enhancing Dependability of Cloud-Based IoT Services through Virtualization," 2016 IEEE First International Conference on Internet-of-Things Design and Implementation (IoTDI), 2016, pp. 106-116.
[27] Díaz, Manuel, Cristian Martín, and Bartolomé Rubio. "State-of-the-art, challenges, and open issues in the integration of Internet of things and cloud computing." Journal of Network and Computer Applications, 2016, pp. 99-117.
[28] C. Doukas and I. Maglogiannis, “Bringing IoT and cloud computing towards pervasive healthcare,” Proc. - 6th Int. Conf. Innov. Mob. Internet Serv. Ubiquitous Comput. IMIS, 2012, pp. 922–926.
[29] H. F. Atlam, A. Alenezi, R. J. Walters, and G. B. Wills, “An Overview of Risk Estimation Techniques in Risk-based Access Control for the Internet of Things,” in 2nd International Conference on Internet of Things, Big Data and Security, 2017, pp. 1–8.
[30] H. F. Atlam, A. Alenezi, A. Alharthi, R. J. Walters and G. B. Wills, "Integration of Cloud Computing with Internet of Things: Challenges and Open Issues," 2017 IEEE International Conference on Internet of Things (iThings) and IEEE Green Computing and Communications (GreenCom) and IEEE Cyber, Physical and Social Computing (CPSCom) and IEEE Smart Data (SmartData), Exeter, UK, 2017, pp. 670-675.
[31] J. Zhou, Z. Cao, X. Dong and A. V. Vasilakos, "Security and Privacy for Cloud-Based IoT: Challenges," in IEEE Communications Magazine, vol. 55, no. 1, pp. 26-33
[32] Zahra Zandesh, Marjan Ghazisaeedi, Murthy V. Devarakonda, Mohammad Sayad Haghighi, Legal framework for health cloud:A systematic review, International Journal of Medical Informatics, Volume 132, 2019, 103953, ISSN 1386-5056
[33] E. Cerritos, F. J. Lin and D. de la Bastida, "High scalability for cloud- based IoT/M2M systems," 2016 IEEE International Conference on Communications (ICC), Kuala Lumpur, Malaysia, 2016, pp. 1-6
[34] S. Mittal, N. Negi and R. Chauhan, "Integration of edge computing with cloud computing," 2017 International Conference on Emerging Trends in Computing and Communication Technologies (ICETCCT), Dehradun, India, 2017, pp. 1-6
[35] M. Aazam and E. -N. Huh, "Fog Computing and Smart Gateway Based Communication for Cloud of Things," 2014 International Conference on Future Internet of Things and Cloud, Barcelona, Spain, 2014, pp. 464-470
[36] Flavio Bonomi, Rodolfo Milito, Jiang Zhu, Sateesh Addepalli, "Fog Computing and Its Role in the Internet of Things", in the proceedings of ACM SIGCOMM, August 17, 2012, Helsinki, Finland.