Proceedings of the Third International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC 2019)
IEEE Xplore Part Number:CFP19OSV-ART; ISBN:978-1-7281-4365-1

# *Key Technologies and challenges in IoT Edge Computing*

Soumyalatha Naveen
School of Computing & IT,
REVA University, Bengaluru, India
soumyanaveen.u@gmail.com

Manjunath R Kounte
School of Electronics and Communication,
REVA University, Bengaluru, India
manjunath.kounte@gmail.com

***Abstract*- In recent years, the tremendous growth of interconnected devices results in a new technology called Internet of Things (IoT). Cloud computing assists the IoT applications to store the data and perform computation in order to control and manage the vast amount of data generated by these IoT devices. But the major challenge in Cloud computing is to meet requirements of many real-time applications of Internet of Things. Whereas, Edge is a computing architecture that helps to communicate, manage, store, and processes the data that quickly returns the response. This is made possible by moving these functionalities closer to the end users. Edge computing and cloud computing are independent as wells as mutually beneficial to many applications. This paper discusses the overview of IoT, communication technologies and protocols required for IoT, data transfer in IoT. Cloud services to store, process and to analyze the data generated from IoT devices are explored.**

***Keywords - Cloud computing, Edge computing, IoT.***

## I. INTRODUCTION

In this digital era, Internet of Things (IoT) is an emerging field used for various domains with the advanced communication technologies, protocols with fast intelligent data analytical software to enable the computing services by making use of cloud and edge architecture based on user requirements and quality of service for different kinds of applications.

Through IoT, devices or things are made to interact with each other in turn to enable machine to machine communication by enabling Radio-frequency identification (RFID), actuators and sensors for intelligent decision making based on the user context to improve the quality of lives.

Over the period of time IoT is used in plethora of domains[1] such as medical field, industrial, transportation etc and architectural standardization enables to provide the high-quality services to the people, to improve the quality of life as well as to increase the economy of the world.

The explosive growth in the number of connected devices generates massive amounts of data, which led to the development of data analytics in cloud forms cloud computing and hence made an emerging technology and used in various domains for varieties of purpose. Cloud computing with IoT applications is used when the applications require high availability, processing and need ample storage space. [2].

Extended capability of IoT enables data collection, data storage and data analytics at the end-user made suitable for time stringent real-time applications. As the main criteria for real-time application is real-time interactions with very minimal delay [3] and very quick response by maintaining Quality of Service (QoS) even though with increased number devices. As a solution, edge computing paradigm is widely used in many applications.

Edge computing paradigm boosts the applications with IoT by eliminating the offloading of the information to the cloud or from the cloud to the close proximity of end devices [4] at the edge. Due to the advancement in mobile computing with smart phone, wireless sensor nodes and communication technologies and manufacturing technologies led to the huge increase in the edge computing.

The contribution in this paper is to provide a insight of Internet of Things, IoT with cloud and edge computing. Discussed Benefits, challenges and difference between edge computing and cloud computing. The rest of this paper is organized as follows: Section II provides the details of IoT, Section III briefs cloud computing and section IV describes Edge computing.

## II. New perspectives in IoT

Internet of Things (IoT) is an approach to interrelate many computing device to communicate with each other and has an ability to transfer data over the wired or wireless network. The objects, things or any devices are made

smart by embedding the sensors within it to make the data collection and to analyse the data to produce the output with or without human-to-human or human-to-computer interaction. The capability of Internet of Things (IoT) to connect many physical objects such as street lights, wearable's etc. to communicate, exchange data and to derive actions. This extended the capability of using IoT in various IoT applications such as smart TVs, Smart speakers, Smart toy, Smart wearable for medical applications and smart appliances, smart meters, smart city, smart traffic monitoring, weather condition monitoring devices.

### *A. Components of IoT*

An IoT system consists of four components as shown in Figure 1. They are physical devices embedded with sensors, network connectivity, data processing, application user interface.

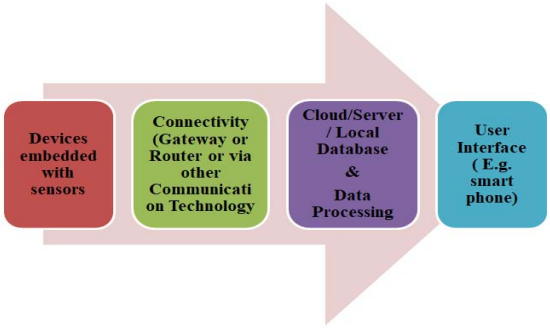


**Figure 1: Components of IoT**

The objects or electronic devices are made smart by embedding multiple sensors within it which enables devices to collect context based data such as audio, video, signal, temperature etc. from the surrounding environment and hence generates enormous amount of data .These data generated by IoT devices has the characteristics such as huge volume, value, in various forms which contribute variety, veracity, velocity. .

These devices are connected to the cloud via IoT protocols to the nearby edge gateway via various data protocols such as Message Queuing Telemetry Transport, client-server model with Web transfer protocol, HyperText Transfer Protocol and by using data communication protocols such as Mosquitto, Extensible Messaging and Presence protocol, Lightweight Machine to Machine, Simple sensor Interface protocol over communication technologies[5,6,7] such as Wi-Fi, Bluetooth, Cellular networks, Ethernet, Zigbee etc. Bluetooth is a short range communication technology commonly used in wearable products to transmit or receive the data.

The smart devices are configured to send the data either to the local database or to the cloud over the wired network.

As shown in Figure 2; the smart devices are configured to send the data over the wireless router then to the cloud by any one of the communication technology. Usually the smart devices send data to the cloud over the cellular network. With the different ways we can send the information to the cloud service depending on the requirements, bandwidth, cost, power, coverage area.

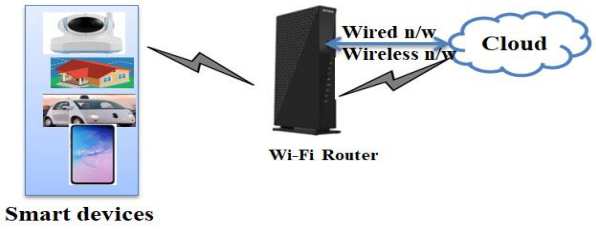


**Figure 2: Data transfer in IoT**

Once the data is collected in the cloud, data analytical software performs processing of the data, valuable information will be extracted from this data and it is made available to the user. Huge data storage and data analytics at cloud are benefited characteristics compared to using local database technologies such as DBMS, RDBMS.

In the cloud, analytical tool or artificial intelligence algorithms performs data processing to retrieve valuable information. This information can be made available to the end-user through application programming interface.

### *B. Benefits and Challenges in IoT*

Internet of Things is employed in various domains such as agricultural, medical field [8] etc. to make human lives simpler and more convenient. Few benefits of the IoT are listed below in Figure.3.

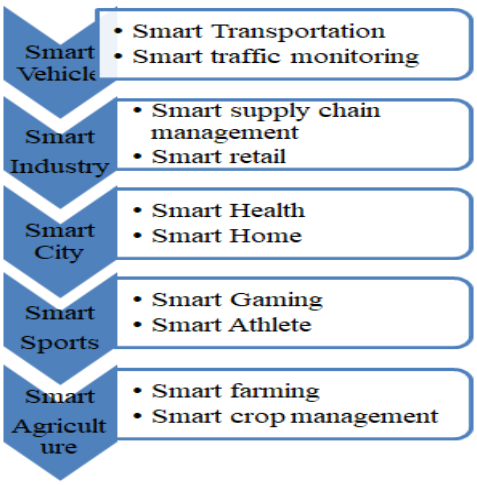


**Figure 3: Applications of IoT**

Internet of Things is an evolving technology and it is still growing and can be used in plethora of domains. As Internet of Things will continue to grow it open up

opportunities for new challenges and threats. Few are few listed.

- Diversity of data will be produced by the IoT devices. Analysing this data and to produce the valuable information to the owner is complex due to the various kinds of data such as text, audio, video, images, video, signal, noise etc. generated by the IoT devices.
- Data retention policy to retain the data for a day or month or year or decades depending on data such as Surveillance data, alert data, aircraft data and the applications.
- As IoT devices are connected to the internet, cyber-attacks on IoT data and vulnerable to malware is a potential risk in IoT. Providing the security and privacy to the IoT data is a very big challenge.

## III. Challenges in Cloud computing

In the worldwide many applications uses cloud computing for storing huge amount of data, processing, analysing for the purpose of statistical analysis or to get the valuable insights from the data to generate the value from it. IoT is creating more sophisticated devices for varieties of applications and hence creates massive amount of data to be stored, shared and moved from place to place. Cloud services used to do the entire above task and to provide flexibility and more efficiency for the users. This cloud based services are very useful for the business needs. They will be using the cloud services as public cloud, private cloud and business cloud depending on their need [9].

Cloud computing is widely used in the many application which generates vast amount of data and can tolerate delay. Even though cloud services are used in plethora of domains few applications require real-time data analytics and needs valuable insights immediately. For these kinds of applications we cannot use cloud due to the following reasons.

- Nowadays many application demands for very minimal end-to-end delay[10] and needs very quick response
- Networks are often unreliable and reliable connections [11] are available only in limited locations; but cloud computing needs robust connection to transmit and receive the data to and from the cloud.
- Data is stored, processed and retrieved from the cloud and hence more network latency.
- Data generated by the sensors, all the way pass to the cloud over internet through many networking components. Chances of hacking the data are more and hence data privacy and security is less.

## IV. EDGE COMPUTING ARCHITECTURE

The enormous growth of IoT applications also enabled to gain the popularity to the edge computing paradigm [12, 13]. Edge computing architecture is similar to cloud computing architecture with enhanced efficiency in processing and storing the data closer to the source to reduce the bandwidth and the response time.

Edge computing architecture as shown in Figure.4 provides the framework for the functional building block for deploying the hardware and software.

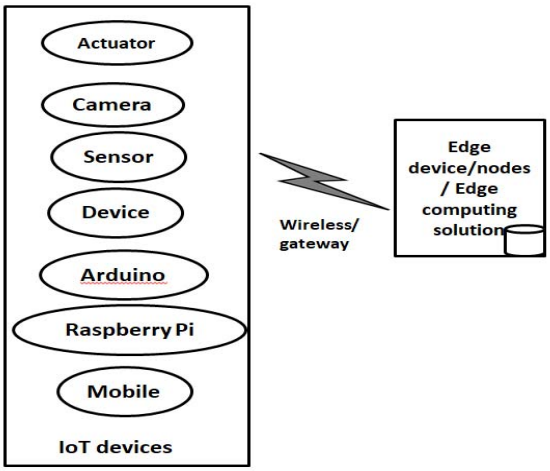


**Figure 4: General IoT Edge computing architecture**

Vast amount of data generated by IoT devices are heart of IoT system. These data will be collected in the edge node or edge device and will be stored and analyzed. The data will be processed immediately based on the context at the edge device. The edge computing system resides close to the end-user or IoT devices to reduce the response time to get the result and to optimise the bandwidth of the network. Edge computing will do the following tasks:

- Managing the IoT devices and to Collect the data
- Provide high security[14] for the data from sensor to gateway
- Execute hands-free on boarding of devices
- Ingest, collect, store and analyze data at the edge.

### *A. Challenges in Edge computing*

Even though with the increasing popularity of edge computing, it also facing many challenges [15, 16,17] as shown in Figure 5.

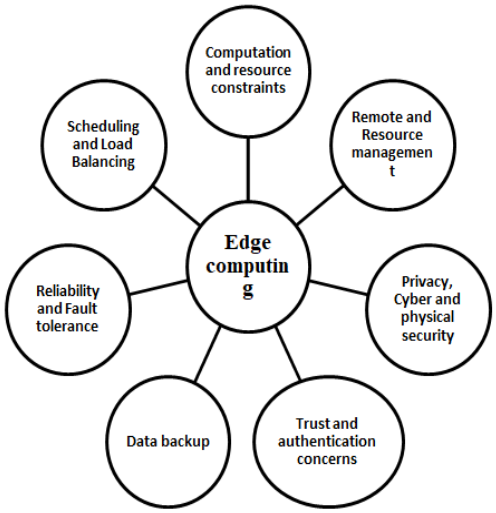


**Figure 5: Challenges in Edge computing**

### *B. Cloud Vs. Edge computing*

Edge computing cannot replace [18] cloud compute; however they are beneficial to the different extremely large scale IoT applications. Table 1 discusses the difference between edge and cloud computing [10].Cloud computing provides many services irrespective of amount of data generated, processing speed with good network connectivity and already used in many applications. Even-though Edge computing provides limited services but can be used for real-time applications.

### *A. Advantages of Edge computing*

Edge computing is an emerging new paradigm of computing, wherein storage and processing is performed in Edge devices for performing computation-intensive and for latency-critical tasks.

TABLE I. Edge Vs. Cloud computing

| **Features** | **Edge computing** | **Cloud computing** |
|---|---|---|
| Location | Distributed nodes and systems but near to end-user | It can be in any remote Location |
| Response time | Low | High |
| Dynamic Mobility | High | Low |
| Processing and Decision making | At Local edge device | Remote cloud |
| Communication | Real-time interaction | Constraints with bandwidth and network |
| Size of Storage | small | Huge in size |
| Context awareness | yes | No |
| Operational environment | Decided by the customer | Controlled by cloud operator. |
| Device heterogeneity | Highly supported | Limited support |
| Computing capability | Medium | High |
| Cost of development | Low | High |
| Applications | Suitable for real-time critical applications | Supports most of the application |
| Deployment | Does not require much careful planning | Requires careful planning |
| Bandwidth | Can operate without much network connectivity. | Requires good network connectivity |

The figure.6 lists out the benefits [19, 20 ] of edge computing paradigm. Edge computing enables real-time data analytics near the source and hence provides very quick response time with reduced consumption of network bandwidth.

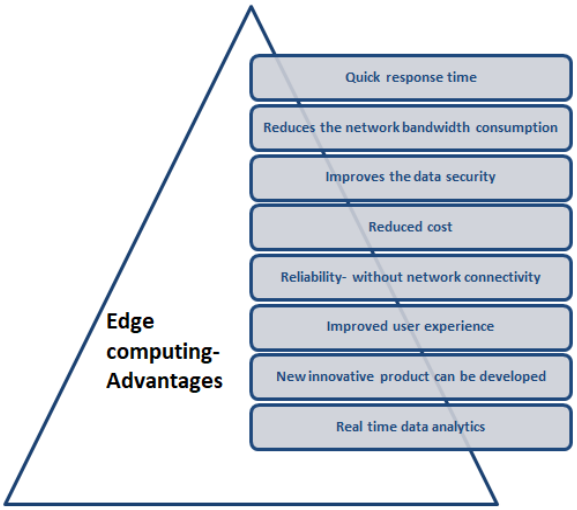


**Figure 6: Benefits of Edge computing**

## V. CONCLUSION

Computing paradigms are widely used to provide the better services along with Internet of Things applications. In this emerging area of computing paradigm, cloud computing can be used to analyze and store massive amount of data. Cloud computing is an ideal solution when there is a high availability of good network bandwidth and Internet services. Edge computing is reshaping the technologies and enables many innovations. In this paper key technologies, challenges and benefits are discussed. Edge computing is a promising approach for reduced bandwidth usage, data privacy protection with quick service response. Edge computing is suitable for stringent timing requirement applications.

## REFERENCES

[1]. Shree Krishna Sharma, Xianbin Wang, "Live Data Analytics With Collaborative Edge and Cloud Processing in Wireless IoT Networks", IEEE Access, vol. 5, pp.4621-4635, March 2017

[2]. Volkan Gezer, Jumyung Um, Martin Ruskowski, "An Extensible Edge Computing Architecture: Definition, Requirements and Enablers", International Conference on Mobile Ubiquitous Computing, Systems, Services and Technolgies(IARIA), 2017

[3]. Yousefpour, Ashkan, Genya Ishigaki, and Jason P. Jue. "Fog computing: Towards minimizing delay in the internet of things." In *2017 IEEE international conference on edge computing (EDGE)*, pp. 17-24. IEEE, 2017.

[4]. Hang Liu, Fahima Eldarrat , Hanen Alqahtani, Alex Reznik, Xavier de Foy, Yanyong Zhang," Mobile Edge Cloud System: Architecture Challenges, and Approaches", IEEE Systems Journal, Vol.12, no.3, pp.2495-2508,, September 2018

[5]. Yang Liu, Jonathan E. Fieldsend, Geyong Min, "A framework of Fog Computing: Architecture, Challenges and Optimization", IEEE Access, Vol.5, pp.25445-25454, October 2017

[6]. Capra, Maurizio, Riccardo Peloso, Guido Masera, Massimo Ruo Roch, and Maurizio Martina. "Edge computing: A survey on the hardware requirements in the internet of things world." *Future Internet* 11, no. 4 (2019): 100.

[7]. Plakhteyev, Anatoly, Artem Perepelitsyn, and Vyacheslav Frolov. "Edge computing for IoT: An educational case study." In *2018 IEEE 9th International Conference on Dependable Systems, Services and Technologies (DESSERT)*, pp. 130-133. IEEE, 2018.

[8]. Pandian, A. P. (2019). ENHANCED EDGE MODEL FOR BIG DATA IN THE INTERNET OF THINGS BASED APPLICATIONS. Journal of trends in Computer Science and Smart technology (TCSST), 1(01), 63-73.

[9]. Salman Raza, Shangguang Wang, Manzoor Ahmed, Muhammad Rizwan Anwar, "A survey on vehicular Edge computing: Architecture, Applications, Technical Issues and future Directions", Wireless Communications and Mobile Computing, Volume 2019, Article ID 3159762, 19 pages, Wiley , Feb 2019

[10]. Mung Chiang, Tao Zhang, "Fog and IoT: An Overview of Research Opportunities", IEEE Internet of Things Journal, Vol.3, no.6, pp.854-864, December 2016

[11]. Soumyalatha, N., Rakesh Kumar Ambhati, and Manjunath R. Kounte. "Performance evaluation of ip wireless networks using two way active measurement protocol." In *2013 International Conference on Advances in Computing, Communications and Informatics (ICACCI)*, pp. 1896-1901. IEEE, 2013.

[12]. Datta, Soumya Kanti, and Christian Bonnet. "An edge computing architecture integrating virtual iot devices." In *2017 IEEE 6th Global Conference on Consumer Electronics (GCCE)*, pp. 1-3. IEEE, 2017.

[13]. Syed Noorulhassan Shirazi, Antonios Gouglidis, Arsham Farshad, David Hutchison, "The Extended Cloud: Review and Analysis of Mobile Edge Computing and Fog From a security and Resilience Perspective", IEEE Journal on selected areas in communications, vol.35, no.11,pp.2586-2595, November 2017

[14]. Naveen, Soumyalatha, and Manjunath R. Kounte. "In Search of the Future Technologies: Fusion of Machine Learning, Fog and Edge Computing in the Internet of Things." In *International conference on Computer Networks, Big data and IoT*, pp. 278-285. Springer, Cham, 2018.

[15]. Grover, Jitendcr, and Rama Murthy Garimella. "Reliable and Fault-Tolerant IoT-Edge Architecture." In *2018 IEEE SENSORS*, pp. 1-4. IEEE, 2018.

[16]. Cristian Martin, Manuel Diaz, Bartolome Rubio, "An edge computing architecture in the Internet of Things", IEEE International Symposium on Real-Time Distributed Computing(ISORC), July 2018

[17]. Singh, Sachchidanand. "Optimize cloud computations using edge computing." In *2017 International Conference on Big Data, IoT and Data Science (BID)*, pp. 49-53. IEEE, 2017.

[18]. Jianbing Ni, Kuan Zhang, Xiaodong Lin, Xuemin (Sherman) Shen, "Securing Fog Computing for Internet of Things Applications: Challenges and Solutions", IEEE Communication Surveys & Tutorials, Vol.20. no.1, pp.601-628, October 2018

[19]. Enzo Baccarelli, Paola G. Vinueza Naranjo, Michehe Scarpiniti, Mohammad Shojafar, Jemal H. Abhwajy, "Fog of Everything: Energy-Efficient Networked Computing Architectures, Research Challenges and a Case Study", IEEE Access, vol.5, pp.9882-9910, June ,2017

[20]. Hesham EI-Sayed, Sharmi Sankar, Mukesh Prasad, Deepak Puthal, Akshansh Gupta, Mnoranjan Mohanty, Chin-Teng Lin, "Edge of Things: The Big Picture on the Integration of Edge, IoT and the Cloud in a distributed computing Environment", IEEE Access, vol.6, pp.1706-1717, December 2017