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# Precedence & Issues of IoT based on Edge Computing

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***Abstract*—In the network of IoT, a huge amount of data is frequently generated, major messages through complicated networks serving device-to-device communications are swapped and also, sensitive smart world frameworks are controlled and monitored by thousands of gadgets and sensors. To extenuate the acceleration of overcrowding of resources in the network, as an approach edge computing, has risen as a modern approach to resolve requirements of confined computing as well as IoT. In this paper, a brief introduction of Internet of Things and edge computing is discussed which consists of general concepts of IoT and its components, basic introduction of edge computing, and structure of edge computing. After that, fundamental concepts of cloud computing, edge computing and IoT are introduced by comparing their features with each other and a structure of IoT based on edge computing is also illustrated with a slight introduction of the architecture of both the edge computing and IoT. Moreover, the advantages of using the technology of edge computing to assist the technology of IoT are provided as well as the efficiency of integrating these two technologies together is demonstrated. Then, the issues like security and privacy, advanced communication etc. related to combination of IoT and edge computing system are discussed and finally, the conclusion of the paper is presented. So, basically, in this paper, an extensive survey is conducted to analyze how the usage of edge computing progresses the performance of systems of IoT. The performance of edge computing is studied by comparing delay of network, occupation of bandwidth, power utilization, and many other characteristics.**

***Keywords—Edge Computing, IoT, Cloud Computing, Named Data Networking, Wireless Networks.***

## I. INTRODUCTION

In a world influenced by digital technology, the technology of the Internet of Things plays a major role in human lives. It has constructed an environment that connects many devices or systems to give best and smart performances in every action. The prevalence of the technology of the Internet of Things has constructed a new development home, mobile phones and many other embedded applications, that are all linked to the internet. Through contemporaneous connection network framework linked by millions of nodes of IoT [1] interlinked gadgets can gather and swap their discontinuous data with each other. After that, a diversity of applications of IoT can supply more precise as well as more concentrated performances of network for end users. In this situation, via technology the IoT, many more devices and sensors are being inter-associated in a large number.[2]

With a lot of beneficial cases of IoT, here comes the time-sensitivity, which means that those response times which are short in nature do not negotiable. The case of time-sensitivity is a very critical situation of some of the applications of the technology of IoT [3] for example, smart cities smart transportation, and smart electricity etc. while in case of traditional cloud computing, their services indubitably are not able to indulge the requirement because all the procedures of computation required to transferred the data to the server of the cloud and on the top of it, the definite network modes and bandwidth are taken up by a large-scale content transfer.[4] Hence, the huge delays in the networks will come out as the output, and that are not plausible for those applications of IoT that are time-sensitive in nature and create a very critical problem for the IoT [5]. Moreover, there are many gadgets of Internet of Things that have definite power, so to enhance the lifespan of those gadgets, it is essential to maintain the power consumed by organizing computation of those gadgets that have both high computational as well as power capacity.[6] Furthermore, considering the case of services based on cloud computing it has been observed that, the speed of information transfer will be influenced by the huge traffic of the network that causes increase in costs of power utilization and increase in times of transmission. Thus, serious issues like scheduling/organizing and processing should be studied [7].

In this paper, we will epitomize the trailing works [8] current endeavors and offer our perception on Edge IoT based on edge computing. The technology of edge computing environs the storage as well as the computing of data that is being featured at the system "edge" nigh the end user [9], and in traffic flows, the peak will be extenuated because of the close positions of nodes of edge computing to the end users. Therewith, during the process of storage or computing of data in IoT, the need for bandwidth of the concentrated network and the delays in the transfer of data are mitigated and reduced by the edge computing technique.[10] Apart from this, moreover, it can also transmigrate both communication as well as computation from the nodes with a definite supply of power to the nodes of edges along with the considerable resources of power. By doing this, the lifespan of the whole IoT system will be expanded in respect of the extended lifetime of the nodes having definite battery power.[11]

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This research paper is designed in such a format that in Section I, an introduction is given about the edge computing-based edge IoT. After that, in Section II, observations and perceptions related to the IoT and edge computing are illustrated. Furthermore, in Section III, the integration of both the technologies i.e. edge computing and IoT, in Section IV, benefits of the technology of Internet of Things based on the technology of edge computing and in Section V, challenges or issues related to IoT based on edge computing are discussed. In the last section, conclusion of overall paper is provided which is showing on integration, how the technology of edge computing fulfills the requirements of IoT and makes it much better by overcoming its negative points.

## II. REVIEW OF EDGE COMPUTING & IOT

In this part, the basic ideas and observations of the edge computing and IoT will be observed, as well as the potential or possibility for concatenation of these technologies will also be discussed.

### *A. Internet of Things*

The gadgets of IoT are becoming a part of the mainstream culture of electronics and humans are ingurgitating smart gadgets into their lives and homes faster than ever. The more data that IoT gadgets gather, the smarter they will become.[12] Cities are transforming into smart cities through the use of gadgets that are IoT linked. Think of smart traffic lights that gather data on traffic, and use that data to sync lights to peak traffic times and make the functioning of traffic lights easier.[13]

Under mentioned different-different promulgated technologies, that are,

- smart city,
- smart homes,
- smart transportation,
- smart healthcare and
- smart electricity

These technologies make people to do their functions because without spreading IoT in their work and their homes, people will not be able to function out. IoT instigates a way to create the systems in a flexible and cost-effective way, by an open set of components which are included and associated easily to our workplace.[14] So, whatever the future holds for IoT, smart gadgets will become convoluted into the lives of humans. Hence, the IoT technology is the key to the oncoming time period and will definitely influence the daily life of the coming users. In the area of business, a major role is also played by the technology of IoT. Thus, in the coming time period, gadgets of IoT will be considered as the most significant data resources for the big data [15]. Now, we will delineate three various models of communication for Internet of Things in the under-mentioned.

- **Device-to-Device Communication:** The model of gadget-to-gadget communication shows two or more gadgets that directly link and communicate between one and other gadgets, rather than through an inter-medial application server [16]. These gadgets interact over various kinds of networks, together with but not finite to IP (Internet Protocol) networks or Internet.

As an instance, consider the figure 1 that is showing how a smart switch communicating with the smart light over Bluetooth 4.0. Generally, in a large number of applications, this type of communication model is used, for example, smart office systems or automatic monitoring in electrical systems, which via transferring packets of small data interact with each other.[17]

The deficiency of reconcilability is the major issue of the model of device-to-device interactions from the viewpoint of users, in which distinct gadgets from distinct producers use various protocols. However, protocols like Bluetooth-Wave, or ZigBee [18] are used by these gadgets in this model to build a machine-machine communication and using the smart home gadgets as an instance, gadgets of ZWave protocol cannot interact with the gadgets of ZigBee protocol. Due to these problems of reconcilable make the perception and choice of users limited.[19]

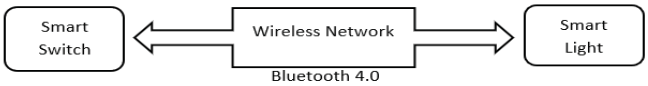


Fig. 1. An illustration of model of device-to-device communication

- **Device-to-Cloud Communication:** In the model of gadget-to-cloud communication, the gadget of IoT links directly to a service of the internet cloud like a provider of application services to exchange or swap the data and monitor the traffic of messages, depending upon the ranges of space of storage or ability of computations of the machines.[20] As represented in figure 2, this approach continuously takes benefit of current procedures of communications like conventional wired Ethernet or Wi-fi connections to install a link between the gadget and the network of Internet Protocol, which finally links to the services of cloud. It is essential to utilize the structure of the network to raise the execution of the model of machine-to-cloud communication.

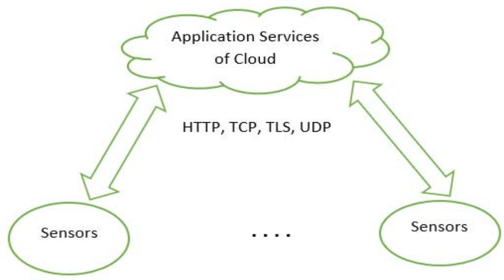


Fig. 2. An illustration of model of device-to-cloud communication

- **Machine-to-Gateway Communication:** The model of gadget-to-ALG (application layer gateway) is recognized either as a middleware box or a proxy box in the machine-to-gateway communication model. The framework of machine-to-gateway communication model is shown in the figure 3. Some security check methods that are based on software or other services such as, translation algorithms of protocol or data implement either on a gateway or any other device of network, which between the application services of cloud and the gadgets of IoT, functions as a middleware bridge.[21] Thus, this automatically decreases the IoT gadgets' utilization of power, and also enhances the adaptability as well as security of the network of IoT. As an example, consider a smart cell phone that functions as the entrance, executing some of the operations to do interaction with the gadgets of Internet of Things and with the system of cloud too.[22]

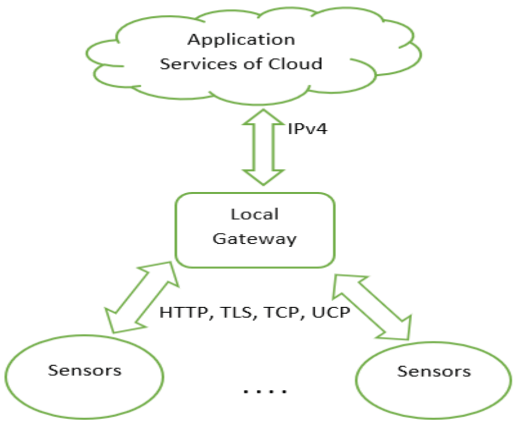


Fig. 3. An illustration of model of device-to-gateway communication

### B. *Traditional IoT Components*

Generally, there are various kinds of components in the network of IoT that are mentioned below.

- Devices/Sensors: Sensors or gadgets in the IoT network, help in gathering even a minute data or info from the encircling environment. All the gathered data can have different degrees of complications ranging from a simple temperature controlling sensor.[23]

A device can have one or more than one sensor that can packed together to perform more than just sense things. For instance, our mobile phone is a gadget that has more than one sensor like accelerometer, GPS, camera but the mobile phone does not simply sense things.

So, in the IoT, all the end gadgets and sensors will be interlinked which allows them to swap their content with each other and give extra performances.[24]

- Connectivity: After collecting the data that gathered data is sent to a framework of cloud, and this process requires a means of transport. The sensors are linked to the cloud through different mediums of transports and communication like Bluetooth, Wi-Fi, cellular and satellite networks, WAN (wide-area networks), wide area network of low power and many more. So, in the IoT system, opting the right and best connectivity is important.

- Gateways of IoT: The systems of the sensors and the core networks are connected by the gateways of IoT to the servers of cloud. For applications of IoT, when the end nodes produce resource needs, then they transmit the actions of storage or info processing to the servers of cloud. Before sending further the data to the servers of cloud, it is essential in the network to perform preprocessing of the data. Hence, the data from the gadgets or sensors are gathered and sent further to the servers of cloud by the gateways of IoT. Moreover, this component of IoT also carries out the preprocessing of data to avoid the data's redundancy in the network as well as sends further the output of the processing of info back to the end users from the servers of cloud.

- Cloud/Core Network: Servers of cloud receive the info as well as needs from the end users via backhaul networks. The servers of cloud have considerable efficiency for both storage as well as computation to endorse applications of IoT. Hence, the servers of cloud have the ability to indulge the needs of resources of various applications. After the completion of preprocessing, the servers of cloud send the outputs of data back to the end users.

### C. *Edge Computing*

Basically, the technology "Edge Computing" is utilized as a type of catch-all for different technologies of networking including ad hoc networking or peer-to-peer networking, different-different kinds of setups of cloud as well as other disseminated systems. A structure that makes use of the edge of the cellular network for performing operations is considered as mobile edge computing or networking, which is known as another foremost kind of the edge computing.

Improving network security is the primary advantage of edge computing. In the age of Internet of Things, there is a lot of focus on the architecture of security, where more and more various gadgets are getting various types of access to a network. The technology of edge computing also reduces the distance travelled by the data in a network. To increase capacity and security for many systems of business, it is a continuous and famous medium of boosting networks.

### D. *Architecture of Edge computing*

It has been observed that, the servers of cloud, the servers of edge computing are nearby to the end users in a network. As illustrated in figure 4, typically, the edge computing's main architecture is disarticulated into three forms which are elaborated below.

- Far-End: The communication delay is considerable in the networks due the farther deployment of the cloud servers from the end gadgets or users. But still, in the atmosphere of far-end, the servers of cloud supply more storage of data as well as more power of computing.
- Near-End: In the atmosphere of near-end, the traffic flows in the network is supported by the distributed gateways. Most of the storage as well as computation of data migrate to this atmosphere of the near-end. During the processing, with a little increment in the delay, the end users obtain a better performance on storage and computation of data.
- Front-End: The atmosphere of front-end supplies more communication and much better receptivity from the side of end users. But at the atmosphere of it, most of the needs cannot be indulged because of the finite efficiency of end gadgets.

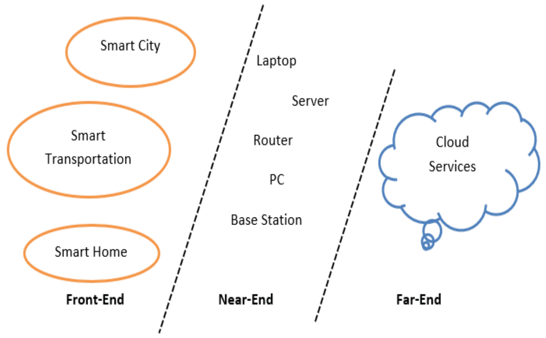


Fig. 4. The general structure of networks of edge computing

## III. INTEGRATION OF EDGE COMPUTING AND IOT

It is cleared from the figure 4 that both the IoT and edge computing have same features are shown below in the table and as a reference, cloud computing is also added.

TABLE I. FEATURES OF CLOUD COMPUTING, EDGE COMPUTING AND INTERNET OF THINGS[25,26]

| | **Components** | **Computation** | **Deployment** | **Big Data** | **Response Time** | **Storage** |
|---|---|---|---|---|---|---|
| ***Cloud Computing*** | Virtual Resources | Unlimited | Centralized | Process | Slow | Unlimited |
| ***Edge Computing*** | Edge Nodes | Limited | Disseminated | Process | Fast | Limited |
| ***Internet of Things*** | Physical Devices | Limited | Disseminated | Source | NA | Small |

In the figure 5, a three-tier structure of IoT based on edge computing is represented. This architecture has similar tiers as of the architecture of edge computing, and here all gadgets of IoT are act as the end users for the edge computing. To indulge the needs of applications of IoT, a satisfying computational efficiency, fast time of response and also, enough space of storage are offered by the edge computing.

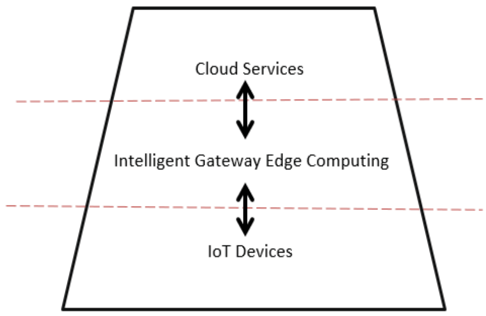


Fig. 5. Three-tier structure of IoT based on edge computing

As a facet of IoT, edge computing can produce capabilities in a large amount for services of IoT because networks of IoT are sensors and actuator gadgets-based in edge area and the data of IoT procreated from sensors and actuator gadgets are collected through a gateway. Except on data of IoT, other operations like control, computing and network operations are also very extraordinary to endorse services of IoT.

## IV. ADVANTAGES OF IOT BASED ON EDGE COMPUTING

As we noticed that the major objective of the technology of edge computing is to decentralize the data handling. This provides many advantages over the conventional cloud. Now, the benefits of IoT based on edge computing will be illustrated in this section.

- Increases Security of Data: IoT solutions show a perfect goal for cyber-attacks while, on the other side, edge computing helps to secure the network and improve the confidentiality of the overall data. It is almost impossible to take down all the system or lose the whole data with a single attack because the data is disseminated as well as decentralized among the gadgets where it is generated in the network.
- Reduces Operational Costs: When most of the data is stored and processed "at the edge", then there is no need of sufficiency of cloud storage. Moreover, filtration of unnecessary information and backup of necessary information can be easily done. And, as an output, the infrastructure of edge computing-based IoT costs will inevitably reduce.
- Unlimited Scalability: Dissimilar from cloud computing, edge computing allows to scale the

network of IoT as required, without any reference to the existing storage or its cost.

- Better Performance of App: As discussed in preceding sections, it takes some time for the data to travel back and forth between the gadget and the data center. The lag time can be reduced and overall performance of app can be improved by processing and storing the data close to its source.
- Improves Reliability and Efficiency of Business: Decreased cloud storage and lower data traffic leads to more efficient business operations. Moreover, issues of connection won't be enormously problematic as they are for other IoT services that depend on the cloud.

## V. Issues of IoT based on Edge Computing

From the previous section it is clear that for edge computing-based IoT, there are many advantages. Now, in this part, the issues related to IoT based on edge computing will be discussed as shown in figure 6.

Management of Resources: The IoT and with edge computing are the part of the family of disseminated systems, and thus both have issues of management of resources that emerge out.[27] This issue of resources management can be handled through different kinds of mediums such as auction-based schemes and optimization.

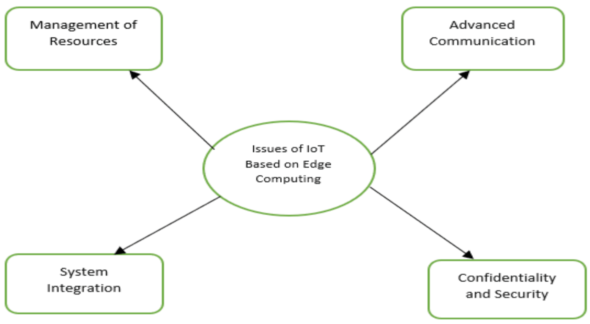


Fig. 6. Issues of Edge Computing based IoT

- Advanced Communication: Like the technologies of coming time period 5G cellular networks, inclusive of Massive MIMO (Multiple-Input and Multiple-Output), Millimeter-Wave and UDNs (Ultra-Dense Networks), are improve output, renovating frequently, support interlinked groups (in a huge number) and progressing to decrease delay in networks. In technologies of communication, with these progress or advances, edge computing technology will profuse as mixture of mentioned technologies which can be proves inevitable.
- Confidentiality and Security: The disseminated architecture has many advantages for IoT. However, the privacy as well as security of this disseminated structure is a major issue. In respect of confidentiality, it is noticed that the data which is sensed from the gadgets of systems of IoT is recorded at edge nodes, which can be proved more dangerous than the servers of cloud. Hence, this issue of security and confidentiality of data should be considered.
- System Integration: In the atmosphere of edge computing, supporting different types of gadgets of IoT and various requests of service is also a major issue. There are many new naming schemes have been introduced, including Mobility First, and also NDN (Named Data Networking), which are structured for edge computing.

## VI. Conclusion

In respect of the improvement of IoT, the technology of edge computing is a rising solution to the arduous and complicated issues of maintaining thousands of gadgets or sensors, as well as the congruous sources that they need. In comparison of the paradigm of cloud computing, the edge computing migrates enumeration and storage of info to the "edge" of the system nearest to the end users. Hence, to mitigate the needs of bandwidth in the IoT network, edge computing reduces the flows of traffic and it also reduces the cost of sending data. Moreover, the data sending delay between the servers of cloudlet or edge and the end users or devices can be reduced by edge computing which results in shorter time of responses for the real-time application of IoT in comparison of conventional services of cloud. Lastly, the structure of edge computing for IoT, all the motives of implementation, plans for operation offloading, and also, confidentiality and security risks and their congruous counter measures of edge computing are examined.

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