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Edge computing vs. Cloud computing: Challenges

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Abstract

High density of IOT devices generates huge amount of data which creates network congestion. Higher demand for low latency and stable connections for vital IoT devices causes network bottlenecks. Edge computing combine's network edge storage, computing, and network resources to provide computer infrastructure that enables developers to develop and deploy edge applications quickly, guided by IoT and 5 G communication vision. Edge computing gives advantages of speed, bandwidth dependency, privacy and security and lower cost. Edge computing brings services close to end device. The aim of this paper is to provide a detailed study of the recent development of edge computing. The significance of edge computing over cloud computing is discussed. In edge computing, this paper tries to identify open research challenges.

Keywords: IoT, Cloud Computing, Edge Computing

1. INTRODUCTION

Nowadays tremendous usage of IOT devices like smart phones and watches, locks, home voice controller etc. are going on which creates huge amount of data which is stored and perform some task using data centers on the cloud through internet. Thanks to the pervasiveness of cloud as we can access the data from cloud anytime anywhere with proper internet connection. Daily task like video streaming, photo uploading, mail checking, file sharing etc. are done with cloud, Cloud computing provides end-users with on-demand services that include storage services, processing services, and computing resources. Services such as Platform as a Service (PAAS), Software as a Service (SAAS) and Infrastructure as a Service (IAAS) that provide data storage and processing are provided by cloud computing. As different services are provided by Cloud Computing but to make system reliable and secure with single infrastructure is difficult and costly also. Distance between the resources and cloud is one of challenge to maintain the response time, latency and bandwidth, one of the solution to this challenge is Edge Computing (EC)[1]. It is new concept in computing which brings cloud computing services and utilities closer to end users. Edge computing manages computational data, services and applications on edge network. Edge computing contains different heterogeneous devices which communicates with network and perform task like storage of data and processing of data. Edge computing has three major models shown in fig 1., as 1.Cloudlets 2.Fog Computing 3.Mobile Edge Computing. European Telecommunications Standards Institute [2] has given these models where in Cloudlets we can access cloud by using resources of computer which are available in local network. Fog Computing allows applications to run directly on the network's edge. Users of Mobile Edge Computing can use Base Station computing services.

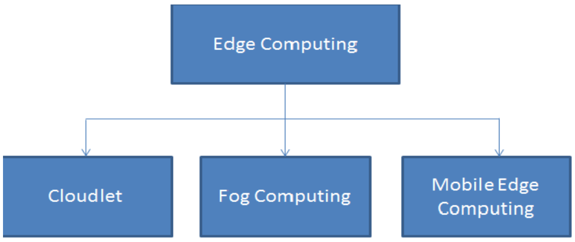

Fig 1. Models of Edge Computing

The main differences between cloud computing and edge computing can be defined as [3]

1. Location of servers
2. Cloud computing services are located on the internet, while edge services are located on the edge network.
3. Cloud computing is having high jitter and edge computing is having lower jitter.

   While jitter implies latency and latency variability, delay is between the action of the user and the response of a web application to that action.

4. Cloud computing uses centralized model and Edge computing uses distributed model.

Edge computing is immerging technology which made possible to process large amount of data generated by IoT. Edge collects the data from IoT devices process that data at device or edge and then send selected data to cloud. This can significantly impact latency as it reducing the movement data or the distance of data it travels.

Advantages of Edge Computing

1. Speed to data transmission is more
2. Bandwidth dependency is less
3. Data transmitted with more privacy and security.
4. Lower the cost as data generated by sensors/IoT devices are used locally and less data transmitted remotely.

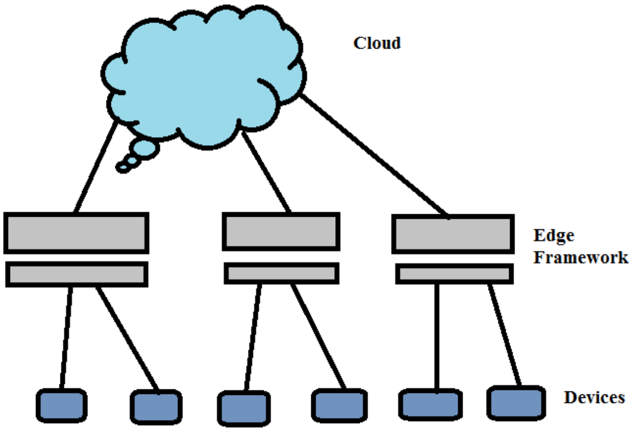

Fig 2: Edge computing overview

Why we need Edge Computing:

IOT generates tremendous data in form of new business insights, automating business and production processes etc data must be analyzed and processed at the edge of WAN in order to maximize the capture, delivery, processing, analysis and storage of what can quantity of petabytes of data every day Edge computing helps to address cost, bandwidth and latency issue across a broad range of IOT application, here are the reason why we need edge computing.

1. The amount of data generated is enormous than the network's ability to process it, so send the data to edge computing device instead of sending the data to clouds (Reduce the amount of cloud data that is transmitted and stored).
2. To transmit the data to cloud process that data and to take appropriate action at the end requires more time and latency also, so this can be done on the edge device (Reduce the lag time in data transmission and processing)
3. Edge computing helps to prioritize data that needs attention.

2. RELATED WORK

The authors in [4] has proposed an architecture which decides, the task should be offered to the cloud or another edge server by analyzing available resources and network layers, and also this architecture focuses on migration of task with minimum efforts. Three layered architecture [5] named Global Edge Computing Architecture that includes IOT layer, Edge layer and Business solution layer, resulting in edge device data analysis in real time. In the IOT and Business solution layer, the author used blockchain technologies to provide a higher level of security. [6] To reduce resource consumption and to ensure trust evaluation mechanism for IOT cloud system which ensures IOT security because other trust evaluation mechanism consumes more resources, proposed mechanism has three layers and it solves internal attack issue. In [1] demonstrates work for IIOT Industrial IOT which is used to improve industrial production efficiency as decision making latency is high, bandwidth resources is more, privacy of data is also low , for this an architecture is proposed which compose of two layers Data layer and Edge layer. As a Near Edge, Mid Edge, Far Edge layer, the Edge layer is split again into three sub layers. With this proposed architecture, decision-making latency is significantly reduced, bandwidth resources are saved, and data is protected. This paper analyzed edge computing challenges in IIOT and discussed them in the context of 5G-based edge communication, load balancing AI and data secrecy. This paper has also introduced block chain in edge computing for security of sharing data. An idea of edge-based security for IOT applications is suggested in[3], where the concept of edge-centered IOT architecture is presented in which we can deploy edge-layer security solutions for IOT applications. The security architecture based on the Edge has three categories: user-centric, device-centric, and end-to-end security. IOT devices have resource constraints so that they cannot support firewalls, so this paper discusses the edge-based firewall. Intrusion Detection system for edge at the edge layer is also discussed. AI based approach for IOT [7], is discussed in which two stage process of AI i.e. Model building and inference is used, where model is built in cloud and inference is done at edge, architecture based on this is proposed which includes policy model. An idea about merging edge with IOT [8]to solve real life problems. This paper had discussed an edge-IOT based architecture known as EH-IOT, the author concluded that about reducing dependency of IOT cloud analytics and storage facility and results in it shows that bandwidth between IOT and local edge devices increased and processing latency can be decreased. Edge nodes have limited resources, so it is a challenge to deploy AI workload on edge nodes, so researchers have come up with different AI optimization methods to overcome it. The current optimization is discussed as lightweight model design, design in three phases of AI model design, training and inference. If AI applications need to be deployed on edge nodes it requires support of edge computing, specially mobile and IOT devices. Firstly, to comply with the basic operation of AI, edge nodes need to provide appropriate hardware and programming libraries.

Secondly, to understand the resource management and task scheduling of edge nodes, an edge computing platform is required. Edge intelligence recognizes [10] that the future of AI enabled edge devices at mass has been explained in this paper to demonstrate that this author has taken real-time example of number plate/object detection.

[11] presents a classification of various evaluation metrics that evaluate the performance of Cloud, Fog and Edge computing. The paper shows a comparison between the performance metrics supported by existing simulators. The author explained how this kind of metrics can assist ordinary users in the future the use of SLA (Service Level Agreement) in their services and how it benefits to the business. A comparative analysis of different Mobile Edge Computing (MEC) frameworks with respect to performance parameters like system performance, network performance, deployment overhead, system migration overhead from this analysis

author has asserted that MEC is achieving 1ms latency is given in [12]. [13] Focus on edge server placement in the Mobile Edge Computing Environment. The author identified the problem of edge server placement with the aim of balancing edge server workload and access delay between mobile user and edge server and suggested a solution that balances and reduces the delay. Dataset used is the shanghai telecom, result comparison revels that proposed solution performs better than existing solution in terms of access delay and workload balancing. UAV enabled wireless powered Mobile Edge Computing (MEC) has a resource allocation problem for both partial and binary computation offloading mode is studied and [14] proposes two algorithms that are alternative optimization in two stages and alternative optimization in three stages, the author of this algorithm showing that the allocation of resources with these algorithms is superior to the use of disjoint optimization schemes.

[15] The user should be aware of the time needed to execute the task on the edge server so that the user can plan a well-planned task. For the prediction of Task Execution Time (TET) task offloading algorithm is proposed named Maximum Efficiency First ordered (MEFO)which gives best performance for both TET prediction and task processing delay and energy consumption. In edge computing, edge servers [16] are deployed near mobile devices so that devices can offload job on edge server with low latency, problem here is the how to dispatch and schedule the job so that job response time is minimized for this time require to complete the task should be known. To solve this problem author has proposed algorithm named On Disc which gives processing time of job before its completion so that next upcoming task has no need to wait for longer. Users can also offload their task to offload point, but offload point has limited resources, so [offloading] has provided a model for several users, multiple offload point and structured task, then the author has formalized the issue of offloading decision, which is NP-hard problem, so author has designed a method which uses backtracking but the time complexity for the same is epidemic. Based on improved genetic algorithm and greedy strategy, this technique is designed to reduce this method in which method-based greedy strategy performs better[17] has given the idea of how fog computing or edge computing is used in the processing of data from diabetes devices linked to medical IOT, because patients with diabetes require a rapid response to sensor input, which can cause delays if cloud computing is used. Use of cloud computing for large scale data in medical raises network traffic and latency so fog computing is introduced and [18] has proposed Fog assisted Healthcare system which collects the data from different wearable sensors and send it to fog layer where different functions like features selection, classification, aggregation etc. is performed then network layer forwards data from fog layer to cloud layer where data storage, statistical research, patient centric recommendation is done and then service layer gives clear idea to user/patient about report through visualization and suggestion on the report, with the experimental result it is shown that low latency, bandwidth efficiency and higher classification accuracy is more in fog. Advances of Internet of Medical Thing (IoMT) and 24/7 healthcare service requires effectual and reliable monitoring of patients so edge computing and cloud is required so [19] has introduced a model called ETS-DNN(Effective Training scheme Deep Neural Network) in edge. First, IoMT observes the patient and sends the captured data to the edge, using HMWWO (Hybrid Modified Water Wave optimization) to perform the EST-DNN model for diagnosis, it explores new parameters and resolves the local optima problem and its integration into L-BFGS(limited memory Broyden-fletcher-Goldfarb-Shannon)model which discovers efficient solution to the problem, SM (Softmax) layer performs classification and assigns the class label appropriately then this report is transferred to cloud server and then forwarded to healthcare professional for further action. Smart city terminals have minimal processing capacities so they do not process assorted and hybrid application services. In this way, edge computing offers more capabilities for terminals with edge computing terminals that can discharge the services, but privacy is the key problem here, so[20] the Intelligent Offloading Method (IOM) has proposed three models of service response time, energy consumption, load balancing that ensures privacy protection during service discharge. [21] to manage the real time traffic in smart city. An architecture named vehicular. The goal of the architecture is to take advantage of fog service providers and vehicular communication, edge integration and cloudlet efficiently discharge network traffic, response delay is reduced, fog computing (VFC) with three layer cloud layer, cloudlet layer and fog layer.[22] has explored new research opportunity in edge computing systems like cloudlet, Airbox, Firework, Cloud-sea, SpanEdge, CloudPath, FocusStack, ParaDrop all these systems having end devices are Mobile devices, IoT devices, Firework. Node with different edge nodes like router, servers local clusters, Fog, cloudlet.These systems has three and two layer computation architecture and having different targets to achieve security, path computing ,streaming processing, resource integration author has given comparison of different open edge systems like Edge XFoundry, ApacheEdgent, CORD, Azure IoT Edge and akraino Edge Stack. Has presented energy efficiency enhancing strategy for performance consideration and technologies for Deep leaning packages model on edge. The survey [23] analyses the implementation of edge intelligence on different layers from a macro view. Authors have proposed a six-level rating to describe edge intelligence. As a key artificial intelligence technique, deep learning (DL) and edge computing are expected to benefit one another. In the [24] survey, various applicable scenarios and fundamental enabling techniques for edge intelligence and smart edge have been comprehensively introduced and discussed In short, the key issue of extending DL from the cloud to the edge of the network is: How the edge computing architecture can be designed and developed to achieve the best DL training and inference performance under the different constraints of networking, communication, computing power, and energy consumption.

3. DISCUSSION

We have focused on comparing computing and edge computing, though. Cloud computing uses a remote server for data management, such as data storage and data processing, where all these tasks are moved closer to the edge devices, as in edge computing [25]. International Data Corporation forecasts that by 2025, more than 150 billion will be linked globally. Cloud computing-based centralized processing methods are not sufficient to handle such vast data. The horizon of edge computing that calls for data processing at the edge has been pushed by these challenges. The authors in [4, 5, 21] have suggested and discussed the layered architecture of edge which two and three layers of architecture have mostly been suggested. Edge Computing optimizes IoT devices and different applications by bringing computing closer to the source of data. Authors discussed the various applications such as smart cities, healthcare, diabetes, etc. and how edge computing is useful in edge data processing, such as delaying data processing in the case of autonomous vehicles, which can lead to significant losses. Various techniques such as mobile edge computing, artificial intelligence, deep learning and fog computing Have been used by various authors to demonstrate the importance of edge computing over cloud computing. Edge computing is still in the inception ,framework to expedite are not available yet, Cloud computing frameworks such as Amazon web services, Google App Engine and Microsoft Azure can support data demanding application but to process real time data on edge is still an open research area[26]. To deploy application on node, connection policies need to be taken into consideration. Some challenges that need to be addressed are as follows:

1. 1.General purpose edge computing on edge nodes- To upgrade the resources on edge the research is there [paper-v1-Ref23] where example of wireless home router which can be upgraded to support extra workload.
2. Determining Edge Nodes- To map the task on suitable resource or node for performance improvement, manipulating edge of network require mechanism to find suitable node this cannot be manual as number of nodes in network is more, there are existing method for cloud like benchmarking which is not practical in terms of determining edge nodes.
3. Partitioning of task and offloading on edge node- partitioning the task and offloading it on multiple edge node or with in sequence first data centers then edge node or vice versa, there is need of scheduler which deploy task on edge node properly.
4. Edge Intelligence- Edge devices can perform light weighted tasks to make them perform complex tasks with higher edge latency and edge intelligence in data processing performance, (Artificial Intelligence) AI models can be trained to perform prediction and decision making but for this large amount of data is required which is hard for edge devices to have large resources and For high-complexity AI models, increasing the computing power of edge devices or partitioning the AI model on edge devices is a challenge.
5. Data Sharing Security- Massive data from sites, multiple devices and infrastructures and data sharing, As the performance of edge devices is very limited, it can lead to serious consequences, such as intrusion and destruction., so it is difficult to run powerful security algorithms on edge devices, so one of the challenges is the introduction of Blockchain in edge [4].

4. CONCLUSION

In this paper we have studied how edge computing is beneficial over cloud and we presented challenges in the edge computing. After surveying literature it can be concluded that Edge computing is emerging area, where researchers are working to increasing network performance by reducing the network latency. Edge computing is beneficial over cloud computing for better data management, security practices, lower connectivity cost and reliable connection.

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