

INTEGRATION OF EDGE COMPUTING WITH CLOUD COMPUTING

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Abstract— In this paper, we try to integrate edge computing with the cloud computing paradigm. There are several issues and challenges in cloud computing paradigm which can be resolved by edge computing. So, in this paper we have discussed about those issues and given an idea that how edge computing is able to resolve that issues.

In this paper, first we have discussed about edge computing with its definition and data flow diagram followed by its applications in various fields like smart city, smart home, cloud offloading and image and video analysis, then at last we have discussed about the issues and challenges of cloud computing followed by the idea of how edge computing can solve that issues.

Keywords— Edge computing, Cloud computing, Internet of Things (IoT), Zigbee, Wi-Fi, etc.

I. INTRODUCTION

Cloud Computing has become very popular around 2005 [1]. The idea of storing, processing and managing data at the clouds has really produced a great change in working and living style of us. For example: Facebook, Twitter, WhatsApp, Google Apps, etc. has been widely used in our daily life.

Internet of Things (IoT) first came into existence in 1999 and from then, the idea of “making each and everything as smart as they can produce their own computer sense information, so that they can be controlled and managed without the human intervention” has been implemented in many other fields like home, environment, transport, healthcare, etc. [2],[3]

Since IoT has been becoming so much popular in the present era, so it is estimated by Cisco Global Cloud Index that data produced by people, machines, and things will reach 500 zettabytes by 2019, however, the global data center IP traffic will only reach 10.4 zettabytes by that time [6]. It is also estimated by Cisco Internet Business Solutions Group that more than 50 billion things will be connected to internet by 2020 [4].

So, cloud computing is not only efficient to handle such a large amount of data because if so, load on the network get increased, and processing time and response time of the applications running on the cloud get increased.

So, due to the pull from IoT it is important to overcome this limitation of cloud computing. To enhance cloud computing efficiency, the concept of edge computing comes into existence.

We are going to discuss the concept of edge computing in detail in this paper followed by the issues regarding the implementation of these concepts.

II. EDGE COMPUTING

Edge computing is defined as processing the data at the edge of the network. In simple words, it can be said that process the data as much as it can be processed at the edge of network because data always produced in bulk at the edge and then send the processed data to the cloud.

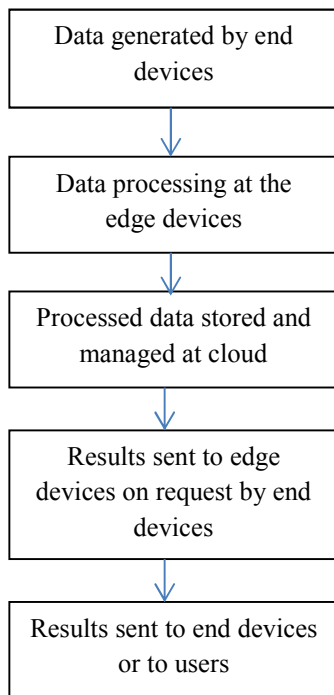


Fig 1: Data Flow Diagram of edge computing

There are below few reasons which show why edge computing is necessary with cloud computing and makes you able to understand how it is enhancing the performance of cloud computing:

1) *Data Processing at the Edge*: As we have discussed earlier that generation of a lot of data known as big data from various applications and social media is increasing day by day and all of the data has been computed, processed and stored at the clouds. Due to this reason, response time to user is increased. So to avoid this situation, it is better that there must be a data processing capacity at the edge of the network. If the data that is generated by the source is processed at the edge, i.e., close to the source then response time gets shorter,

efficiency of processing is increased and network pressure gets reduced.

2) *IoT getting popularized*: As we have mentioned above that in few years that there will be billion of devices that will be connected to the internet and almost all the electronic and electrical devices will be related to IoT. So, only cloud computing will not be efficient to handle such a large quantity of data generated by IoT devices because of following reasons:

- There is a huge amount of data generated at the edge which requires a lot of unnecessary bandwidth to send the data to the cloud.
- The privacy and security of data is the major concern in cloud computing.
- Sending a large quantity raw data to cloud also leads to wastage of network resources and more consumption of energy. So, offloading some computing tasks to the edge could be more energy efficient.

Edge computing can help in overcoming the above mentioned issues of cloud computing.

3) *Shift from data consumer approach to data consumer as well as data producer approach*: The conventional model followed in the cloud computing paradigm is given below. According to the conventional model, the end devices act usually as data consumers only, for example, one watch a video online on his smart phone. This model is not sufficient to implement IoT. But according to present model approach, the end devices act both as data consumers and data producers. For example: The data is also generated by people from their mobile phones [7]. This shift from data consumer to data producer/consumer needs a smart functionality at the edge.

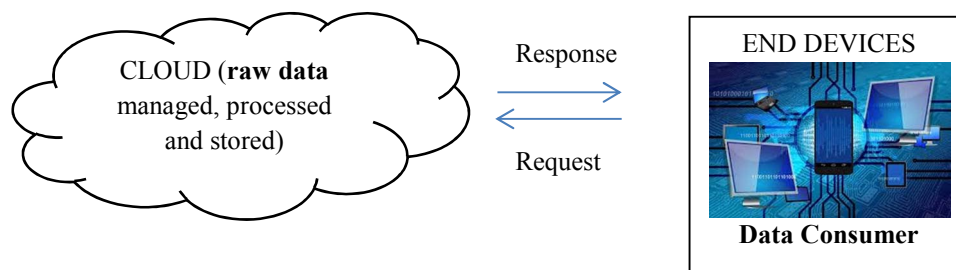


Fig 2: Conventional model for cloud computing paradigm [7]

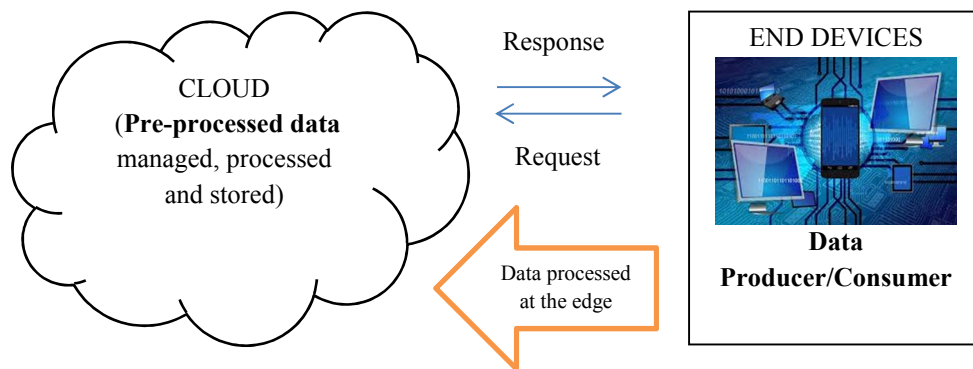


Fig 3: Modern approach for edge computing paradigm [7]

Table 1: Data generated by various social media per minute [5]

S.No.	Applications	Contents shared/minute
1.	YouTube	400 hours of new videos
2.	Facebook	4.00 million posts
3.	Twitter	0.35 million tweets
4.	Instagram	2.50 million posts

For example,

The above table shows the amount of content shared by various applications or social media per second.

Since, the contents shared by above mentioned applications mostly include videos and images,

that are of very large size and require a lot of bandwidth for uploading. So, it would be more suitable to process such kind of data at the edge of the network instead of uploading raw data directly to cloud. The video clip should be demised and adjusted to suitable resolution at the edge before uploading to cloud.

III. APPLICATIONS

A. Image and Video Analysis

As we have discussed earlier, edge computing helps in reducing the amount of data at the clouds by processing most of the data at the edge of a network. This feature will prove to be very beneficial in the growing era of smart devices and network cameras. Video and image analysis becomes very easy.

For instance, a child is missing and we have network of cameras which are embedded in each vehicle and in urban cities[7]. So, it is possible that image of the lost child is captured by a camera. But it is extremely difficult to transfer all the data of the camera to the cloud. And if we do so, it is advisable that it would not be done because of privacy concerns and traffic cost. So in this case, use of edge computing can help in resolving the issue. Only the request of searching the child will be generated by the cloud and this request will be sent to all end devices like mobile phones, tablets etc. of the target area and the devices will search their local camera and then report the result on the cloud again.

B. Smart Home

IoT plays a great role in making a home smart, i.e., many devices which are used in our daily life such as smart TV, smart light, smart refrigerators, etc. are besides added with Wi-Fi module, also embedded with various wireless sensors and controllers which generate a huge amount of data and this data must be mostly used in homes. So, instead of sending all the data to the cloud, it is better to process and manage the data at the edge gateway which has a

specialized edgeOS and from the gateway all the devices of home are connected. EdgeOS needs to collect data from mobile devices and all kinds of things through multiple communication methods such as Wi-Fi, Bluetooth, ZigBee, or a cellular network[7]. In this way, the response time to each device get reduced and the burdens for Internet bandwidth get released. There are some issues and challenges like data security, isolation of data, reliability of data etc. prevails in implementing edge computing for smart home which will be discussed later in the paper.

C. Smart City

A city can be smart if it has smart transportation, smart healthcare, smart utilities etc. and we know that all the above specified fields or sectors are approaching towards IoT, so edge computing will prove to be the best option for making a smart city and the concept of edge computing is flexible. It can be easily expanded from a smart home to a smart city. Edge computing would be the best platform due to following qualities:

- 1) Decrease in response time to user and low latency: As data is processed at the edge, so response time to users get extremely reduced because the data transmission time to cloud is saved. It is beneficial for those applications which require urgent response and low latency such as health emergency issue, public safety, etc. Decisions and diagnosis could be made as well from the edge of the network.
- 2) Processing of data at the edge: This feature of edge computing makes edge computing more efficient than cloud computing. For instance, consider a city having population of 2 million and 300 PB of data is generated per day including the data from all sectors such as healthcare, transportation, etc. So, it is more realistic and beneficial to process such an excessive amount of data at the edge instead of sending the data at the cloud because if we do so, the load on the channel and the data transmission time get increased.
- 3) Location Awareness: Data could be collected and processed on the basis of geographic location in edge computing. Therefore, it is an ideal platform for applications like transportation, utility management, etc.[7]

D. Cloud Offloading

In the example of cloud computing, approximately every manipulation is done in the cloud i.e. the data and requests are processed in the cloud itself and then the result is generated. Every small manipulation takes time and because of that user have to wait for the result. From the numbers of

researches the cloud offloading is define in terms of energy-performance tradeoff in a mobile-cloud environment [8]–[12]. In edge computing, the edge contains manipulating devices which manipulate the data and reduces the work load of the cloud. From last decades, raw data is directly sends to the internet which results increment in response time. In case of IoT, the data is created and devour at the edge. Thus, the modus operandi on data is cached at the edge in case of edge computing. One of the best applications of edge computing is online shopping service. In this, a customer frequently updates its shopping cart according to his/her choice. By default all the required changes has to be done by the cloud and then the new updates are updated on customer shopping cart. This complete process takes much time depending upon the load on the server as well as the speed of a network which result bad experience of a user. As now day's mobile devices contains advance features which makes it more smarter due to this user uses mobile for many application but it creates problem while online shopping because of low bandwidth of a mobile network. So, it is important to improve the user experience, especially in the response time. In such a scenario, if the shopping cart is updated at edge before the cloud server this can drastically reduce the response time. Now every changes i.e. the addition of item, updating in the cart, deleting in the cart etc. has to done and cached at the edge node. Because of this user request fulfill in short period of time. Whatever manipulations are done on data at the edge node is synchronized with cloud. Edge computing creates synchronization problem when multiple edge nodes are there but it has many application i.e. it reduces the response time in real time application like entertainment games, augmented reality, and connected health etc. and it improves the time sensitive application significantly.

IV. CHALLENGES OF CLOUD COMPUTING AND SOLUTIONS BY EDGE COMPUTING

A. CHALLENGES

1) Latency

In cloud computing, the raw data is transferred directly to the cloud or internet without any data processing or manipulation. As we have discussed earlier, a huge amount of data generated (i.e., big data) by various applications and social media stored on cloud. So, the processing and searching time in such a huge amount of data by servers at the cloud get increased, due to this response time to users get increased. Thus, the condition of latency [13] prevails which weakens the users' experience.

2) Cost

A huge amount of data is collected from the “things” as a result of some application (i.e. IoT application) and that data is sent to the data center i.e. the cloud needs huge amount of storage as well as the bandwidth for the transmission because of this it cost too high but whenever we design any system this should be cost effective [14].

3) Security and Privacy

Data is mostly at risk when it is in transition state. As IoT is getting popularized now-a-days, the number of IoT devices connected to the internet is also increasing day by day, due to which security threats and new vulnerabilities get increased. So, in cloud computing security and privacy of data is a major concern.

4) Duplicity and debasing of data

In IoT, generated data moves across the network which cost money as well as it affects the data dependability, more the data moves across the network more will be the data debase[14].

B. SOLUTION

As we have mentioned above in the paper, that in edge computing, data is processed and managed at the edge of the network and processed data will be transferred to cloud. This extremely reduces the amount of data sent to the cloud due to which the bandwidth and the resources that are required to transmit the data get also reduced which makes data transmission cost effective.

In case of edge computing, as the data is previously processed at the edge, so the searching and processing time at the cloud get extremely reduced and because of that the servers can respond to users' request more quickly and response time to users get reduced.

In Edge computing, data is processed within a local area network because of this it prevents the data hacking and theft. If the devices that is connected with management systems are automatically add or removes the devices from the network, which is defined by the IT- policies can further reduce the vulnerability.

Manipulation before the cloud computing i.e. at the edge node reduces the requirement of storage at the cloud i.e. data center results in lowering the prices and reduces complexity. It also restrict non-threatening data debase which comes into play when large amount of data is transmitted throughout the network.

V. CHALLENGES AND OPPORTUNITIES IN EDGE COMPUTING

1) Data privacy and Data security

Data privacy and Data security is the major concern at the edge in the edge computing paradigm, because all the data from the end devices come to the edgeOS for further processing. For instance, in a smart home various smart devices are deployed with sensors and other IoT devices which share all their information on the gateway, so by just analyzing readings of the usage of water or electricity, one can find very easily that home is vacant or not. Therefore, it can be said that data security and privacy is one of the major challenges of edge computing.

2) Cost

Cost is also the major challenge in implementing edge computing. Since, the devices at the edge are increased and moreover, managing the data shared by various end devices at the edge leads to increase the cost of the whole system. So, proper cost model should be designed for implementing edge computing system.

3) Resource Management

At the edge of the network, service management is one of the most important services that should be handled properly because simultaneously so many requests are sent by the users, in which some are critical services (i.e. health related problem) which require more faster processing than ordinary services, so we need to set the priorities for different services which is really difficult task to manage. In this isolation of different requests is another big issue at the edge of the network because when data reaches simultaneously at the edge, it may be possible that data of different requests get mixed and the real information gets lost .As a result the users are not able to get the desired output and due to this it reduces the user experience.

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