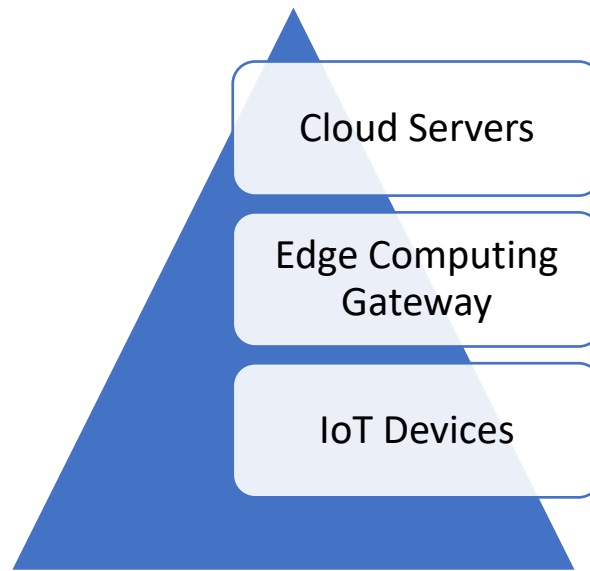


INTRODUCTION:

Edge Computing (EC) is a technology which is developed to overcome the limitations which was encountered by Cloud Computing and IoT. The limitations of Cloud Computing (CC) with IoT are, it requires large amount of time to process the data which is generated by IoT components with a stable network [1]. To overcome this drawback, EC uses to process the data at the edge of the network which can send the limited traffic to the centralized cloud servers to reduce the bandwidth usage and network latency [1]. The big advantage for CC by implementing EC is the heavy loads in the cloud servers can be off loaded.



When EC is tied up with the IoT atmosphere it shares the computing resources with IoT devices which gives certain benefits like.,

- Volume of information produced may surpass the CCs transmission capacity.
- Could not connect to cloud servers at any time.
- Information pre-processing can be done by EC [1]

Edge Computing can be used in:

- Countryside regions
- Coalfield
- Workshops, harbors, and aerodromes

Edge and Cloud Computing:

Earlier cloud computing transmits all the information which it collects from the end users to the cloud data centre over the network in a centralized way which gives the solution to the computation and storing problems [2]. In recent times, cloud computing has grown well in the computation market with various technologies like balancing the load, distributed and parallel computing, storing the information in the network, and virtualization. As IoT get very popular in the number of devices connected to the IoT network is also grows rapidly and huge amount of data is engendered [3]. This creates the issue in the performance of cloud computing, as the network bandwidth of cannot meet the real time performance, which

creates a flaw in transmission of bandwidth, consuming energy, securing of data, protecting the users information and load balancing [2].

Similarities and Variances:

The development of edge computing cannot be a substitute for cloud computing in the aspect of business application and intelligence [4]. Both cloud and edge computing should coordinate together to help the digital transformation to the greater extend. Information which are available at the edges need to be briefed in the cloud network only. So, Cloud computing is on stage in the development of IoT devices [2].

Edge computing has two physical characteristics over cloud computing.

1. Focuses on the locally available data.
2. Work better in analysing of minimal data.

Hence in smart devices cloud computing is the most appropriate choice for processing the comprehensive information in a centralized environment. On the other hand, edge computing can be utilized in the local services as it is very close to the data source it can be used in moderate smart analysing [2]. Consequently, without uploading all the information to the cloud environment, that information can be handled locally which reduces the burden in the network helps in utilizing the network bandwidth effectively [5].

Merits of Edge Computing:

Deprived of transferring the information to the cloud environment, devices at the edge of the network stores and process the information which eventually reduces work load on the cloud devices. On this aspect edge computing is having the following advantages [2].,

1. Faster in response
2. Reduces the intermediate transmission of data.
3. Provides security.
4. Lowers bandwidth, energy consumption, and cost.

Building Blocks of Edge Computing:

The building blocks of edge computing is sub divided into three different blocks as below:

1. Terminal Block
2. Boundary Block
3. Cloud Computing Block

All these blocks work together to create an effective edge computing architecture which reduces the workload of Cloud computing.

Terminal Block:

The terminal block encompasses a wide array of devices that are connected to the network, together with movable devices and several IoT devices such as smart devices, sensors and more. In this block, gadgets serve not only as information consumers but also as information earners [2].

The primary focus in the terminal block is on enhancing the perception capabilities of the devices rather than maximizing their computing power [2]. Consequently, hundreds of millions of devices within this layer actively gather diverse raw information. This information is then communicated to the upper layer, where it is stored and processed through calculations and analysis [4]. The main goal of this approach is to minimize terminal service delays and efficiently manage the enormous volume of data generated by these devices.

Boundary Block:

The core block of the architecture lies at the border of the network which consists of border nodes which are strategically placed between terminal devices and cloud resources which comprises of access and base points, switches, routers, etc.

The primary function of the boundary block is to provide unified connection and access to terminal devices and ensure smooth communication with the upper layers [5].

Secondary function is it has to store and process the data which are uploaded by the terminal devices. The data processing can range from simple data to complex data which totally based on the requirement of the application [2].

The main advantage of the boundary block is its closeness to the end user and terminal devices which allows faster transmission and makes real time data analysis.

Cloud Computing Block:

Cloud computing block is composed of storage devices and high-performance servers with robust computation and storing proficiencies, making it ideal for tasks requiring extensive information study, such as systematic conservation and commercial verdict provision [2]. The cloud computing centre attends as a everlasting storehouse for the information conveyed by the edge computing block, which also takes the task of analysing which are unable to complete by the boundary block due to lack of resources as well as processing the publicly available information [3].

Moreover, the cloud computing block has the elasticity to dynamically regulate the positioning policy and procedure of the edge computing block based on control procedures [4]. This allows the cloud to improve the performance and allocation of resource at the edge, ensures well-organized and active operation of the entire cloud-edge computing ecosystem [2].

KEY TECHNOLOGIES AND FUNCTIONALITIES:

The development of edge computing which gives a swift growth in the field of IoT which gives a huge contribution for the smart society [2]. The significant technology of the edge computing will have different levels such as

1. Reducing computation
2. Flexibility management
3. Reducing traffic
4. Storage acceleration
5. Network controller, etc.

Among this reducing the computation and the flexibility management play the vital role which is to be discussed.

Reducing Computation:

The reducing of computation technology cut down the delay caused by the transmission of data over the networks, in addition to this it also reduces the work load on the central network [5]. Two main drawbacks faced by this reducing the computation is i) reduction verdict ii) allocation of resources [2]. Among this, the reduction decision is about by what method to reduce the tasks, at what quantity to be reduced, and what to reduce for the independent devices.

- i) **Reduction Verdict:** which discusses the problem related to the User Equipment which decides what method to reduce the tasks, at what quantity to be reduced, and what to reduce [2]. In this reduction system User Equipment consists of a code analyser, system analyser and decision engine. This execution is divided into three stages like
 - a) **Code analyser:** determines what to be reduced which depends on code information partition and the type of the application [3].
 - b) **System analyser:** has to monitor numerous constraints like existing bandwidth, scope of information to be reduced or the resource utilized to perform a task.
 - c) **Decision Engine:** decides whether to reduce the burden or not [2].
- ii) **Allocation of Resources:** Upon completion of reduction verdict our duty is to take into account about the problems in practical allocation of resources. Currently, allocation of resource nodes is mostly considered into two main types: single-node allocation and multi-node allocation [2].

Flexibility management:

Edge computing depend on the physical properties to support the flexibility of the applications which serves users in its circle. Two main problems faced by flexible management are

- i) **Discovery of resources**
- ii) **Switching of resources**

Discovery of resources: The user of the network needs to discover the available resources quickly in the circle with the appropriate resource while shifting from one node to the other node [5]. In edge computing model it has to adjust to the mixed resource environment in addition to that it has to make sure about the rapidity in discovering the resources which will be helpful to the application programs to offer services to the end user nodes without any disrupt [2].

Switching of resources: is once the users in the network wants to move, the computation properties which are used by the movable applications also swapped between numerous devices [3]. Switching of resources will also migrate its service package to make sure about the reliable service to all the nodes [2].

Reducing traffic:

Reducing the traffic in the edge mobile network is the important aspect in portable or movable edge computing. Reduction in the traffic cannot be done blindly as it has to follow the traffic reduction rules in the mobile edge computing [2].

Storage acceleration:

Storage acceleration procedures can expand the user knowledge and improve the competence of the content circulation [5]. Once the content is stored in the mobile edge, users of the mobile edge network can avail the content without having any repetition, which also reduces the delay in the network which are requested by the user which improves the performance of the network [2].

Network controller:

The edge network encompasses a portion or the entirety of the aggregation layer network and the access layer network, constituting the final segment of the network that facilitates user access [4]. In terms of significance, edge networks hold strategic importance as commercial networks situated between established core networks and large user bases. This solution introduces an efficient workload slicing scheme that leverages software-defined networks (SDN) to handle data-intensive applications across multi-edge cloud environments [2].

PRIVACY AND SECURITY:

The biggest threat in edge computing is protecting the user information from the attackers. While processing the information along with that securing the data and privacy for the user has to be given. Smart users will always be a threat in a shared network [5]. Additionally in this active atmosphere protecting the data is a hard task which faces four different challenges.

1. Multiple Authorization
2. Data propagation control and security
3. Resource constrained terminals.
4. Efficient privacy protection

To overcome these challenges faced in the privacy and security, protection in edge computing can be divided into four different steps [2].

1. Information Security
2. Individuality Validation
3. Confidentiality protection
4. Access regulator

Information Security:

The fundamental of creating the secure edge computing environment is maintaining the information security and its determination is to provide discretion and integration of data [4]. The ultimate goal of this is to

- Divide the ownership
- Regulating the farm out information

- Regulating the storage

Which gives a solution to the problems like loss of information, information outflow and prohibited information functions [3].

The objective of information security in edge computing involves adapting and transferring data security measures from existing computing models to the edge computing framework. This adaptation entails the parallelization of distributed computing structures within edge computing [2]. Despite the constraints posed by limited terminal resources, the system effectively integrates characteristics such as edge-based big data processing and a dynamically changing environment. Through this integration, the goal is to create a nimble and decentralized data security protection system [4].

Individuality Validation:

Prior to utilizing IoT services, users are required to undergo individuality validation. This is essential due to the nature of edge computing, which functions as a scattered and collaborative computing environment hosting various confidence provinces [3]. This authentication process involves not only assigning distinct identities to each entity but also encompassing mutual authentication mechanisms across diverse trust domains.

The primary focus of identity authentication encompasses three key areas:

- Authentication within individual domains
- Authentication spanning multiple domains
- Seamless handover authentication.

Confidentiality protection:

While not all authorized entities within edge computing can be considered fully trustworthy, it is noteworthy that user identity details, location information, and private data are retained within these partially trusted entities [2]. This situation can potentially give rise to privacy concerns. Currently, the focus of privacy preservation revolves around the portable cloud and fog computing. Consequently, the sphere of confidentiality protection has interest within the context of exposed interconnection-based edge computing [3].

The primary focus of confidentiality protection is

- Safeguarding data privacy
- Ensuring the privacy of location information
- Fortifying the protection of individual identity privacy.

Access regulator:

Access regulator is a key technology to ensure security to the system and defending end user confidentiality. At present, the most widespread access regulator policies include attribute and role-based access regulator in which attribute-based access regulator will be suitable for distributed architecture [2].

All together access regulator is the significant technology which make sures the protection to the devices and safeguarding the user's information from unauthorized access [4].

APPLICATIONS OF EDGE COMPUTING:

The application of the emerging technology will depend on its capacity to find a solution to the setbacks which are already available system. Below are some of the applications of edge computing [2].,

- Video Cache edge computing
- Edge calculation with 5G
- Live broadcast in edge computing network.
- Analytical preservation
- Security proctoring

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