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A Survey on Mobile Edge Computing: Focusing on Computation Offloading and Resource Allocation

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A SURVEY ON MOBILE EDGE COMPUTING: FOCUSING ON COMPUTATION OFFLOADING AND RESOURCE ALLOCATION

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ABSTRACT:

Driven by vision of the Internet of Things devices and cloud server communications, in recent decade of years centralized cloud computing shifted into the distributed cloud computing towards Mobile edge computing. Due to frequent communications devices and cloud server may cause the execution delay and Maximize the latency. The Mobile Edge Computing provides computing and storage at the edge of the network, which enables to reduce latency time and resource allocation. The main aspect of Mobile Edge Computing is to focus on the Offloading, Orchestration, Resource Allocation. The Computation offloading plays crucial role in Mobile Edge computing. In edge computing offloading to be done at the gateway of the origin device itself, and resource allocation processed through the dynamic task partitioning. In this paper, an extensive survey about the mobile edge computing offloading, Resource Allocation, Orchestration hierarchy, Framework and Network placement, and also discuss about the edge server placement and accessibility in both physical and virtual environment.

Key Terms: Edge computing, computation and communication offloading, orchestration, Mobile block chain technologies.

1.INTRODUCTION :

In a last decade of years Internet of Things (IoT) with cloud computing has become new paradigm of computing, which will impact every aspect of routine life incorporate with wireless technology and virtual storage management such as mobile, IoT devices, Wireless devices, etc. Emergence of the computing technology, the cloud has proposed with distributed environment. In Centralized classical cloud models for data acquisition and storage typically ensure data integrity [1]. However, the exponential growth in

volumes of bigdata, the classical cloud management will face several problems such as data availability, High data requests to the multiple users and handling big data process. In this context, envision a reliable distributed cloud models to improve the performance of cloud [18].

The fog computing is another type of distributed cloud computing technology, which is virtual based distributed model. In this data acquisition, storage and computation done at network layer itself and transform the data at the logical stream of network edge. The fog to be processing and controlled based on the internet instead of the network gateways and switches in a classical communication [4].

In fog architecture data storage and processing take place in LAN at network layer, it enables aggregation of data from multiple devices. Furthermore, fog computing infrastructure enables to collect data from various different devices [2]. This can handle big data analytics processing to reduce the latency timing, better offloading and orchestration support process.

In an Edge computing, data are to be collected in real time, which can reduce the latency and data secure data transmissions. In edge computing data maintenance and Networks process on the edge of the network provide near real time analytics that helps to optimize performance and increase uptime [4].

In conventional distributed cloud computing, both Fog and Edge computing are providing the identical operations and performances. however, in the performance the fog will perform on the network side and the edge computing will perform on the originated device, where the data has to be proceeded and also data to be handled in device itself [9][10].

In this survey paper to deals with edge computing, offloading algorithms, orchestrations algorithms, and block chain technologies are used to improve secure data transmissions, and also striking the balance between keeping the data in the edge and bringing into the cloud when it is needed. It will be more effective to analyse the data in the originated devices. Summary of the existing surveys on multi-access edge computing [6], are listed in table 1.

THEMES	**REFERENCE**	**MAJOR CONTRIBUTION**
Architecture and computation Offloading	[1],[9],[15]	Review of Edge Computing Architecture and Computation Offloading

Orchestration	[13],[14]	Application of Orchestration in multi mobile edge computing
Resource Allocation	[4],[8]	-survey on serverless and deviceless edge computing
Mathematical Framework	[4],[11],[17]	-Survey on edge computing in SDN. -Adaptive Extensive file systems -Multi user and Multi-tasking edge computing systems
Research Directions	[3],[10]	-Introduction about Edge Computing Architecture Infrastructures. -Issues, Challenges, Future work in Mobile Edge Computing
Edge computing with block chain technologies	Proposed model	A survey on Effective and secure data transmission in edge computing with block chain technologies algorithms -Centralized cloud edge computing with offloading and orchestrations

Table 1: Summary of surveys

Multi Edge computing

The section II deals with basic ,application ,Virtual Management ,Physical Management Server specification and Architectures of edge and Mobile Edge Computing .In Section III deals with the computation and communication offloading also describe about the offloading on the edge and also on the cloud server, types of offloading ,Existing

surveys and current scenarios in this surveys .Section III deals with the orchestration, section IV deals with the resource allocation and block chain technologies , finally conclusion and future work addressed.

II. EDGE COMPUTING:

In Cisco's white paper [20], showed that global data traffic grows up to10% from 2018-2023 this will grow up to three-fold values and usage of internet values 122 exabytes at the end of 2022.It's also anticipated that the number of connected IoT devices increased into millions comparing to the upcoming decades. Despite of above process it will require higher number capabilities, limited data storage resources, communication, orchestration and offloading process [16][17]. When compared above usages edge computing with distributed cloud has to process and manage data in a secure way in the origin of the device itself [4].

The main challenges in IoT with centralized cloud has security, interoperability, privacy, over the air upgrades, Huge data volume, real time data processing, Actionable insights, complex event processing, and standardization [6].In an IoT and server communications huge number of data volume has to be consumed in the origin of the devices. For an example, car connected with GPS to communicate with cloud server it will produce 4TB of data per day per car while it required minimum 200 sensors needed to communicate. With these types of large data to be produced the data storage processing and management will not be reliable and may a data to be lose [2].

The distributed cloud model has to insights the data as defined in the databases, with that only necessary data to be gathered and mined in the big data process, the processed data should be analysed in 4 ways as descriptive, diagnostics, predictive and prescriptive [11].

In a network communication, Gateway is the first device to communicate with higher layers. which is the network device, and has already connected with the internet. Gateway has done with how much of data has to be processed in cloud and how much od data to be processed locally. In edge computing the communication has to done at the gateway itself [14].

In a fog computing, the computation and storage process are to be done at the network side which is the intermediate node. These intermediate nodes have to be used optionally due to high cost and also latency time. So, the insights of processing start from the edge itself. In edge architecture part of the data processing

done at the edge computing remaining part to be done at the fog or intermediate node and finally data processing done at the cloud server [12].

The edge architecture showed in the figure 1, has to be processed in the origin of the device gateway. which will be smaller storage space for the data processing, the storage will be either physical or virtual. In this, the router will be gateway which will be vary depends on the types of data to be transferred and processed. In edge computing, the edge server issued only for big analysis and a smaller number of data it can be proceeded through offloading without knowledge of the server [17].

In the edge architecture shown in figure 1 there is 3 types of layers, such as cloud, fog and edge layers. The edge server requires this number of layers because of that real time data processing and data storage. This will be processed with minimal bandwidth allocation and energy efficient power management data transmissions.

The edge computing doesn't replace cloud, it complements the cloud server to reduce work load. The primary insights of edge computing are, minimal storage capacity and fit into space for historical related data. In edge computing, the current data to processed in the edge server and historical data to be processed in the intermediate node. These are done by the edge computing remote administration, monitoring and control [3].

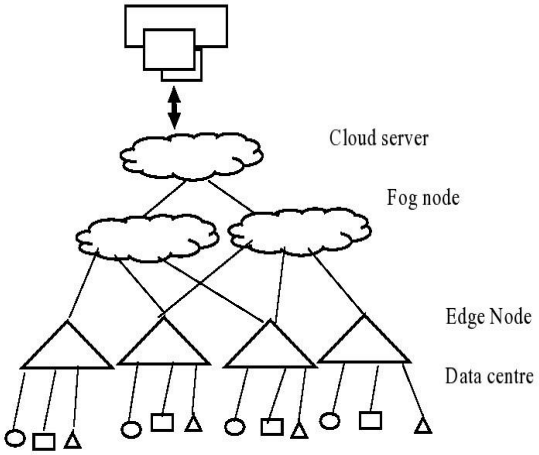

Figure 1: Edge Architecture

Mobile Edge Computing:

The Mobile Edge Computing is the extensible version of the Edge Computing, which will mainly use in the telecom-oriented business. Due to increase of the number of mobile uses and bandwidth allocation, the mobile should be connected with IoT devices and Cloud Servers. To toggle this kind of issues mobile edge computing has to be established. This will perform based on the clustering techniques to process the node at the edge of the network [7].

The demand for Mobile edge Computing is increasing to process High band width data with low latency and less power consumption, to improve the quality of the wireless technology services and also quantity of services. In traditional network perform traffic control flow forwarding and filtering of packets. while in the mobile edge computing, cloud process is deployed in the base station itself [5]. In mobile edge computing separate space is allotted in the base station itself. part of the process done at the edge itself and remaining process is performed at the cloud process.

As shown in table 2, the existing comparison is tabulated between Mobile Edge Computing and Mobile Cloud Computing in terms of the latency, server location, Backhaul usage and Deployment. When compare with Mobile edge computing and Edge Computing, The Mobile Edge Computing performs with the low latency 1ms, proximity, High bandwidth performance (100 Mbps to 1Gbps), Real time insights, Access the Radio Access Network (RAN) only the authorized users [3][11].

The main goal of the Mobile Edge Computing is that optimizing the mobile resources by hosting computing mobile intensive applications, optimizing the large amount of the data before transforming the data to the cloud, Enabling the cloud services within the close proximity of the end users, Providing context aware secured services with the help of RAN information[17]. The Mobile edge computing has to be support both on the wired, wireless and virtualisation process.

	Mobile Edge Computing	**Mobile Cloud Computing**
Server Location	Wi-Fi Routers, LTE Base stations, Wireless Gateways	Large scale data canters
Deployment	Deployed on the organizations, industries and telecom department	Deployed large IT industries, require sophisticated configuration and planning
Backhaul usage	Infinite frequent usages	Limited frequent usages
System Management	Hierarchical Structure	Centralized Structure

Latency	Less than ten milli seconds	More than 100 milli seconds

Table 2: Comparison between Mobile edge computing and Mobile Cloud computing

III.EDGE COMPUTING COMPUTATION AND COMMUNICATION MODELOFFLOADING:

In edge computing offloading is a technique, in which data process from server or application are transferred through edge of the network nodes and cloud vice versa. With this, augmenting the computing devices through the collection of nodes to the cloud for process requests. The offloading generally divided into the two types such as (I) offloading from user devices to edge (II) offloading from cloud to edge [10]. The offloading to be done at the edge or user devices are called as the computational process while done at the cloud server that will communication model process.

Orchestration:

The orchestration is the term refers to combining the automated thigs into the single formation. In edge computation orchestration refers the framework of edge computing, which will be representing about the architecture of edge computing [17].

The edge computing architecture shown in the figure 1. The orchestration work flow will automatically large amount data to transmitted, and managed. The goal of orchestration is to streamline and optimize frequent, repeatable process to ensure the secure data transmission [15].

Offloading from the user devices to the edge:

The offloading from the user devices to the edge, which is also named as the Application offloading or Binary offloading. The offloading processed this type in a user devices or edge server itself. With this type there is no partitioning, only the whole data to be offloaded locally.

The offloading from the user devices techniques performed based on single hop edge node. This will be performed based on the application partitioning and caching mechanisms. The application partitioning has four mechanisms: Brute Force, Greedy Heuristics, Simulated Annealing and fuzzy logic [20].

The Brute Force technique has comprehensive approach, which will

include all kinds of data transmission in the cloud, edge and user devices. This technique performed based on the minimal execution time and task scheduling process. This will not be suitable for the real time data processing. The Greedy Heuristics approach merely minimize the execution time on the mobile device. This has to initialise the offloading process in the edge node. Another approach is the Simulated Annealing which will performed based on the utilization of the cloud, edge node, user devices, completion time and total costs [12].

The main goal of fuzzy logic technique is to improve the quality of services measured by multiple access rate and Service access rate. These four-application partitioning measured by the 3 models such as Graph based, Component Based and Neural Network based [9].

In a multiple edge node utilization with low power and minimal bandwidth utilization to use the V2MX algorithms and Balanced Resource Task Allocation [BRT] algorithm to be used in the Ultra dense Network and Software Defined Network.

Offloading from the Cloud to Edge:

The offloading from the cloud to edge process or offloading the data at the cloud server and forwarded it to the edge node or user devices, which is also be named as the partial offloading. The partitioning offloading, the data has to be partitioned and transferred to the user devices or edge nodes, the partitioning has to be done with graphical mode, to use the Direct Acyclic Graph [DAG]. which is finite graph with no cyclic nodes [17].

This type of offloading avoid replication in the databases storage itself at the time of data transmission from the cloud to the edge node. This will be generally called as the server offloading. The server offloading has partitioning parameters that are functional aware, geography aware and latency aware. This kind of application process will be a backend process and also to be used for long haul process like database-oriented process [11-15].

These processes are used in the virtual machine-oriented process, the server-oriented offloading mainly used for the gaming-based technology and also for real time processing of the data, but application oriented offloading support for the minimal execution process. This type of offloading should be needed to access the data from cloud to edge and vice versa. Both of this techniques support with the Virtual Machine [18].

The combining computing, communication and Resource allocation for edge collaborative system will leads to

perform based on TDMA techniques [19], to process with segmentation strategy to minimize weighted sum delay of the mobile devices and closed form task splitting strategy with minimal energy.

The computing performance of Cloud/Fog/Edge are shown in the table 3. With this process to computing process done in the edge node is more cost effective. Here we are using both server/Application oriented offloading.so that the storage space and application utilization also be managed. These offloading processes are done with the network of edge and Framework of the edge nodes [21].

The edge framework has performed based on the containers [2]. The containers are used to virtual machine process. The framework and container-based services has to be support to handle the wearable devices such as smartwatches, gazettes and wallets etc. it is mainly used to support for gaming technologies as it has to support the migration process the graphic virtualization videos.

Characteristics	**Cloud**	**Fog**	**Edge**
Latency	High	Low	Low
Bandwidth utilization	High	Low	Very low
Response Time	High	Low	Low
Storage Capacity	High	Low	Low
Sever Over Head	Very High	Low	Very Low
Energy Consumption	High	Low	Low
Network Congestion	Very High	Low	Very Low
Scalability	Medium	Medium	Low
Quality of Services and Experiences	Medium	Medium	Low

Table 3: Computation process of CLOUD/FOG/EDGE

The summary of the existing work to be listed in the Table IV, which gives the simulation result to study about the Multi edge binary offloading to reduce the power and CPU utilization 20 to 30% [5-10], and balanced initialization of workload to reduce the service delay time 9.1% [11-15]. In reference [11-20] proposed the simulated Annealing Algorithm[SAA] ,LoAd Balancing ,and Latency -Aware workload offloaDing[LEAD] .These algorithms has to perform optimized offloading in the edge of the server ,A work load allocation to the edge nodes studied in

the reference [11].The performance SAA Algorithm has affected with the Randomized and real time data processing ,when comparing with the LEAD algorithm ,The computing edge nodes to the resource allocation issues has to be occurred and in LAB algorithms there is initial allocation edge node problem issues .Initially these issues to be handled by the BERT[11]algorithm .The BERT algorithm has the split into three categories as:

- Load balancing is realized in the initialization of the edge node itself.
- Allocating resources to the edge node should be optimized
- Converting the task allocation problem into semi definite programming to resolve the issues

A task offloading scheme proposed in the reference [13], to select an appropriate edge server from available sources according to the available sources. This can be mostly used for the physical oriented edge server. Sometimes the load of edge server will be heavier and also large number of offloaded to the distant cloud servers. This will degrade the data transmission to the devices, mainly for mobile communications. The classical TCP protocol will not support the high-end computing devices. The improved TCP protocol has to be proposed with that additionally calculate the communication delay time.

In reference[3],[13] ,online offloading techniques are proposed with the algorithm Lyapunov optimization which can be used for Mobile Edge Computing offloading data transmission with minimal latency time and minimal bandwidth utilization, which can be used for the 5G based mobile internet access with the integrated LTE/WI-FI link selection and data transmission

Framework	**References**	**Techniques**	**Methods**	**Contributions**
Partial offloading and binary offloading	1, 10	Application oriented and cloud-based offloading	Direct Acyclic Graph [DAG]	- minimal execution time - minimal Bandwidth utilization - minimal Latency time

Partial/Binary offloading	4,7	Cloudlet based mobile user computation offloading Base Station Based computation offloading	Deep Supervised Learning Dynamic Voltage Scaling	Reduced power and latency consumption 29-30% respectively Load Balancing Edge server and Cloud Server placement -
Binary Offloading	12, 15	Dynamic Node RED based	Tab Deployer Cloud Link	- Parallel Execution
		Approach		of local nodes - CPU Utilization -IoT Gateway Execution
Multiple edge Node offloading	11, 16	Workload optimization allocation model	Balanced Initialization, Resource, and Task Allocation(BRT)Algorithm,V2MX algorithm	- Reduces the service delay 9.1% - Balanced Initialization of workload to the edge nodes
sensing-intensiv	12	IoT edge node relocating	Confident information coverage based IoT edge node	- Energy

e offloading		methods	relocation [CICENR]	balanced and Direct replacement approach -To Handle redundant IoT node
Binary Offloading	14	Deep Reinforcement Learning Methods	Federated Learning based policy training Algorithm	-Bandwidth utilization computation task offloading
Dynamic Mobile edge computation offloading	15	Energy Efficient Computation offloading	-Mobile device Priority determination algorithm -CPU frequency task offloading L-R based Algorithms	-MEC server placement -Heterogeneous Network Task optimization and frequency scaling
Binary offloading	17, 18	Resource Allocation at Low power edge devices	Iterative Bandwidth Allocation	Bandwidth allocation and offloading management

Table 4: Comparison of paper offloading techniques

LODCO ALGORITHM:

The Lyapunov optimization based dynamic computation offloading (LODCO) algorithm is to solve execution time management problem and also multipurpose mobile edge computing data transmission [11]. In reference [11-20], the simulated Annealing Algorithm[SAA]is proposed ,LoAd

Balancing ,and Latency -AwarE worklod offloaDing[LEAD] .These algorithms has to perform optimized offloading in the edge of the server ,A work load allocation to the edge nodes studied in the reference [11].The performance SAA Algorithm has affected with the Randomized and real time data processing ,when comparing with the LEAD algorithm.

IV RESOURCE ALLOCATION AND BLOCK CHAIN TECHNOLOGIES

Resource Allocation:

The main challenges for the edge computing offloading is the offloading in the dynamic resource allocation that are running on the edge clouds. The resource allocation to single node may not be done, it will be optimized and performed with the multiple nodes with their operation and service quality [18].

Resource allocation is not a one-time performance, which will be performed with the continuously adopted user movements. With this device node can move arbitrarily, which is main issues in the mobile computing, VR.AR types of data transmissions [12].

In reference [13], To resolve the resource allocation problem in edge computing offloading and optimized data processing, the Deep Reinforcement Learning [DRL] algorithm is proposed. This approach to maximize the long-term benefits of data handling in the edge server. It will used to energy efficient data transmission, less energy consumption and no need of prior knowledge about the network statistics. The Resource management to handle by the two kinds of techniques Graph Based Techniques and cluster-based technique.

Security Authentication and Authorization process:

In edge computing secure data transmission, Authentication and Authorization of the data to be managed and controlled by the Secure Swarm Toolkit [SST] Authentication and Authorization algorithm. This is performed based on the session key and distributed key. The session key is temporary key and distributed key is the dBase key management. [18].

Mobile Block Chain Mining:

Mobile block chain technologies can be used to develop an applications with mobile devices, which can be used to mining large amount of data from the server .To access the block chain

technologies in mobile devices may cost to lose of energy and battery power .To restrict this issues an auction based edge computing resource allocation [8] has to be proposed. This will be performed in the gateway with block chain protocol.

In mobile edge computing offloading handling large amount data leads to overlap in the edge server and also needs of the large amount of energy to be required. To toggle this mobile block chain technology in the edge computing has to be proposed [6]. which is to be implemented in the distributed environment with the function blocks. The hierarchical representation of the block chain in the cloud server to the edge forwarded data. In reference [17] to use LiTi Chain block chain functional algorithm, with this algorithm the block will be in lifetime until block has to be deleted to maintain the connectivity.

In the previous offloading techniques only focus on the computational resources, in our proposed system consider about the computational resources are considered. The large amount of data to be handled and offloaded in the both computational and communicational process which is shown in figure 2.

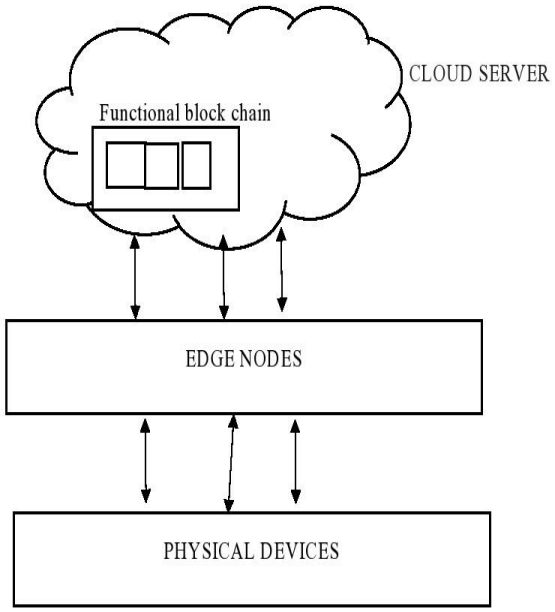

Figure 2: Hierarchical Distributed Control System Model for Edge Computing

Conclusion:

Edge computing offloading has potential solution for energy efficient data transmission with low power and minimal bandwidth, the edge computing offloading also have some difficulties as the general-purpose computing without prior knowledge, discovering edge nodes, partitioning and offloading the task, uses of edge node publicly and securely. In this survey presented comprehensive overview about the edge computing, mobile edge computing, Computational and communicational offloading, Framework and network Management.

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