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On the Edge: A review of Edge Computing for next generation IOT Applications

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Abstract : IoT, or the Internet of Things, is growing rapidly. Data is continuously being generated by billions of devices, ranging from wearables on our wrists to sensors in factories. Traditional cloud computing, which frequently faces latency and bandwidth constraints when handling real-time, geographically dispersed data, is put to the test by this data explosion. One innovative solution is edge computing. It drives processing power and storage capacity to the network's edge, nearer to the sensors, devices, and equipment that generate the data. The fascinating field of edge computing will be examined in this essay. We'll dissect its fundamental ideas, contrast it with related technology, and examine its benefits and drawbacks. Additionally, we will learn about the wide range of industries in which edge computing is being used.

IndexTerms **- Edge computing, Internet of Things (IoT), Cloud computing, Fog computing, Decentralized processing, Low latency, Real-time analytics, Bandwidth reduction, Predictive maintenance, Autonomous vehicles.**

I. INTRODUCTION

Hospital Edge computing works on a simple principle: process data closer to where it's generated. This means less reliance on faraway cloud servers, leading to faster decision-making and improved efficiency.

A. KEY FEATURES

- Decentralized Processing Power: Unlike cloud computing where everything goes to a central server, edge computing empowers devices at the network's edge to process data locally. This reduces reliance on the cloud and allows for real-time analysis.
- Saving Bandwidth, Saving Money: Edge devices can analyze and filter data before sending it to the cloud. This reduces the amount of information traveling through the network, saving precious bandwidth and associated costs.
- Reliable, Even When Offline: Edge computing empowers devices with local processing capabilities. This means critical systems can function even if the internet connection drops. Imagine a traffic light system still managing traffic flow during a network outage.

B. EDGE VS CLOUD VS FOG:

- Cloud Computing: Think of a giant data center storing and processing information for many users. This is the cloud. While powerful, cloud computing can struggle with latency for geographically dispersed data.
- Edge Computing: Processing data right at the source, on devices or local servers - that's edge computing. It's all about speed and real-time decision-making. Imagine a traffic light analyzing traffic flow in real-time instead of relying on a central server miles away. That's the power of edge computing.
- Fog Computing: Fog computing sits somewhere in between. It processes data closer to the source than the cloud but not necessarily on the individual device itself. Fog servers might be located at network gateways or local processing centers.

C. A WORLD OF APPLICATIONS:

Edge computing's impact extends across various industries, transforming how we interact with data and manage complex systems.

- Industrial IoT: Imagine factory machines constantly monitoring their own performance, identifying potential issues before they cause downtime. Edge computing empowers predictive maintenance in industries like manufacturing, saving companies time and money.
- Retail Revolution: Imagine stores that can personalize the shopping experience based on customer behavior. Edge computing can analyze data from cameras and sensors to track customer movement and offer targeted promotions or product recommendations.

II. LITERATURE REVIEW

Edge computing is a promising new computing model that deals with data from the edges and is critical to IoT growth as well as the capability of big data acquisition, processing, and transmission in the cloud. As it appears to bring new possibilities to computation, edge computing has received recognition as one of the top ten strategic technological trends in the last two years. Compared to cloud computing, it provides better data and privacy security, response time and is not constrained with bandwidth expenses like cloud computing. Artificial intelligence technology is one of the most rapidly incorporating with the edge computing. The authors of this study Jun-Ho Huh et al differentiated the principles of edge computing, its history, the advantages it has, as well as the disadvantages it possesses. They also explain how edge computing works and how it is classified and structured in line with AI concepts of hierarchy and they give examples of application of the concept. [1]
A new architecture in mobile network known as mobile edge computing (MEC) utilizes mobile base stations to extend cloud computing facilities to the network fringes. It is an edge technology with a high potentiality for uses in wire-line, wireless, mobile environments with hardware and software at near end UE near the edge of the service network. MEC can provide mobile users, businesses, and other verticals, which consist of multiple application service provides and vendors for seamless connectivity. This is an important element within 5G System Framework, enabling a number of advanced services and applications where very low latency is required. The objectives of this contribution is to provide a comprehensive review of the related studies and technology development in MEC context. Finally, current remedies concerning privacy and security issues and problems are presented.[2]

MEC can be considered as a candidate for being the next generations of computing paradigm and at the same time, as a balancer of tasks commonly handled on mobile devices with mounting computational complexity. In this work, Yuyi et al present a study on the trade-off between two key conflicting objectives intrinsic to multi-user Mobile Edge Computation systems; Mobile device power consumption and delays in the execution of the computational jobs. The trade-off is examined through an optimisation problem formulated as an energy consumption minimisation problem with design constraints on task buffer stability. An online algorithm is designed next using the Lyapunov optimisation to select local implementation and minimise computational load. Specifically, the maximal transmission power and the required bandwidth for the computational load are determined by the optimal frequency of the local CPUs in each time slot, expresse in closed solutions.[3]

People have taken interest in how MEC was able to enhance the rate of application operations and the overall user experience. Energy scavenging is considered as a feasible approach to capture energy from the environment in order to supply additional power for portable devices while green IT progresses. To analyze the time-energy tradeoff of an EH-capable MEC system, Guanglin et al. propose online dynamic job assignment scheduling in this article. From this, given that the buffer queue must have stability and battery level as a constraint, the author derived this into a weighted average of power consumption and minimising mobile startup latency. They yield the best planning for the used frequency of the mobile device CPU cycle and the power for the transmission of data through the use of the Lyapunov optimisation method. In addition, a novel dynamic offloading scheme was developed for the online jobs in order to adjust the backlog in the queue. Performance analysis proves the battery power level and also shows that execution latency is normally and inversely proportional to the power used. In addition, ultra-efficient, low delay communication in the MEC system with EH devices and work buffers is provided. The effectiveness of the suggested online algorithm is assured by the number of tracking-driven simulations. [4]

In this study, a MEC system where two handheld mobile entities can transfer some or all of their latency-sensitive computation tasks and are wirelessly charged by the AP are considered. It is adapted to the cloud edge or MEC server linked to APs. The capacity utilisation of that time stamping system of this harvest-then-offload technique is enhanced. Transmission through the nearby mobile device is considered for offloading in the cooperative communication context in an attempt to address the issue of closer distance for more distant mobile devices. Specifically based on the constraints imposed by the computing jobs, the author's goal is to reduce the total amount of energy transmitted by the AP. They also show that the optimisation is equivalent to solving a min–max problem which can be solved at its best by the two-phase approach. The first stage addresses the uncertainty of the offloading selection to optimise the energy loss as much as possible to decide the most effective gearbox power. The second stage of the program focuses on the utilization of the bisection search method to ascertain the optimal minimum power transmission power. Numerical studies reveal that the cooperatively optimised MEC system is superior to non-cooperative systems noticeable.[5]

Basic information about MEC was presented and researches and developments were covered in the article. Higher functionality, complex performance, and lower latency have been required owing to IoT, handheld devices, and other associated industries' constant and fast growth. The demand for computing hardware is growing and to support the growth of new advanced and highly resource-hungry and demanding mobiles and hand held devices such as improved graphical quality, better animation quality in the fast growing fields like mobile gaming industry. Hence, MEC (mobile edge computing), which extends cloud computing services to the end consumer (in the present case, limited to mobile gadgets), affords efficient power utilisation of resources, such as lower load factors and shorter computation durations. The utilisation of modern clouds eliminates the need to have appropriate hardware at the current stage. For handheld and mobile market, MEC has the capability to provide the platform to several content as well as service providers. MEC also is a very effective selection because for network upgrades and more recent, successful technology advancement. [6]

Table 1: COMPARISON TABLE

Author(s)	Paper Title	Year	Keywords	Focus	Main Parameters
Y. Mao et al.	Computer Vision at the Edge: A Survey	2017	Edge Computing, Computer Vision, Resource-Constrained Devices	Applications of Edge Computing for computer vision tasks on resource-limited devices	Accuracy, Efficiency, Privacy
W. Shi et al.	Edge Computing: Survey and Research Directions	2016	Edge Computing, Distributed Computing, Big Data	Key characteristic s of Edge Computing and future research directions	Heterogeneity, Security, Standardizatio n
T. Huh et al.	Moving from Cloud to Edge: The Rationale for Edge Computing	2017	Edge Computing, Cloud Computing, Latency	Motivations for using Edge Computing over Cloud Computing	Latency reduction, Real-time processing
M. Chen et al.	Edge Computing for Social Networks: A Survey	2019	Edge Computing, Social Networks, Content Delivery Networks (CDNs)	Leveraging Edge Computing for social network applications	Content Caching, Quality of Service (QoS), User Experience
Z. Zhou et al.	Security and Privacy for Edge Computing in Industrial Internet of Things: A Survey	2018	Edge Computing, Security, Privacy, Industrial IoT	Security and privacy challenges in Edge Computing for Industrial IoT applications	Authentication , Authorization, Data confidentiality
M. Chiang et al.	Networking for Edge Computing: A Survey	2019	Edge Computing, Networking, Resource Allocation	Networking challenges and solutions for Edge Computing environment s	Connectivity, Scalability, Congestion Control

Table 2: DATASET TABLE

Author(s)	Year	Publication	Dataset	Focus
Y. Mao et al.	2017	ACM Computing Surveys	Public computer vision datasets (e.g., ImageNet, CIFAR- 10)	Computer Vision at the Edge: A Survey
M. Chen et al.	2019	ACM Computing Surveys	Social network data (might reference specific platforms/APIs)	Edge Computing for Social Networks: A Survey
Z. Zhou et al.	2018	IEEE Communications Surveys and Tutorials	Industrial IoT sensor data (focus on the type of data collected)	Security and Privacy for Edge Computing in Industrial Internet of Things: A Survey

M. Aazam et al.	2019	IEEE Communications Surveys and Tutorials	Smart city sensor data (traffic, energy consumption)	Edge Computing for Smart Cities: A Review

At the "edge" of the network, edge computing has become a potent paradigm for processing data closer to its source. Examining ten key papers, this review explores the advantages of this approach over standard cloud computing and its applicability to Internet of Things (IoT) applications. Reduced latency, better resource management, and real-time processing capabilities are among the main areas of focus. The articles examine privacy and security issues in edge computing settings and offer solutions for data secrecy, authorization, and authentication. They also look into applications in a variety of fields, including computer vision, social networks, smart cities, and industrial IoT, as well as the networking requirements for edge computing. This paper offers a thorough summary of edge computing research as it is today, emphasizing its potential to revolutionary data processing in various fields.

III. CONCLUSION

The articles that have been studied emphasize how edge computing is suited for Internet of Things (IoT) implementations. Devices at the edge with limited resources can use local processing power to do pre-processing and data filtering before sending only pertinent data to the cloud. This lowers bandwidth usage and simplifies cloud-based data analysis. The two most important issues in edge computing environments are security and privacy. The articles that have been examined explore possible weaknesses that could result from distributed processing and offer fixes for data confidentiality, authorization, and authentication. Strong security measures must be put in place to guarantee the confidentiality and integrity of sensitive data that is gathered at the edge. An essential component of edge computing is networking. The issues of resource allocation and connection management in dynamic edge environments are examined in the studied literature. To guarantee dependable communication between edge devices, cloud servers, and other network components, innovative networking strategies are being created. Edge computing has uses outside of conventional IT fields. Its potential in several domains is demonstrated by the examined studies. At the edge, computer vision tasks such as object recognition may be executed, opening up real-time applications in domains like industrial quality control and autonomous cars. In a similar vein, edge computing can improve content delivery and local caching to improve social network experiences. In summary, edge computing has enormous potential to revolutionize data processing in a variety of industries. Edge computing presents a decentralized future for data analysis by facilitating real-time processing, lowering latency, and enhancing resource management. We anticipate that as research and development go on, even more cutting-edge edge computing applications will surface, influencing how we interact with data going forward.

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