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# A Study of Data Security and Privacy Techniques in Edge Computing

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**ABSTRACT:**

Cloud Computing has revolutionized how people store and use their data. However, there are some areas where cloud is limited, latency, bandwidth, security and a lack of offline access can be problematic. To solve this problem, users need robust, secure and intelligent on-premise infrastructure of edge computing. Traditional cloud computing is no longer sufficient to support the diverse needs of today's intelligent society for data processing, so edge computing technologies have emerged. It is a new computing paradigm for performing calculations at the edge of the network. Unlike cloud computing, it emphasizes closer to the user and closer to the source of the data. At the edge of the network, it is lightweight for local, small-scale data storage and processing. Thisarticle mainly reviews the related research of edge computing about the forming factors, privacy and security issues in cloud computing solved by edge computing, faster response time, various techniques for secure searching etc.

## 1. INTRODUCTION

The rapid development of technology has seen an increase in the number of IoT devices in recent years. This number is expected to increase more in the future as well. In the year 2019 itself, more than 6 billion IoT devices are in use. The rise in the number of devices means the increase in data generation. This voluminous data generated from the devices is creating problems as the processing of this data is a challenging task.

IoT devices generate data whichis stored on the cloud. This data needs faster processing and response. However, due to the increase in transmission latency the IoT device user might face some performance troubles. Transmission latency increases due to the increase in the distance between the cloud and the IoT device user. Thus, the closer the user to the cloud, the better is the performance speed of the device.

The concept of Edge computing came into the feature in order to sort out this problem. Edge computing is somewhat similar to the Content Delivery Network (CDN) but edge server processes the data generated from IoT devices in edge computing instead of the centralized cloud server. There is an edgeserver near the IoT device user, whichserves as a bridge between the cloud and the user. This decreases the data transmission latency and the user experiences a speedy performance of the device.

There are some areas that require minimal transmission latency such as smart homes, cloud gaming, video streaming, smart devices, etc. If there is a delay in data transmission in these areas then the impacts can be dangerous. For example, in the case of self-driving cars the response from the cloud should be very quick. If there is a delay in transmission of response after the car sends the data tothe central server, consequences can be dangerous,as the car cannot take human-like decisions on its own. Thus, edge computing reduces the transmission latency when voluminous data has to be transmitted.

Edge computing helps in real-time data processing without any sort of transmission latency. Since the data is processed near the user device, the usage of Internet bandwidth is also reduced. These features of edge computing are making it a fundamental constituent for organizations. According to one of thestatistics of Gartner, 50% of the data generated by an enterprise will be created and processed by edge computing rather than centralized cloud data centres by 2022.The important parameters taken into account are as follows,

**Network Bandwidth:** The storageof more data demands the expansion of bandwidth. Thus, the network bandwidth needs to be increased with the increase in the amount of data while edge computing is used.

**Security:** Due to the distributed structure, edge computing is vulnerable to security exploits. This type of architecture increases attack vectors that may result in malware infections

.**Compliances:**The data stored over Edge servers need verification for compliances and regulations as data is one of the key components of any business organization.

**Latency:**The distance between the user device and cloud affects the transmission latency. Sometimes there is an increase in latency that may result in disastrous consequences.Hence, edge computing along with solutions brings some challenges too. These difficulties can be overcome by consulting with cloud experts to start utilizing the benefits of edge computing. So, the implementation of edge computing in any business surely helps in the growth of the business.

## 2. RELATED WORK

Zhang et al. [1] presented a comprehensive analysis of the data security and privacy threats, protection technologies, and counter measures inherent in edge computing. Specifically made an overview of edge computing, including forming factors, definition, architecture, and several essential applications. Thus, the survey summarized about cryptographic technologies for solving data security and privacy issues in edge computing.

Cui et al. [2] proposed a primitive named proxy-aided cipher text-policy ABE(PA-CPABE), which outsources majority of the decryption computations to edge devices. The proposed PA-CPABE frame work has an advantage in which the key distribution does not require any secure channels. They presented a generic construction of PA-CPABE and formally proved its security.

Li et al. [3] proposed an efficient time-domain multi-authority outsourcing attribute-based encryption(ABE) scheme (TMO) to outsource the computation to edge nodes to enhance security and performance with a dynamic policy updating method for secure data acquisition and sharing in the edge computing. The security analysis and the experimental results showed that TMO can indeed efficiently enhance data security with low overhead in the edge computing environment.

Ullah et al. [4] proposed and discussed the design, implementation and evaluation of integrated NDN with ECC in order to achieve fast information response time, so the frame work combines well known innovative technologies: NDN and ECC.NDN offers network layer content and services, increased caching, built-in modality, built-in security, and interest aggregation. NDN with ECC reduces the backbone traffic on the edge node and cloud node.

Zhu et al. [5] presented an objective of the special issue is to report high-quality state-of-the-art research contributions that address these key aspects of MEC (Multi-access Edge Computing) enabled IoT and novel applications. Thus they proposed solutions for resource management and allocation,multimedia processing, as well as novel applications.

Wang et al.[6] discussed that for the Industrial Internet of Things(IIoT),Public-Key Encryption with Keyword Search encryption is a promising techniques to maintain data stored in clouds secure and also to improve the efficiency of searching. The lightweight designed ESPEemployed outsourcing PEKS and hidden structures in the itsmodels, which are promising to accelerate encryption andsearching according to our analyses.

Niu et al.[7] proposed a two type of collision attack on block ciphers: one by making use of leakages from linear layers and other is the scalable collision attack. In addition, a novel scalable collision attack of general applicability and high-efficiency is proposed andapplied to masked linear layers and masked S-boxes. It can reach an equal level of performance compared tothe second-order power analysis with acceptable off-line search, which improves the known collision attacks significantly.

Alabdulatif et al.[8] introduced a novel EoT computing framework for secure and smart healthcare surveillance services. Clustering-based techniquesare applied to analyze biosignal data in a secure mannerand developed a distributed analysis approach. The FHE ensured the privacy of outsourced biosignaldata from its source and while it is processed in both edgeIoT devicesand cloud computing and encrypted analysisresults can be retrieved by data owners and decrypted in asecure side.

Xiao et al.[9] provided a comprehensive survey on the most influential and basic attacks as well as the corresponding defense mechanisms that have edge computing specific characteristics and can be practically applied to real-world edge computing systems. Mainly focused on the following four attacks: distributeddenial of service attacks, side-channel attacks, malware injectionattacks, and authentication and authorization attacks.

Carvalho et al.[10] proposed the use of joint parallelism between wireless and cloud domains to efficiently respond to mobile data deluge. They presented and evaluate two design examples –parallel computation of offloadmethod(PCOM) and parallel transmission and storage method(PTSM) which outlines the benefits of parallelism for computation-hungry applications. These two designs are able to make an efficient use of the network resources and support a heavy instantaneous workload by means of the parallelism.

Liu et al.[11] proposed methods to satisfy the increasing demand of mobile data traffic and meet the stringent requirements of the emerging Internet-of-Things(IoT) applications such as smart city, healthcare and augmented/virtual reality (AR/VR),the fifth generation(5G) enabling techniques.

Malong Ke et al.[12] proposed an advanced frame structure design to reduce the access latency and studied about grant-free massive access in cell-free massive MIMO-based IoT, where multiple APs cooperate in the network to serve massive UEs.Moreover, by considering the cooperation of all access points (APs), they investigated two processing paradigms at the receiver for massive access: cloud computing and edge computing.

Hassan et al.[13] investigated, highlighted, and reported on recent advances in edge computing technologies with respect to measuring their impact on IoT and established a taxonomy of edge computing by classifying and categorizing existing literature, and by doing so, we reveal the salient and supportive features of different edge computing paradigms for IoT.

Donno et al. [14] gave an idea of how the different paradigms evolved and what the main research trends are today. Then, starting from this global picture, we focused on each of the paradigms, explaining main characteristics, architecture, and main features, along with considerations on how they interact and influence each other. We concluded by remarking how relevant Fog computing is and arguing that Fog is the glue that keeps IoT, Cloud and Edge computing together.

Taleb et al. [15] introduces a survey on MEC and focuses on the fundamental key enabling technologies. It elaborates MEC orchestration considering both individual services and a network of MEC platformssupporting mobility, bringing light into the different orchestration deployment options. And also analyzes the MEC reference architecture and main deployment scenarios, which offer multi-tenancy support for application developers, content providers and third parties.

Shirazi et al. [16] pointed out the influence and strong impact of the extended cloud (i.e., the MEC and fog) on existing communication and networking service models of the cloud. Although the relation between them is fairly evident, there are important properties, notably those of security and resilience, that we study in relation to the newly posed requirements from the MEC and fog.

Wang et al. [17] introduced and discussed : 1) the application scenarios of both; 2) the practical implementation methods and enabling technologies, namely DL training and inference in the customized edge computing framework; 3) challenges and future trends of more pervasive and fine-grained intelligence. This information scattered across the communication, networking and DL areas.

Alfakih et al. [18] presented a computation offloading which has become an effective way to overcome the constraints of mobile devices (MDs) by offloading delay-sensitive and computation-intensive mobile application tasks to remote cloud-based data centers. Smart cities can benefit from offloading to edge points in the framework of the so-called cyber–physical–social systems (CPSS), as for example in traffic violation tracking cameras.

Hou et al. [19] integrated mobile edge computing nodes and fixed edge computing nodes to provide low-latency computing services cooperatively. For better exploiting these heterogeneous edge computing resources, the concept of software-defined networking (SDN) and edge computing aided IoV (EC-SDIoV) is conceived. Moreover, in a complex and dynamic IoV environment, the outage of both processing nodes and communication links becomes inevitable, which may have life-threatening consequences.

He at al. [20] proposed EUAGame, a game-theoretic approach that formulates the EUA problem as a potential game. We analyze the game and show that it admits a Nash equilibrium. Then, we design a novel decentralized algorithm for finding a Nash equilibrium in the game as a solution to the EUA problem. The performance of this algorithm is theoretically analyzed and experimentally evaluated. The results show that the EUA problem can be solved effectively and efficiently.

Thors et al. [21] discussed radio-frequency (RF) electromagnetic field (EMF) exposure evaluations are conducted in the frequency range 10–60 GHz for array antennas intended for user equipment (UE) and low-power radio base stations in 5G mobile communication systems. A systematic study based on numerical power density simulations considering effects of frequency, array size, array topology, distance to exposed part of human body, and beam steering range was presented.

Xia et al. [22] discussed Edge computing, as an extension of cloud computing, distributes computing and storage resources from centralized cloud to distributed edge servers, to power a variety of applications demanding low latency, e.g., IoT services, virtual reality, real-time navigation, etc. From an app vendor’s perspective, app data needs to be transferred from the cloud to specific edge servers in anarea to serve the app users in the area.

Yuan et al. [23] proposed a reliable and lightweight trust mechanism for IoT edge devices based on multi-source feedback information fusion. First, due to the multi-source feedback mechanism is used for global trust calculation, which is more reliable against bad-mouthing attacks caused by malicious feedback providers. Then, we adopt lightweight trust

International Journal of Futuristic Research Evaluation inEngineering (IJFREE) Volume: 2Issue :6December 2020evaluating mechanism for co-operations of IoT edge devices, which is suitable for largescale IoT edge computing because it facilitates low-overhead trust computing algorithms.

Ren et al. [24] performed data processing at the network edge, mobile edge computing can effectively overcome the deficiencies of network congestion and long latency in cloud computing systems. Toimprove edge cloud efficiency with limited communication and computation capacities, we investigate the collaboration between cloud computing and edge computing, where the tasks of mobile devices can be partially processed at the edge node and at the cloud server.

Qinglin Qi et al. [25] discussed about Fog computing and edge computing extended the compute, storage, and networking capabilities of the cloud to the edge, which will respond to the above-mentioned issues which is based on cloud computing, fog computing, and edge computing, a hierarchy reference architecture is introduced for smart manufacturing. The architecture is expected to be applied in the digital twin shop floor, which opens a bright perspective of new applications within the field of manufacturing.Wenxiao

Shi et al. [26] proposed the share-based edge computing (SEC) paradigm with the mobile-to wired (M2W) offloading computing. By sharing the idle resources under control of SEC servers, tasks from mobile devices can be computed on wired devices. Moreover, a well-designed computing allocation and sharing (CAS) algorithm is proposed to ensure the low fail ratio and the high utilization ratio of the SEC paradigm.Yunzhao

Li et al. [27] proposed a deep reinforcement learning algorithm is proposed to solve the complex computation offloading problem for the heterogeneous Edge Computing Server(ECS) collaborative computing. The problem is solved based on the real-time state of the network and the attributes of the task, which adopts Actor Critic andPolicy Gradient's Deep Deterministic Policy Gradient(DDPG) to make optimized decisions of computation offloading.

Li Lin et al. [28] provided a comprehensive perspective on this trend. First, we give an insight into the architecture refactoring in edge computing. Based on that insight, it reviews the state-of-the-art research on computation offloading in terms of application partitioning, task allocation, resource management, and distributed execution, with highlighting features for edge computing and illustrate some disruptive application scenarios.

Zhi Zhou et al. [29] conducted a comprehensive survey of the recent research efforts on EI. Specifically, we first reviewed the background and motivation for AI running at the network edge. They then provided an overview of the overarching architectures, frameworks, and emerging key technologies for the deep learning model toward training and inference at the network edge.

Marjanovic et al. [30] proposed an edge computing architecture adequate for massive scale MCS services by placing key MCS features within the reference MEC architecture. In addition to improved performance, the proposed architecture decreases privacy threats and permits citizens to control the flow of contributed sensor data. It is adequate forboth data analytics and real-time MCS scenarios, in line with the 5G vision to integrate a huge number of devices and enable innovative applications requiring low network latency.

Hesham El-Sayed et al. [31] carried out existing data analytics and decision-making processes from our current highly virtualized platform of wireless networks and the Internet of Things (IoT) applications. There is a high possibility that these existing methods will encounter more challenges and issuesin relation to network dynamics, resulting in a high overhead in the network response time, leading to latency and traffic.

McKay-Bukowski et al. [32] used The Kilpisjärvi Atmospheric Imaging Receiver Array (KAIRA) is a dual array of omni directional VHF radio antennas.It is operated by the Sodankylä Geophysical Observatory. It makes extensive use of the proven LOFAR antenna and digital signal-processing hardware, and can act as a stand-alone passive receiver, as a receiver for the European Incoherent Scatter very high frequency incoherent scatter radar in Tromsø, or for use in conjunction with other Fenno-Scandinavian VHF experiments.

Baktir et al. [33] observed that bringing computational infrastructures to the proximity of the user does not magically solve all technical challenges. Moreover, it creates complexities of its own when not carefully handled. In this work, these challenges are discussed in depth and categorically analyzed. As a solution direction, they proposed that another major trend in networking, namely Software-Defined Networking (SDN), should be taken into account.

Wang et al. [34] proposed MOERA, a mobility-agnostic online algorithm based on the "regularization" technique, which can be used to decompose the problem into separate subproblems with regularized objective functions and solve them using convex programming. Through this we are able to prove that MOERA can be a parameterized competitive ratio, without requiring any a priori knowledge on input. MOERA can achieve an empirical competitive ratio of less than 1.2, compared to static approaches.

Babou et al. [35] proposed a solution to solve the problems of latency on HEC servers caused by their limited resources. The increase in the traffic rate creates a long queue on these servers. By leveraging, based on clustering and load balancing techniques, they proposed a new technique called HEC-Clustering Balance. It allows us to distribute the requests hierarchically on the HEC clusters and another focus of the architecture to avoid congestion on a HEC server to reduce the latency.

Pan et al. [36] investigated the key rationale, the state-of-the-art efforts, the key enabling technologies and also the research topics, and typical IoT (Internet of Things) applications benefiting from edge cloud. They also aimed to draw an overall picture of both ongoing research efforts as well as future possible research directions through comprehensive discussions.

Hassan et al. [37] established a taxonomy of edge computing in 5G, which gives an overview of existing state-of-the-art solutions of edge computing in 5G on the basis of objectives, computational platforms, attributes, 5G functions, performance measures, and roles. They also presented other important aspects, including the key requirements for its successful deployment in 5Gand the applications of edge computing in 5G.

Li et al. [38] proposed Edgent, a framework that leverages edge computing for DNN collaborative inference through device-edge synergy. Edgent exploits two design knobs: (1) DNN partitioning that adaptively partitions computation between device and edge for purpose of coordinating the powerful cloud resource and the proximal edge resource for real-time DNN inference; (2) DNN right-sizing that further reduces computing latency via early exiting inference at an appropriate intermediate DNN layer.

Liu et al. [39] proposed a HierTrain, efficiently deploys the DNN training task over the hierarchical MECC.They developed a novel hybrid parallelism method, which is the key to HierTrain, to adaptively assign the DNN model layers and the data samples across the three levels of the edge device, edge server and cloud center. We then formulate the problem of scheduling the DNN training tasks at both layer-granularity and sample-granularity. Solving this optimization problem enables us to achieve the minimum training time.Belli et al. [40] proposed a probabilistic model for the estimation of the number of mobile nodes to be selected as substitutes of fixed ones. The effectiveness of our model is verified with tests performed on real-world mobility traces. The architectural hierarchy of the network shifts the management of sensing information close to terminal nodes through the use of intermediate entities (edges) bridging the direct Cloud-Device communication channel.

## 3. CONCLUSION

Firstly, forming factors of edge computing are given including the shortcomings of cloud computing. Secondly, we analyze the potential data security and privacy-preserving challenges and the possible security mechanisms are given. And then we point out the open research directions of data security and privacy issues in edge computing. Thus this article mainly summarizes the related research of edge computing about the forming factors, privacy and security issues in cloud computing solved by edge computing, faster response time, various techniques for secure searching etc. Finally, this analysis can be used for future enhancements in edge computing.

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