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A Review on Edge-Computing: Challenges in Security and Privacy

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***Abstract*— Vehicular Ad-hoc Networks (VANETs) enable vehicle-to-everything communication, where vehicles disseminate messages to a Road Side Unit (RSU) periodically. All RSUs send data to a cloud or a central server for detection and analysis of traffic congestion situations on the roadways globally. The existing cloud computing approach is inefficient for analyzing massive amounts of data in a short amount of time while still meeting the needs of consumers. Due to its limited scalability, flexibility, and connectivity, conventional vehicular networks have several issues in resource placement and administration, affecting the quality of service (QoS) and severely affecting VANET services and entire network effectiveness. To address these issues, a novel architecture is known as edge computing — which allows the decentralization of data preprocessing from the clouds to the edge of the network — had been positioned to solve the issues that have arisen while employing cloud computing method. Edge computing is defined by its ability to implement with VANETs to calculate, store, and deliver delay-sensitive communications to vehicles on deadline. Less latency, network off-loading, and context-awareness are just a few of the benefits that it might bring to the global vehicular network (location, environment factors, etc.). Mobile edge computing (MEC), fog computing (FC), and cloudlet are the primary methods to edge computing that have been developed. This paper presents a survey on cloud and edge computing, a detailed comparison of the existing research, characteristics, requirements for enabling edge computing, and challenges.**

Keywords*— *VANET, Cloud Computing, Edge Computing, Mobile Edge Computing (MEC), Vehicle to Everything(V2X), Privacy, Security

I. INTRODUCTION

VANETs were first presented in 2001 like a multi-hop mobile wireless communication system. In a certain communication range, vehicles automatically connect to the mobile network [1]. The linked vehicles may broadcast their position, speed, and other data with one another. Vehicle-to-everything(V2X) includes Vehicle-to-Vehicle communication (V2V) and Vehicle-to-Infrastructure communication (V2I), which are two VANET communication modalities. These modalities are used to exchange information and provide mobility for people. Computation, connection, scalability, adaptability, and intelligence are the problems with the current VANET design [3]. Vehicular Cloud Computing (VCC) was created to make use of the benefits of Cloud Computing while providing computing services to VANETs [2]. Traditional approaches place heavy traffics on the RSUs and cause more interruptions. To address the current issues of computing efficiency, reaction time, and resource consumption, this study presented the Edge Computing (EC) idea. This paper offered edge base dissemination in VANET to increase efficiency and scalability.

The rest of the paper is well-ordered with 7 sections as follows: These are in order of literature survey, background, characteristics, the necessity for enabling edge computing, challenges, use cases and needs of edge computing for 5G and IoT based applications, conclusion and followed by a future scope section respectively.

II. RELATED WORK

This section summarises a comparative study of the existing analysis of edge computing, along with a problem statement.

A. Literature Survey

H. Liu et al. [6] presented a hidden Markov model (HMM) that works on calculated method for a trust of the vehicle that improves the precision in malicious behaviour recognition, as well as a trust-based management approach, works on the alliance chain, helping to enhance the effectiveness to keep trust up-to-date and querying on the security premise. The model needs to simulate for findings that it is acceptable and practicable, as well as useful in terms of trust evaluation and management. I. Martinez et al. [7] established four steps for implementing a fog infrastructure, examined their limits, outstanding concerns, and differentiated current frameworks to build a fog infrastructure design for IoT application support. They looked at the key contributions and overhead of fog frameworks, as well as the capabilities and limits of simulation tools for assessing the proposed fog infrastructure. W. Z. Khan et al. [8] provided a detailed overview of current advances in Edge computing, focusing on the most important uses, also emphasized the necessity of Edge computing in real-world circumstances and reaction speed for many applications. The paper ended with a list of needs and a discussion of open research issues in Edge computing. J. A. Badarneh et al. [9] suggested a Software-Defined Edge Computing framework for data delivery, demanded by vehicular nodes at the network's edge, which includes the opportunity to blend MEC abilities base stations inside a network, enabling devices to share multiple facilities with help of its V2I user-interfaces more quickly, with improved quality, and with negligible WAN-Latency. They also developed a caching strategy dependent on vehicle level that would allow cars to speak with one another on the road to obtain more immediate facilities via the V2V user interface. It ensures large service availability with improving QoS. The suggested context is designed as an extended portion of the Mininet-WIFI system and tested through a series of examples. H. Jianhua et al. [10] suggested multiple layered analytics for a smart city that depended on fog computing. Fog node functional components are designed in detail. To offer QoS of

TABLE I. COMPARATIVE ANALYSIS OF CONTRIBUTIONS

Authors [Ref]	Journal/Conference & Publishing Year	Objectives	Simulation Tools	Limitations	Result
H. Liu et al. [6]	J. Parallel Distrib. Comput. (ScienceDirect), 2021	A blockchain-based trust evaluation paradigm for Vehicular networks	Hyperledger platform Hidden Markov model (HMM),	Training and testing of HMM to get better results	Trust valuation approach of a vehicle based on HMMs is proposed, causing an increase in the accuracy of malicious activity identification.
I. Martinez et al. [7]	IEEE IoT Journal, 2021	Fog computing proposed framework, Simulation tools, challenges, and prospects	--------------	Integrate the Fog concept with Blockchain	figured out how to construct a workable large-scale fog computing infrastructure that can serve the overall IoT ecosystem.
W. Z. Khan et al. [8]	Future Generation Computer Systems (Elsevier), 2019	A Study on Cloud and Edge computing approaches, applications, and MEC with their issues.	----------	Integration of Edge technique with SDN/NFV and simulators	Studied the concepts of Cloud and Edge computing in-depth with computation based on real-time applications, security, resource management, and data analytics.
J. A. Badarneh et al. [9]	Computers and Electrical Engineering (ScienceDirect), 2018	Software-Defined Edge Computing setup aiming package delivery services between linked vehicular nodes in VANET	Mininet-WiFi	The experiment is not checked for security and storage	mobile edge computing permits vehicles communication services with improved QoS and negligible latency of WAN.
H. Jianhua et al. [10]	IEEE IoT Journal, 2018	To avoid the risks of specialized computer infrastructure and delayed response of cloud computing	Raspberry Pi	Evaluated with limited parameters of fog	QoS used for extensive data analytics applications over multiple layered fog, and alert task admission controller, offloading, and resource allocation algorithms were conceived and built.
Z. Xu et al. [11]	Proceedings of the 12th ACM International Conference on Distributed and Event-based Systems, 2018	A multi-tier paradigm for fog computing applications for smart towns.	SUMO, MaxiNet	Actual data handling in term of space storage is larger	a smart video surveillance system that allows for real-time tracking of all cars.
J. Ni et al. [12]	IEEE Communications Surveys & Tutorials, 2018	Overview on Fog computing, fog computing based IoT usages, difficulties, and research areas in fog computing.	------------	Fog computing protocols and services	Studied the important responsibilities of fog nodes, properties of fog computing, fog-related IoT usages, security and privacy risks, the security and outlined the research challenges.
M. Mukherjee et al. [13]	IEEE Communications Surveys & Tutorials, 2018	Overview of the Fog computing frameworks, the QoS model, service allocation concerns, applications, open research challenges, and future perspectives	------------	Privacy, and Security concerns in fog computing	cutting-edge network applications, key research areas for designing these networks, and addresses fog computing research, open issues, and research trends.
B. Tang et al. [14]	IEEE Xplore, 2017	A hierarchy for decentralized fog computing framework to integrate a huge component of infrastructure, services, and upcoming smart city security.	Hidden Markov model (HMM),	Poor mobility and QoS management.	A prototype had built to estimate the performance for an event of recognition of 12 dissimilar events, and the outcome shows the feasibility of the system will be implemented area-wise in near future.
X. Hou et al. [15]	IEEE Transactions on Vehicular Technology, 2016	a framework for Wireless-Optical in edge computing, and broadband access system supportive to smart towns	-----------	Poor scalability	VFC framework is a system that uses automobiles as infrastructure and makes the most of available vehicular resources.
W. Shi et al. [16]	IEEE IoT Journal, 2016	A review on edge computing, its benefits, case studies, issues, and future perspectives	-----------	Integrating Edge computing framework with other frameworks	established the concept of edge computing, numerous case studies spanning from cloud offloading to smart city, issues, and prospects.

huge data analysis facilities over multiple layers of fogs, and aware job admission control, offloading, and resource allocation algorithms were conceived and built. Z. Xu et al. [11] presented a new approach called forward and backward propagation, which decreases operation delay and communication overhead. They created STTR, a smart surveillance system that embodies these concepts. We build a toolkit based on SUMO to simulate camera detections from network flow and use MaxiNet to simulate fog computing architecture on Microsoft Azure for testing. J. Ni et al. [12] performed a thorough examination of fog computing security for IoT-related features, architecture, and properties of fog computing. They had also explored the many functions related to fog nodes, such as present services, temporary storage, data distribution, and decentralized computing, and looked at various interesting IoT usages based on their fog node roles. They had also explored the security and privacy problems associated with fog computing, including some security attacks and privacy risks. M. Mukherjee et al. [13] provide an overview of several topologies as well as significant research problems. Fog computing, as a next-generation computing paradigm, may be used in several applications. The study outlines the few research difficulties and elementary proposed principles in fog computing, intending to provide fog computing basics and network applications that may help us in understanding the prior research findings and research directions to handle various issues in the future. B. Tang et al. [14] proposed a hierarchy for Fog Computing framework for massive information processing in smart towns. They improved the "smartness" of municipal buildings by implementing sophisticated machine learning algorithms among all levels in the system, and a prototype system for smart pipeline observing was designed to examine the architecture's efficiency. The hidden Markov model, a sequence-based learning algorithm, was effectively employed to notice hazardous events and monitor the security of the pipeline. X. Hou et al. [15] offered a review of cars as sharing and computation infrastructures, that is a novel paradigm named VFC. With the growing number of vehicular terminals, all four possibilities of using moving and stationary cars as communication and computing infrastructures have been addressed. VFC has the potential to significantly increase communication and compute capability, according to their research. Better connection and more possibilities for relaying packets may be obtained with the use of VFC, resulting in more reliable communication with a larger capacity. VFC also outperforms traditional systems in terms of computing performance by maximizing the currently unused computational resources of individual cars. W. Shi et al. [16] proposed the description of edge computing, numerous case studies spanning offloading to smart towns, and interactive edge to implement the notion of edge computing. Finally, they had given many edge computing issues and potential.

B. Problem Statement

A new technology edge computing came into existence to overcome the issues found in cloud computing as privacy, security threats, and latency along with several new challenges in adopting this technology, and edge devices. We had discussed the security issues and challenges to make it easily under stable is the novelty of this paper.

III. Background

This portion explains the basic ideas of cloud and edge computing, and how they vary from edge computing, and also covers the fundamentals of Cloudlet, Fog, and MEC. The purpose of this part is to provide the reader with a good understanding of the study topic.

A. Cloud Computing

Cloud computing is a computing framework that delivers on-request facilities to target users through a pooling of computational services consisting of storing facilities, computing facilities, and some other services [17]. The three most significant cloud-based services are infrastructure as a service (IAAS), platform as a service (PAAS), and software as a service (SAAS). Each company provides on-demand request computing resources such as packets analysis and storage [18]. Moreover, the aforementioned activities, cloud technology emphasizes the differential evolution of common infrastructure among multiple users.

B. Edge Computing

Edge computing directs measure an enterprise's ability, applications, and facilities away from the cloud data servers and toward the network's edges. Service providers and app developers can employ edge servers to avail users of solutions that are very close to customers. Huge bandwidth, lower latency, and actual access to packet headers that may have been utilized in several applications describe edge computing [19]. The internet provider may avail the radio access network (RAN) to Edge customers by giving them access to newer apps and online services. Companies and end customers may also use edge computing to access several additional services [20].

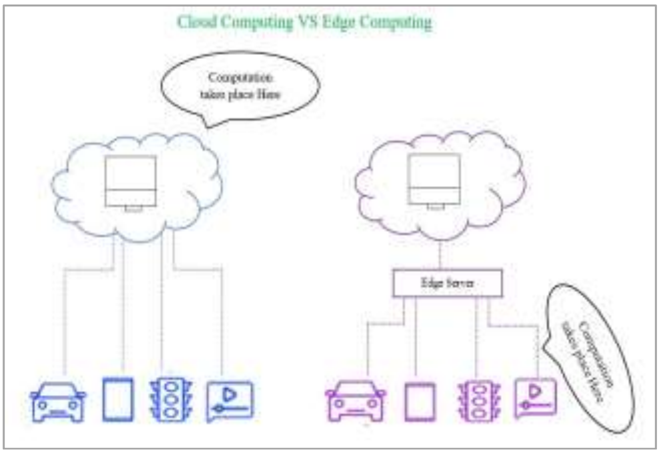

Fig. 1. Cloud Computing Vs Edge Computing

TABLE II: Comparison of Cloud and edge computing

Cloud Computing	Edge Computing
On-request transfer of computing facilities includes servers, storing elements, and software over the network.	It refers to the deployment of data-handling or other network operations away from cloud to edge of the network.
Data centers are placed over the world. Thus, Location coverage is global.	It brings computation nearer to the network edge where the data is gathered at the source.
The average response time is in minutes or days.	The average response time is in milliseconds.
The cloud requires a huge amount of bandwidth.	The amount of bandwidth is significantly reduced.

IV. EDGE COMPUTING CHARACTERISTICS

Edge computing has several unique properties that make it stand out to cloud computing:

A. Dense Geographical Distribution

With edge computing techniques, Cloud services become closer to the consumers by the installation of numerous computing systems on edge networks, [5, 21]. In the succeeding ways, the infrastructure's dense geographical spread aids:

- Rather than traversing the whole WAN, network managers can enable location-based mobility services;
- Big data analysis could be carried out with better speed and with more precision;
- On a broad scale, Edge systems provide real-time analytics. Sensor networks for environmental monitoring and pipeline monitoring are two examples

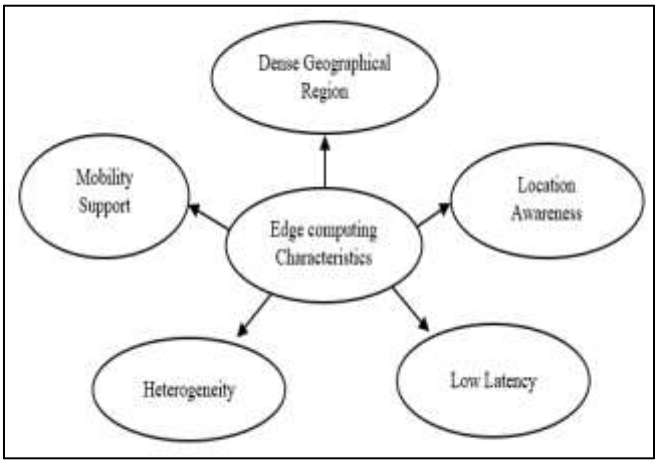

Fig. 2. Characteristics of Edge Computing

B. Location Awareness

The very important feature of the edge computing framework is too aware of the location feature permits mobile users to get facilities from the server of the edge system that is closest to users' current location. To locate electronic appliances, customers have a variety of applications and technologies like GPS, or wireless access points. Numerous edge-based applications like vehicular safety systems and disaster management work on edge computing can benefit from this location awareness.

C. Low Latency

Due to the edge computing concept, handling the resources, services, and lowering latency is possible in-service access. Edge computing reduced latency allows users to run resources as intensive and delay-sensitive apps on resource-rich Edge devices i.e., routers, access points, base stations, or dedicated servers.

D. Heterogeneity

Edge computing frameworks employ a variety of frameworks, designs, processing, and communicating technologies, which is referred to as heterogeneity (destinated systems, edge networks, and servers). The major sources of heterogeneity at last system heterogeneity include software, hardware, and technological variances. The term "network heterogeneity" shows a wide range of communication technologies, influencing the possibilities of using edge services.

E. Mobility Support

Edge computing also enables a mobile system, like a Locator ID Separation Protocol (LISP), used in securing a connection directly with mobile systems, with increasing of mobile devices. The LISP protocol creates a decentralized directory framework by decoupling the location identification of host recognition. The basic idea that allows mobility support in edge computing is to erase the identity of the host from their location identity directory.

V. NECESSITIES FOR USING EDGE COMPUTING

To use Edge computing systems, this section emphasizes critical conditions that must be satisfied and each criterion must be thoroughly covered. The criteria for enabling edge computing frameworks are described in Figure 3.

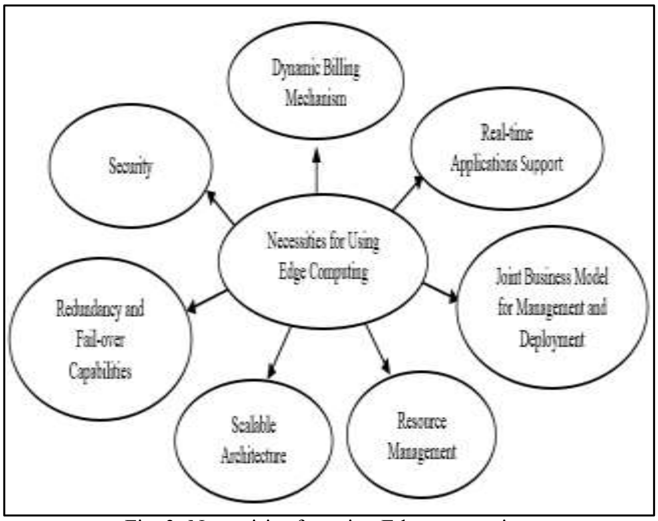

Fig. 3. Necessities for using Edge computing

A. Dynamic Billing Mechanism

User mobility combined with multi-vendor systems creates a difficult user tariff mechanism. If a mobile user is supported with their roaming Edge facilities, a dynamic billing method is necessary between multiple operators of Edge computing frameworks. The prime motive of dynamic billing is the count of different mobile costumers who may demand particular cloud resources with distinct networking criteria like bandwidth necessity and allocation for transmitting data, latency, and delay through Edge-based systems. Resource accessibility, the occurrence of resource utilization, and the timeframe of resource utilization are three factors to take into consideration while designing the dynamic billing mechanism.

B. Real-time Applications Support

Edge computing is designed to deliver a variety of services, especially for real-time applications, and may play a critical role in increasing the learning procedure in research education through e-learning and gamification, for example. As a result, any pre-existing edge dependence network must be capable of handling real-time applications. Gamification is the newest trend in education for improving the learning process, and it is predicted to supplant traditional learning methods [22]. Edge computing is a possible approach for a collection of colleges to decrease costs and computing resources. However, supporting gamification applications need Edge node flexibility, which may alter in response to demand. To make the learning experience more engaging, neighbor edge points should have been able to select powerful and unique edge nodes which may commit their resources to the cluster of institutions, for the real-time oriented game-based units, this strategy reduces latency.

C. Joint Business Model for Management and Deployment

Different agencies own edge computing platforms, which operate under various business models. Edge devices, meanwhile, are designed by diverse manufacturers and have their interfaces, affecting service performance and incurring expensive costs. To address the aforementioned difficulties, a combined governance and distribution business plan is needed to assure high performance while also providing low-cost services to end customers.

D. Resource Management

The service providers had larger service demands, meets the demand by sharing the available resources, and can improve their revenue. Rising offloading and optimizing the changeable computational with system resource sharing, may increase the result from user service demands [14]. A key requirement is shared resource managing for servicing a huge customer across the heterogeneous edge computing platform with different processor, memory, and system capacities. Joint resource management methods may offer minimal handling, communication, power requirements, and well-adjusted delay, which are required.

E. Scalable Architecture

The number of edge devices has expanded too fast improvements in IoT, as has the request for Edge-dependent applications and resources. A scalable Edge computing framework is essential for meeting this performance goal since it may reduce costs. Various characteristics such as virtualizing the resource, trust gained by blockchain technology, and automatic arrangement of Edge and IoT may be used to develop a scalable framework in the Edge computing platform. In the IoT, resource virtualization refers to sharing of IoT resources among several applications.

F. Security

Consumers are being influenced by security concerns raised with a great diversity of edge computing when it comes to adopting these new edge computing devices. The wireless network and physical application have been used by various users to enhance the danger of intrusion, illegal access, and security threats by using the Edge computing frameworks for heavy processing [23]. Authorizing/trusted access control necessitates the use of a secure authentication mechanism for apps and mobile systems. The general security issues are availability, authenticity, secrecy, and data integrity should be met earlier to edge computing placement, but not at the expense of the performance of applications consecutions on these systems.

VI. CHALLENGES

There are a few significant issues that need to be addressed are listed below:

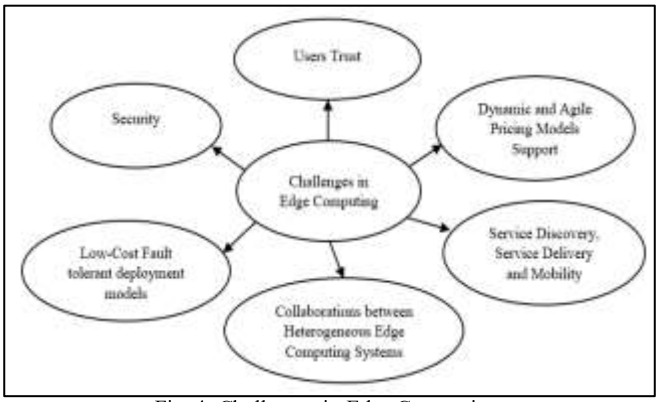

Fig. 4. Challenges in Edge Computing

TABLE III. Challenges of Edge Computing

Challenges	Author's Comment
User's Trust	Consumer trust is strongly linked to the security and privacy of technologies. A newly suggested consumer trust model [24] outlines the important variables (such as security and privacy needs) that influence customer trust in IoT, which may be used in Edge-computing systems.
Dynamic costing of the Models	It is very tough to come up with the optimal cost of models for edge computing frameworks that benefit both service providers and clients. Still, the "pay-as-you-go" pricing model for cloud services [25] may be utilized to construct dynamic costing models for Edge computing frameworks.
Service Discovery, Delivery, and Movement	Seamless service delivery with mobility is also a difficult challenge since mobility has a significant effect on numerous network characteristics, resulting in application performance deterioration [26].
Associations among Heterogeneous Edge Computing frameworks	Edge computing network's heterogeneous design permits edge systems to use the services via numerous wireless technologies and makes associations across these multiple vendor frameworks very tough [27].
Low-Cost Fault-tolerant designs	providing low-cost fault tolerating designs in edge computing is difficult. So, it needs a distant backup server with higher bandwidth and more hardware, both of these are

	expensive.
Security	Edge computing has several issues like recognition, authentication, access control framework, intrusion detection, privacy, and trust management. The inherent qualities of blockchain technology, such as tamper-proofing, redundancy, and self-healing [28], might assist satisfy some security objectives while also posing new issues.

VII. USE CASES AND NEEDS OF EDGE COMPUTING FOR 5G AND IOT BASED APPLICATIONS

The use cases of edge computing are provided below:

A) Autonomous Vehicles:

Edge computing will possibly eliminate the requirement of drivers in all vehicles except the front one, due to the interaction of vehicles with the other with ultra-lower latency.

B) Predictive Maintenance:

Edge computing improves data processing, analysis, and storage by moving the processing and storage nearer to the machine. This allows IoT sensors to evaluate system conditions and do genuine analysis with minimal latencies.

C) In-hospital patient monitoring:

To preserve privacy, an edge on the hospital site might perform actions remotely. Edge also enables individuals to get real-time warnings about unexpected patient patterns or behaviors, as well as the generation of 360-degree patient platforms for complete visibility.

Needs of Edge Computing for 5G and IoT based applications are listed below:

A) To reach the 1ms latency standards established by 5G, edge computing would be required.

B) 5G increases bandwidth, allowing it to manage additional smart connected devices which can react in milliseconds.

C) Edge computing collects and analyzes data. At the network's edge, IoT data reduces network intrusion and transmission costs.

D) ADAS has a strong market presence because to edge and 5G technologies. Additional sensor data should be examined with lesser errors and 10 times quicker than with 4G by combining built-in car sensors with powerful edge computing systems and 5G superspeed.

E) Where security is critical, edge computing extends cloud computing services to remote sites and offers local processing capabilities and storing facilities.

CONCLUSION

In this paper, Overview, characteristics, necessities for using edge computing, and challenges had discussed. We had focused on a deep survey of edge computing. This study provides a thorough reference to edge computing by introducing them from a research viewpoint.

FUTURE SCOPE

In the upcoming intelligent society, in terms of applications, the potential utility of edge computing is unpredictable. As a consequence, edge computing deserves future investigation and study, and we hope to see the use of blockchain to reduce these issues, threads, and challenges.

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