Survey on Edge Computing and Its' Usage in Various Fields

Dhriti Sundar Saha, Ankit Manna, Prasun Kr Mondal, Arindrajit Pal, Subhankar Roy

***Abstract*-- Edge computing is one of the latest blooming technologies in recent years. There are alot of real-life applications being processed through this technology. The problems caused by centralized cloud computing have given way to a possible solution by edge computing. In this paper, we made a survey on potential development of edge computing which include decrease in latency, increase of bandwidth consumption, improved privacy and security. This research also looks at the limitations of edge computing, including the necessity for effective data management techniques and the availability of constrained computing resources. This article also gives us overview of the architecture, applications, and framework of edge computing. To overcome the difficulties and fully reap the rewards of this technology, this study emphasizes the need for ongoing research and development in the area of edge computing.**

***Index Terms*-- Bandwidth, Cloud computing, Edge computing, Latency, Real-time analysis, Round-trip time**

I. Introduction

Edge computing [1] is a distributed information technology architecture that replaces computing resources from clouds and data centers as close to the originating center as possible. The focus of edge computing is to minimize the latency, bandwidth of consumption, and round trip time. Edge computing, in simple terms, is the practice of shifting fewer processes from the cloud to local locations, such as a user's PC, an IoT device, or an edge server[2]. When computation is shifted to the edge of the network, the amount of distance communication needed between a client and server decreases, resulting in a shorter round trip time when requesting data and a greater level of job efficiency.

II. Features Of Edge Computing

A. Privacy and security

The scattered nature of this paradigm leads to a change in the security concepts for cloud computing. With edge computing, data may transit between numerous distant nodes linked by the Internet, necessitating specialized encryption methods separate from the cloud. It is also vital to move away from top-down, centralized infrastructure and towards a decentralized trust model. On the other hand, it is possible to minimize the transfer of sensitive data to the cloud by storing and processing data locally, boosting privacy[2]. The user must disclose their location at the specified time to access the services. However, because Land Customs Stations can use to acquire this sensitive personal data. Furthermore, many of the programs we use every day gather and maintain geo-location data, often without our knowledge. Decision-making assigning tasks to the most appropriate resources to boost performance and make it more scalable.

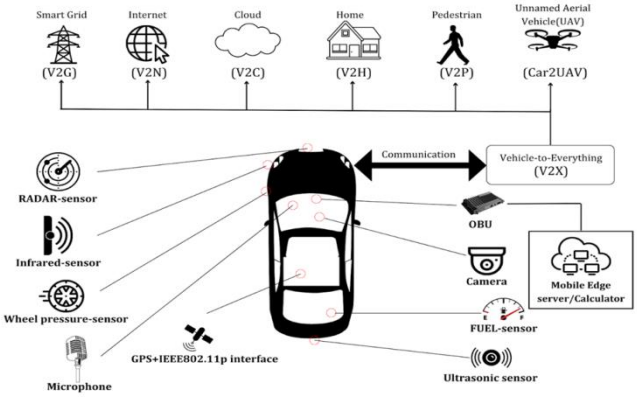

Fig. 1. V2X technology for various communication types

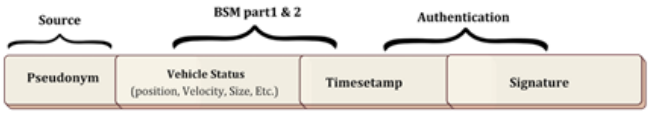

Fig: 2 safety message format.

B. Scalability

With a distributed network,many scalability problems [3]with a dispersed network need to be overcome. It must first consider the heterogeneity of the devices, which have varying performance and energy limits, as well as the highly dynamic environment and the reliability of the connections, in contrast to the more resilient architecture of cloud data centers. Security restrictions could make node communications take longer, which might prevent expansion. By allocating the least amount of edge resources to each task that is offloaded, the present scheduling strategy increases the effective use of edge resources while growing the edge server. Tools for monitoring [5-8] and utility brokerage services incorporate a variety of strategies to make this possible in both tightly and loosely constrained contexts.

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C. Dependability

The ability of a system to offer services that can fundamentally be trusted is known as system dependability. In order to carry out safety with critical operations, the system can also stop failures that are more frequent or severe, as well as outages that last longer than what is acceptable to the user [3]. To maintain service, failover management is essential. A service must be available to users without any disruptions of any kind. Furthermore, edge computing systems must provide means of recovering from failures and alerting users to issues. Each device must maintain the distributed system's overall network architecture for error detection and recoveryUsing real-time monitoring [9]. The issue of collision accidents involving cranes and stationary objects was addressed by Ren et al. [10], who worked to minimize these incidents. A real-time anti-collision system that issues collision warnings and enacts suitable safety measures is their suggested solution. The authors of [11] and [12] proposed different methods for improving safety at construction sites by avoiding collisions between equipment and pedestrians as well. Radio-Frequency Identification (RFID) tags, an interface, a communication protocol, and alerting devices support its solution. Jegen-Perrin et al. [13] proposed a technique for calculating the working area and utilizing RFID sensors to prevent probable collision situations. It suggests using a camera and screen system along with a means to increase driver's visibility on real-time video monitoring to prevent plant-pedestrian accidents. The requirements for all these applications are time-sensitive.

D. Processing Speed

Edge computing can improve an application's responsiveness and throughput by providing analytical processing capabilities close to the end users and so reducing round trip time. A properly built edge platform would perform far better than a traditional cloud-based solution. Edge computing is a far more practical choice than cloud computing for applications that demand immediate responses.

Edge computing allows for such distribution of application components over a range of computing resources [29], including network edge nodes and cloud data centres. The positioning of this application has a big impact on crucial metrics like latency and resource use [14-15]. As a result, application location is a major optimization issue. Continuous optimization of application placement is crucial. The most recent approaches for dynamically re-optimizing edge application placement [16] often rely on a centralized entity to gather data from the entire infrastructure and make decisions based on it.

E. User Efficiency

Complex analytical tools and Artificial Intelligence tools can work at the edge of the system since the analytical tools are close to the users. This edge positioning benefits the system and increases operational effectiveness. The following illustration shows how efficiency gains are produced when edge computing is used and gives some of the solutions [17] for edge-oriented device computing. We can understand the operational effectiveness in three major parts

F. Solutions for Conventional Intelligent Access Control Systems

The existing access control system, which usually uses digital IC cards, fingerprint recognition, password recognition, as well as other tools, has several faults, which include minimum security, hard maintenance, network bottlenecks, and inadequate integration. Intelligent access control is a crucial part of meeting the demands of security automation in intelligent buildings. A system that verifies the mobile smart interface and access control scheme using a quasi-sequence encryption approach was created in 2014 by a team led by Prof. Y Su[18] This system allows the mobile smart interface to control the access control system. Unfortunately, given the technological limitations of the GSM network itself, particularly in the present day, a workable solution for huge data transport is difficult to develop.Internet of Vehicles(IoV) can benefit from the integration of blockchain and Edge Computing's collaborative management of communications and computing resources [19-22], data exchange and management for automated driving [23-25], and collaboration identity verification during consensus procedure. Effective vehicle communications include [26-32], etc. IBEC is primarily used in Smart Grid to create the price and framework for commodities trading [33-36], and to ensure trade security [37-39]. The Industrial Internet of Things (IIoT), smart healthcare, edge intelligence, and artificial intelligence are further IoT situations that the IBEC can help. [40-45], and (AI) supply chain[45-50].

G. Existing Edge-Based Solutions

A strong foundation for creating intelligent cities is provided by numerous sensors and widespread wireless connections, especially as the Internet of Things age approaches and wireless connectivity proliferates. The cloud computing model of centralized processing and urban uplink bandwidth will be severely challenged by the massive volume of data generated by smart cities[51]. The Internet of Things (IoT) amount of data will be processed at the network's edge. More than 40 zeta bytes of data are produced globally as a whole. As a result, smart cities also adopt the edge-oriented devices computing methodUnits

H. Low-Cost Computing

In contrast to all the prior approaches, this method gives us an idea about a low-cost edge computing framework[49] for universal environments. Cell phones commonly accompany the operated object in modern culture, thus for this system, we chose to build the APP on smartphones and use them as the main servers of the edge service system. The purpose for and study into installing AI algorithms at the network's edge are the main topics of Reference [52]. Authors of [53] provided a survey of the most recent ML developments in mobile EC, which also cover the evolution of the 5G network, mobility modeling, power efficiency and security. Research work [54] examines the use of Deep Learning in EC and focuses on

using DL to support the growth of applications[55], such as smart entertainment, smart transportation, smart cities, and smart industrial.

III. EDGE COMPUTING WITH ARTIFICIAL INTELLIGENCE

Recent studies on merging Artificial Intelligence and Edge Computing can be loosely separated into two areas, which perfectly demonstrate their mutual benefits.New evaluations that are related to the fields of edge computing and AI-based research have been published. The focus of the Reference [56-57] is the research towards the installation of AI algorithms at the network edge. A review of the most recent Machine Learning advancements in mobile Edge Computing can be found in Reference [58-59], which also discusses how the 5G network has evolved, mobility modeling, security, and power efficiency. Survey work [59-60] examines deep learning usage in edge computing and its focus to use Deep Learning to support the development of edge applications, such as multimedia having more intelligence, intelligent transportation, intelligent cities, and intelligent industrial. Reference [55] in-depth described how to create an architecture for communication, computational capacity, and the consumption huge energy are the limitations to obtain the optimum performance of deep learning training and reasoning. However, past assessments rarely address the favorable interaction among artificial intelligence and edge computing (particularly classical Ml, DL). Various ML algorithms, like RL and DRL, are also considered in addition to the Deep Learning approaches covered in References [54,55,59,61].

IV. APPLICATIONS OF EDGE COMPUTING

A wide range of products, services, and applications can incorporate edge computing. Many options include:

A. Monitoring security systems

Running code in local networks is much faster than running them in cloud services. The distributed environment of Edge computing also brings new security problems, such as distributed denial of service (DDoS) attacks and jamming attacks that cause illegal distribution of distributed system resources [62-63].

B. Smart Manufacturing

In smart vehicles, the reaction time is very important. Faster reaction time makes better vehicles and reduces accidental probabilities. Energy usage in Internet of Vehicles(IoV) is a significant barrier to its progress[70]. The studies described above, however, do not take into account energy usage while choosing the best offloading strategies[72-73]. To reduce energy usage in Internet of vehicles, Yang et al. [71] proposed a hybrid optimization problem involving power control, user association, and resource allocation.

C. Advanced medical monitoring system

In the case of medical monitoring devices [74] the decisions must be taken very immediately without waiting to hear from the cloud. The code is executed on a content delivery network edge network to efficiently deliver content to users.A system for diagnosing and treating vocal disorders is proposed by Muhammad et al. [75-76]. Before being transferred to the cloud, thesystem's sound data is first analyzed by edge devices. The system is responsible for setting up the CNN model on the edge server. This allows the edge side to detect and classify voice disorders. This solution effectively relieves the strain on network capacity and has lower latency than the way without EC architecture in Reference [77]. The treatment strategy is still determined by a human specialist who receives the diagnosis via this system.

D. 5G-and-beyond networks

We've seen the accelerated development in the field of 5G technology, the increase in computing power of smartphones, as well as the widespread adoption of various smart objects by users in recent years. Mobile edge caching, that also lessens traffic and delays in content delivery, is the practice of caching on mobile edge servers [82]. Let's say that numerous users request access to content at various times. At that time, the continuous broadcast of this well-liked content results in a significant volume of network traffic[83-86].

V. MARKET STUDY AND TRENDS ANALYSIS

Due to the growing adoption of loT sensors and components across a variety of end-user applications, edge computing hardware maintained a 50% market share in Canada in 2021. Edge computing gear is used to lessen the load on cloud and data centers as a result of the volume of data being generated.In 2021, major enterprises held a market share of 80% in China, [87]mostly as a result of the increasing adoption of public cloud computing services by large enterprises.

The valuation is substantially bigger and other research firms also forecast significant increase.From 2022 to 2030, the global edge computing industry is predicted to grow at a CAGR of 38.9%, according to Grand View Research[88] like,

- According to Precedence Research, the global market for edge computing would top $116.5 billion by 2030 and reach $51.2 billion in 2023.
- According to the "2022 Global Edge Computing Market report," the market will reach $90 billion by 2030, in part due to increased edge AI capability document.

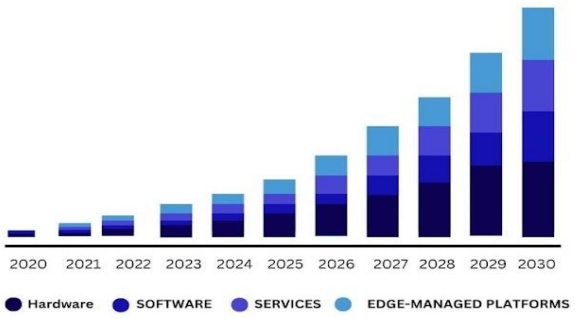

Fig. 3. Edge Computing Market By Grand View Research

VI. CONCLUSION

In summary, this survey article has offered a thorough summary of the advantages and disadvantages of edge computing, as well as recent research in the area. This study has illustrated the potential for this technology to transform computing and enhance a wide range of applications, from IoT to AI, by analyzing the growth and concept of edge computing. As a result, this study will be a useful resource for academics, engineers, and practitioners who want to monitor the development of edge computing and take advantage of its potential to solve practical problems. Others can find a wide range of options and keep exploring the limits of edge computing with the knowledge and insights supplied by this survey.

VII. REFERENCES

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VIII. BIOGRAPHIES

Dhriti Sundar Saha (M'1998) Born on July 17, 1998, Dhriti Sundar Saha completed his 10th grade from KatwaKashiram Das Institution in 2013 and 12th grade from the same institution in 2015, under the WBBSE and WBCHSE boards, respectively. After graduating with a Bachelor's degree in Science from Katwa College, Burdwan University, in 2020, he is currently pursuing B.Tech in Computer Science at the Academy of Technology, expected to finish in 2024. With a keen interest in artificial intelligence, data science, and cyber security, Dhriti actively engages in projects and authored student papers. His last Paper was " A Survey On Chronological Evolution Of Consensus Protocols InBlockchain, ISBN: 978-93-5717-892-1 " He holds a membership in the Students' Chapter CSE, embracing collaboration and continuous learning. He believes in the power of collaboration and continuous learning to excel in his chosen field. He is not an IEEE member.

Ankit Manna (M'2002) is a determined and accomplished individual, born in Chandernagore, West Bengal, India, in 2002. His passion for academics and personal growth became evident from a young age, paving the way for a promising educational journey. Ankit completed his Madhyamik (10th-grade) education under the WBBSE Board at Sri AurobindoVidyamandir, Chandernagore, in 2017, where he excelled in studies and displayed a well-rounded personality through active participation in extracurricular activities. He then pursued his Higher Secondary education (12th-grade) under the CBSE Board at Kalyani Central Model School, where he continued to excel academically and demonstrated leadership qualities.

In 2019, Ankit completed his Higher Secondary education and aspired to pursue a career in engineering. He joined the esteemed Academy of Technology to pursue a Bachelor of Technology (BTech) degree. During his college years, Ankit specialized in a specific branch of engineering, actively engaging in co-curricular and extracurricular activities, including participation in technical clubs, workshops, seminars, and hackathons to broaden his knowledge and practical skills.

Prasun Kr Mondal (M'2002) born on February 11, 2002, completed his 10th and 12th grades from Kalna Maharajas' High School in 2017 and 2019, respectively, under the WBBSE and WBCHSE boards. Currently pursuing a B.Tech in Computer Science at the Academy of Technology, with an expected graduation in 2024, he is actively involved in academic and research pursuits. Prasun has authored his first journal paper and is an engaged member of the IEI Students' Chapter Cse at the Academy of Technology. His research interests encompass cutting-edge technologies and their applications in various domains within computer science. Notably, his last paper titled "A Survey On Chronological Evolution Of Consensus Protocols InBlockchain, ISBN: 978-93-5717-892-1" showcases his expertise in the field. While not an IEEE member, Prasun actively participates in other professional societies relevant to his area of study.

Prof. Arindrajit Pal is a renowned researcher and academic in the field of Computer Science and Information Technology. He holds a Ph.D. (Tech) in Information Technology from the University of Calcutta, Kolkata. Prior to his doctoral studies, Prof. Pal obtained his M.Tech in Computer Science & Engineering from the University of Kalyani. Throughout his career, Prof. Arindrajit Pal has made significant contributions to the academic community. He has published seven international journal papers and presented his research in ten conference papers, showcasing his depth of knowledge and expertise. His research interests revolve around Mobile Ad-hoc Networks, Artificial Intelligence, and Machine Learning, where he has demonstrated a keen insight into emerging technologies and their practical applications.

Subhankar Roy is an accomplished academic and researcher with a strong background in the field of Computer Science and Engineering. He earned his B.Tech degree in Information Technology from the prestigious University of Calcutta, Kolkata, India, in the year 2010. Following his passion for further knowledge and expertise, Subhankar pursued an M.Tech degree in Computer Science and Engineering from the same institution, completing it in 2012. Driven by his desire to contribute to the advancement of knowledge, Subhankar is currently pursuing a Ph.D. from the University of Kalyani, Kalyani, India. His doctoral research is focused on cutting-edge topics within his field of interest. HIs research interests encompass two exciting and rapidly evolving areas: bioinformatics and blockchain. In bioinformatics, he explores the application of computational techniques to analyze and interpret biological data, which has significant implications in the medical and biological sciences. Simultaneously, his involvement in blockchain research reflects his curiosity about the potential of decentralized technologies to transform various industries, particularly in securing and managing digital transactions.