STM JOURNALS

Recent Trends in
Parallel Computing

ISSN: 2393-8749
Volume 12, Issue 1, 2025
January–April
DOI (Journal): 10.37591/RTPC

https://journals.stmjournals.com/rtpc

Review RTPC

Bringing Serverless Edge Computing to School Administration: Challenges and Opportunities

Avhaan Narang*

Abstract

Serverless edge computing is revolutionizing app development by creativity in infrastructure management. However, traditional cloud-based serverless architectures can suffer from latency and reliability issues when serving users at the edge of the network. While edge computing brings storage and computing closer to data sources, upgrading performance and reducing network issues. This paper explores the convergence of serverless edge computing, examining the opportunities and challenges that arise from this integration. Delving into the technical challenges, such as cold start optimization, security, and network connectivity, that must be addressed to effectively deploy serverless functions at the edge. Along with that, exploring the potential benefits, including reduced latency, better reliability, and enhanced privacy. By leveraging serverless functions at the edge, organizations can unlock new possibilities for real-time applications, internet of things (IoT) devices, and autonomous systems. As concluded, a proposal or a new methodology of calculating and distributing exam results of students to their respective parents using serverless edge computing is made. The article also outlines future research directions and best practices for building robust and efficient serverless edge applications.

Keywords: Serverless edge computing, serverless architecture, results distribution, cost-effective, function as a service, hybrid cloud

INTRODUCTION

Combining the advantages of edge computing's low latency and high performance with serverless computing's scalability and flexibility, serverless edge computing is a relatively new paradigm.

Serverless Computing

This cloud computing paradigm enables developers to create and execute applications without the necessity of server management. It eliminates the need for infrastructure management, allowing developers to concentrate on coding.

Edge Computing

This technology brings together data sources, computing power and better performance. It is especially beneficial for applications necessitating real-time data processing and analysis.

***Author for Correspondence**
Avhaan Narang
E-mail: avhaan26@gmail.com

Student, Department of Computer Science, The Daly College, Indore, Madhya Pradesh, India

Received Date: December 24, 2024
Accepted Date: January 08, 2025
Published Date: January 10, 2025

Citation: Avhaan Narang. Bringing Serverless Edge Computing to School Administration: Challenges and Opportunities. Recent Trends in Parallel Computing. 2025; 12(1): 1–12p.

In serverless edge computing, as there are serverless functions, implemented at the network's periphery, very near to the data source, this facilitates very fast processing and response times, as data does not require transmission to a centralized cloud data center.

Benefits are not confined to:

- *Minimized Latency:* By processing data nearer to the origin, serverless edge computing can substantially decrease latency, rendering it optimal for real-time applications.

- *Enhanced Efficiency:* Edge computing manages substantial data quantities and intricate computations with greater efficacy, resulting in enhanced performance.
- *Improved Scalability:* Serverless functions may automatically adjust to accommodate fluctuating workloads, guaranteeing optimal performance.
- *Enhanced Security:* Local data processing in serverless edge computing mitigates the danger of data breaches and security vulnerabilities.
- *Economical:* The pay-per-use concept of serverless computing can diminish operational expenses.

Use Cases

- *Internet of Things (IoT):* Processing data from IoT devices in real-time to enable timely insights and actions.
- *Autonomous Vehicles:* Enabling quick decision-making based on real-time sensor data.
- *Augmented Reality/Virtual Reality (AR/VR):* Providing immersive experiences with low latency.
- *Retail:* Optimizing inventory management and personalized customer experiences.
- *Healthcare:* Enabling remote patient monitoring and real-time data analysis.

Serverless edge computing remains a nascent technology, although it possesses the capacity to transform the development and deployment of applications. As technology advances, we anticipate the emergence of increasingly inventive and potent applications.

LITERATURE REVIEW

The review paper examines the potential of integrating serverless computing with edge computing to mitigate latency in IoT applications. Latency, or delay, poses a significant challenge for IoT applications requiring real-time reactions, such as autonomous vehicles and industrial automation.

Conventional cloud computing frequently results in elevated latency due to the necessity for data to traverse extensive distances to a centralized data center. Serverless edge computing mitigates this issue by relocating computation nearer to the data source, such as edge devices like smartphones or local servers.

This reduces the distance data has to travel, resulting in faster response times.

- *Efficient bandwidth use:* Processing data locally at the edge reduces the amount of data that needs to be sent to the cloud, saving bandwidth and potentially cost [1].
- *Better security and privacy:* Keeping data processing local minimizes the risk of sensitive information being exposed during transmission to the cloud.
- *Scalability and resource efficiency:* Serverless edge computing allows applications to scale easily and use resources efficiently, even when IoT networks have fluctuating workloads.

The paper also discusses different ways to implement serverless edge computing, including fog computing (a distributed computing architecture where resources are placed between the data source and the cloud) and adapting cloud-native technologies for the edge [2].

Serverless solutions, such as AWS (Amazon Web Services) Lambda, Azure Functions, or Google Cloud Functions, provide code execution without the necessity of server management.

Containerization technologies, including Docker and Kubernetes, facilitate the packaging and deployment of software within portable containers.

Edge computing solutions, such as AWS Greengrass, Azure IoT Edge, and Google Cloud IoT Edge, facilitate the management of applications at the edge.

IoT communication protocols: MQTT (message queuing telemetry transport) and CoAP (constrained application protocol) facilitate lightweight data sharing among devices.

ISSN: 2393-8749

The paper concludes that serverless edge computing is a promising approach for building low-latency IoT applications and points to further research directions in areas like security, resource management, and developing efficient deployment strategies. Also the framework of EduEdge App for School Result Communication to parents via edge computing is proposed and will be significant in the coming future [3].

Serverless Architecture

Serverless computing is a cloud computing approach in which the cloud provider autonomously oversees the allocation and provisioning of servers. Figure 1 clearly shows that developers concentrate exclusively on coding the application, without concern about the underlying infrastructure. Figure 1 also has numerous substantial points, though it enhances scalability by allocating resources solely as required, enabling programs to manage fluctuating loads effectively is also taken care of. Moreover, it augments developer productivity by eliminating the necessity for server management activities, like capacity planning and server maintenance. Developers can focus on rapidly constructing and deploying applications.

In a serverless architecture, programs are typically decomposed into microservices, each activated by distinct events or triggers. This event-driven design facilitates swift scaling, enabling functions to be conducted in reaction to specific events, hence enhancing user experience responsiveness. Furthermore, organizations can get advantages from a pay-as-you-go pricing approach, resulting in cost reductions by paying solely for the computing power utilized. Nonetheless, serverless computing has obstacles, such as possible latency concerns and vendor lock-in. Serverless computing is an effective architectural strategy that facilitates swift development and operational efficiency in cloud applications.

Edge Computing

Edge computing is a distributed computing model that positions computation and data storage closer to the point of demand. This approach enhances speed by reducing latency and enabling faster data processing. The growth of IoT devices is elevating the importance of edge computing, which facilitates immediate processing at the device level rather than relying on centralized cloud servers. Figure 2 explains that local data processing significantly diminishes application latency in response to real-time events, which is crucial for contexts such as autonomous vehicles, industrial automation, and smart cities.

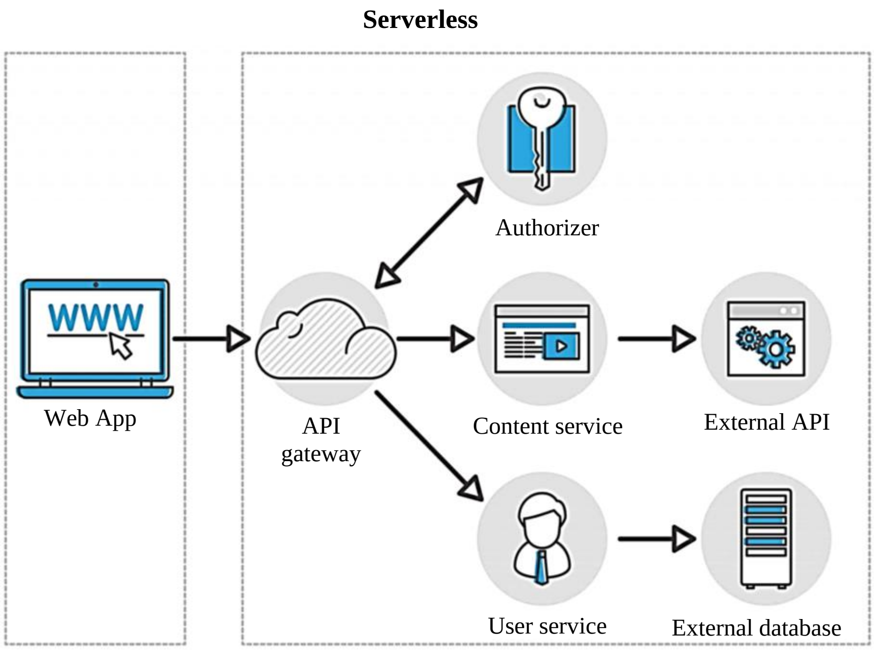

Figure 1. Serverless architecture [4].

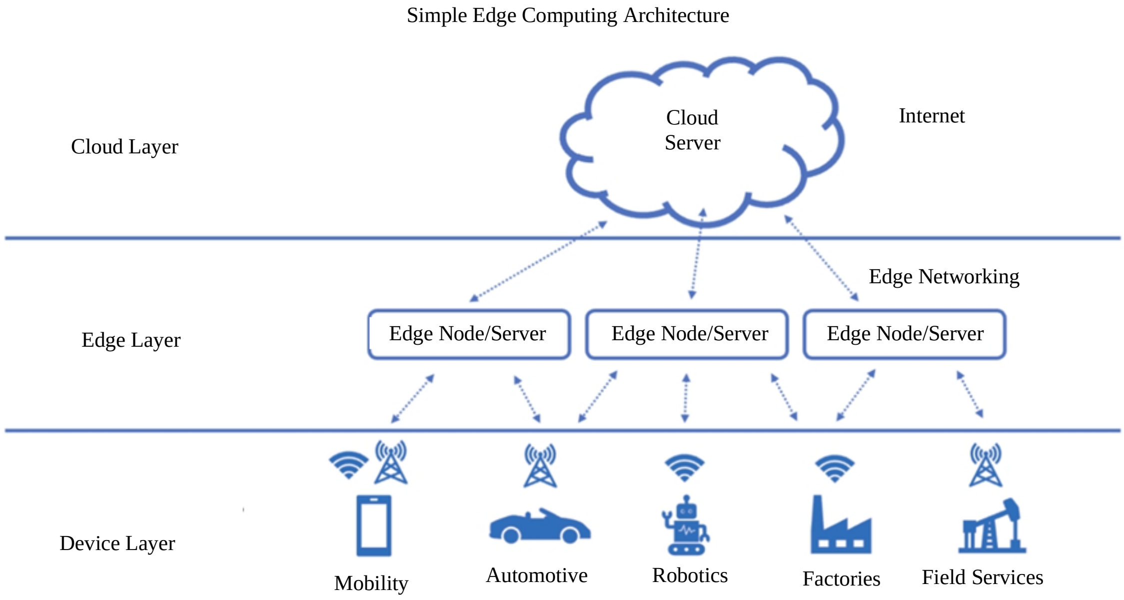

Figure 2. Edge computing [5].

Furthermore, this diminishes the need and volume of data requiring transmission to centralized data centers, hence mitigating bandwidth issues and reducing expenses related to data transfer. It improves security and privacy by keeping sensitive data at its source rather than transmitting it over potentially vulnerable networks.

Nonetheless, the implementation of edge computing may pose complications regarding management and orchestration, particularly in environments with numerous devices. Edge computing enhances conventional cloud architectures by facilitating prompt and effective data management in geographically dispersed settings.

Serverless Edge Computing

The amalgamation of serverless computing and edge computing has the potential to revolutionize application development and deployment across various industries. By merging these two concepts, businesses may leverage the scalability and reduced administrative burdens of serverless architecture while benefiting from the low-latency processing capabilities of edge computing. This connectivity is particularly beneficial for IoT applications necessitating real-time data processing. Edge devices can perform initial data processing tasks and thereafter invoke serverless services to execute more complex computations or launch additional workflows in the cloud [6].

This hybrid methodology enables developers to sustain a highly responsive user experience while optimizing resource use. Serverless frameworks placed at the edge enable applications to automatically scale according to demand without manual intervention. Figure 3 architecture explains that operating expenses might be reduced as organizations are charged solely for the computational resources utilized during execution. Nonetheless, issues such data consistency, security within distributed architectures, and the management of numerous environments must be resolved [7].

Overall, Figure 3 explains synergy between serverless and edge computing offers an innovative pathway towards building resilient, efficient, and scalable applications that are responsive to users' needs.

The IoT is revolutionizing various sectors, including education. While the integration of IoT in schools offers numerous benefits, it also presents significant challenges. Below are some of the key challenges associated with implementing IoT in educational settings.

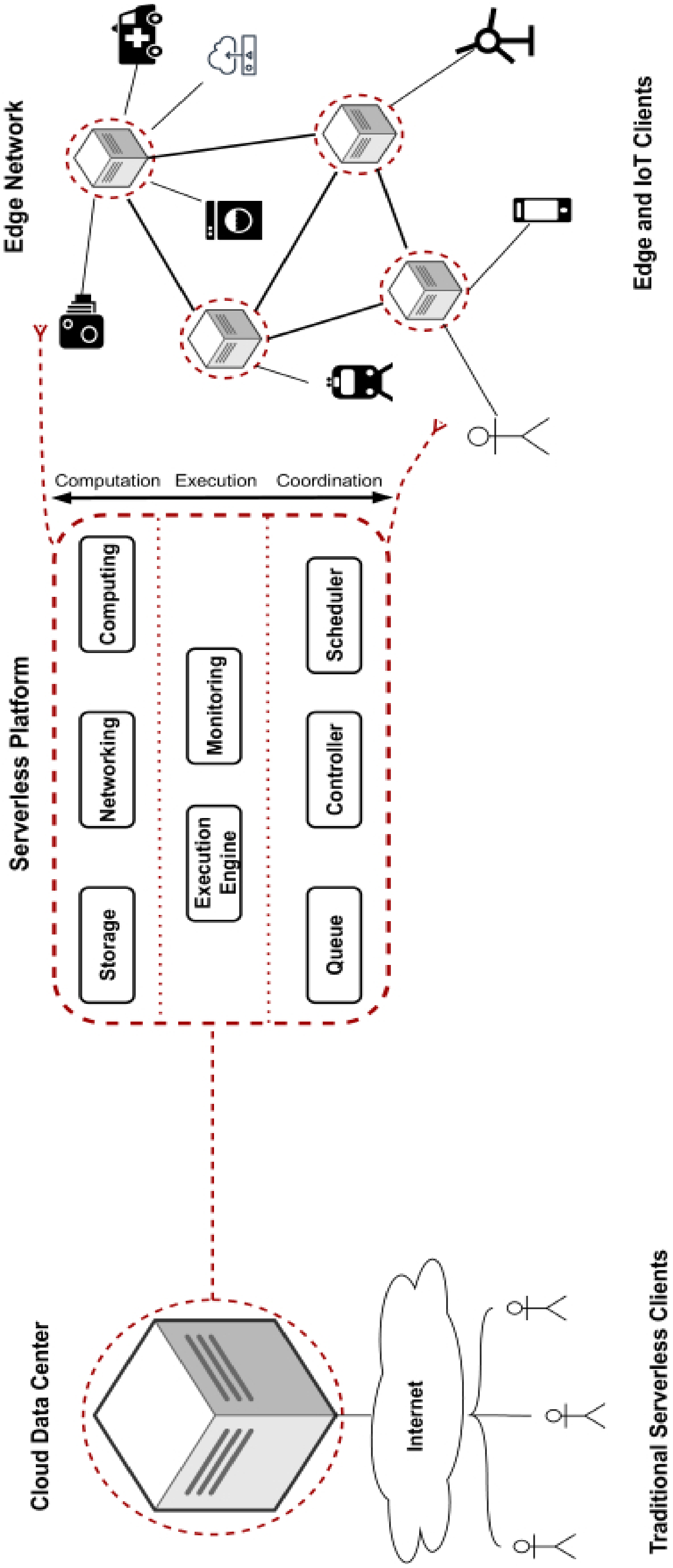

Figure 3. Serverless edge computing architecture [8].

Infrastructure Limitations

One of the most pressing challenges in IoT deployment in schools is the lack of adequate infrastructure. Many schools, particularly in underfunded districts, struggle with outdated physical facilities and insufficient technological resources [9]. This can involve:

- *Network Connectivity:* Reliable internet access is essential for IoT devices to function effectively. Many schools may not have robust Wi-Fi networks or high-speed internet, limiting the potential for IoT applications.
- *Device Compatibility:* Different devices may require varied infrastructures, and ensuring all devices can operate cohesively can be challenging. Schools may need to invest in new hardware or software, which can strain budgets.

Cost Constraints

Implementing IoT technology comes with significant upfront costs. Schools must consider both initial investments and ongoing expenses, including:

- *Device Procurement:* High-quality sensors, smart boards, and other tools can be expensive. Schools need to assess which devices provide the best value and functionality.
- *Maintenance and Upgrades:* Continuous updates and maintenance of IoT systems require additional funding and resources, which may be challenging for public schools with limited budgets.

Data Security and Privacy

The collection and analysis of data generated by IoT devices raise significant concerns about security and privacy:

- *Data Breaches:* Schools must protect sensitive information related to students, teachers, and staff from cyber threats. With the increasing number of cyberattacks, ensuring data safety is paramount.
- *Compliance with Regulations:* Schools must navigate a landscape of privacy laws, such as the Family Educational Rights and Privacy Act (FERPA) in the United States, ensuring they comply with regulations governing student data [10].

Interoperability Issues

The IoT ecosystem comprises various devices from multiple manufacturers. Ensuring these devices work seamlessly together can be a challenge:

- *Standardization:* The lack of universal standards can lead to compatibility issues, where devices from different vendors fail to communicate effectively.
- *Vendor Lock-in:* Schools may find themselves dependent on specific vendors for solutions, limiting flexibility and potentially raising costs.

Training and Professional Development

The successful implementation of IoT in schools heavily depends on the proficiency of educators and staff:

- *Skill Gaps:* Many teachers may lack the necessary skills and knowledge to effectively use IoT tools. Professional development programs are essential to bridge this gap.
- *Ongoing Support:* Even after initial training, continuous support is crucial as educators encounter new devices and software. Schools must allocate resources for ongoing education [11].

Resistance to Change

Cultural and organizational resistance can impede the adoption of IoT technologies in schools:

- *Fear of the Unknown:* Some educators may be hesitant to embrace new technologies due to perceived complexity or fear of failure.
- *Traditional Teaching Methods:* Many educators are accustomed to conventional teaching practices. Resistance to changing pedagogical approaches can be a significant barrier to IoT integration [12].

Impact on Learning Outcomes

While IoT tools can enhance learning, there are concerns about their effectiveness:

- *Variable Outcomes:* Not all IoT technologies lead to improved educational outcomes. Schools need to evaluate the efficacy of specific tools and their alignment with educational goals.
- *Distraction Potential:* With the presence of multiple connected devices, students may become distracted, reducing the effectiveness of instructional time.
- *Disparities Among Students:* IoT implementation can exacerbate inequalities if some students have access to advanced technology while others do not. Schools must ensure equitable access to all students.
- *Socioeconomic Barriers:* Students from lower socioeconomic backgrounds may lack the necessary devices or internet access at home, limiting the impact of IoT tools [13].

Scalability Issues

As schools grow or change, scalability becomes an essential concern:

- *Expansion Challenges:* Schools may face challenges in scaling their IoT solutions to accommodate new devices or integrate with existing systems.
- *Resource Allocation:* Determining how to allocate resources for IoT scaling can weigh heavily on administrative decisions.

Vendor Management

Working with third-party vendors introduces additional complexities for schools:

- *Reliability of Vendors:* Schools need to choose reliable vendors that can provide consistent service and support. The failure of a vendor to deliver on promises can disrupt the implementation of IoT solutions.
- *Contractual Challenges:* Negotiating contracts can be complicated, especially when determining long-term costs and exit strategies

PROPOSED METHODOLOGY OF EDUEDGE

The app EduEdge is built for a school in such a way that teachers can directly upload results via IoT devices, and these results are instantly delivered to parents as they enter the school premises. The edge devices in this setup include mobile phones, computer labs, Raspberry Pi devices, and similar infrastructure.

To implement serverless edge computing in this design, the traditional edge layer, which usually consists of infrastructural devices, can be replaced with a serverless architecture layer. This change reduces infrastructure costs while providing additional benefits. By using serverless platforms like AWS Lambda or Google Cloud Functions, tasks such as data preprocessing, result generation, and login authentication can be shifted to a serverless architecture hosted in the cloud. This method is more cost-effective, improves performance, and allows for effortless scalability.

EduEdge Framework (Figure 4) represents a unique application designed specifically to streamline communication regarding students' results between schools and parents. By leveraging IoT devices, teachers can directly upload results, which are then instantly delivered to parents as they enter the school premises. This innovative approach utilizes a combination of edge devices, including mobile phones, computer labs, Raspberry Pi devices, and other infrastructure, to enhance the educational experience for both teachers and parents.

ALGORITHM

Figure 5 represents the proposed algorithm of the model.

<START>
<Create iOT network with iOT Devices, Computer labs>

<Develop iOT App for mobile phones of parents>
<Create separate logins for Teachers, parents>
<Teachers Compile Data for results>
<Teachers Transfer Data to Cloud Infra>
<As per requirements, cloud infrastructure is used for calculations including ranking of students>
<Results are generated>
<Results are sent to Authentic Parents in vicinity>
<Meetings are held in school after this results dissemination>
<END>

WORKING METHODOLOGY

It is as follows:

- *Step 1:* Using serverless architecture, teachers of the school enter marks and generate results for each student.
- *Step 2:* These results are then uploaded at cloud, then results processing takes place using platform-as-a-service.
- *Step 3:* Because of edge computing, these results are ready to be dispatched
- *Step 4:* Incoming parents' mobile devices are located and results are sent on specific date and time.

The Role of Edge Devices

In the EduEdge setup, edge devices serve as crucial components that enable real-time data acquisition and transmission. These devices collect results from teachers and facilitate immediate updates to parents. For instance, a teacher can input grades into a mobile app on their device. This data is processed through the local network and delivered to parents' mobile devices as they arrive at the school.

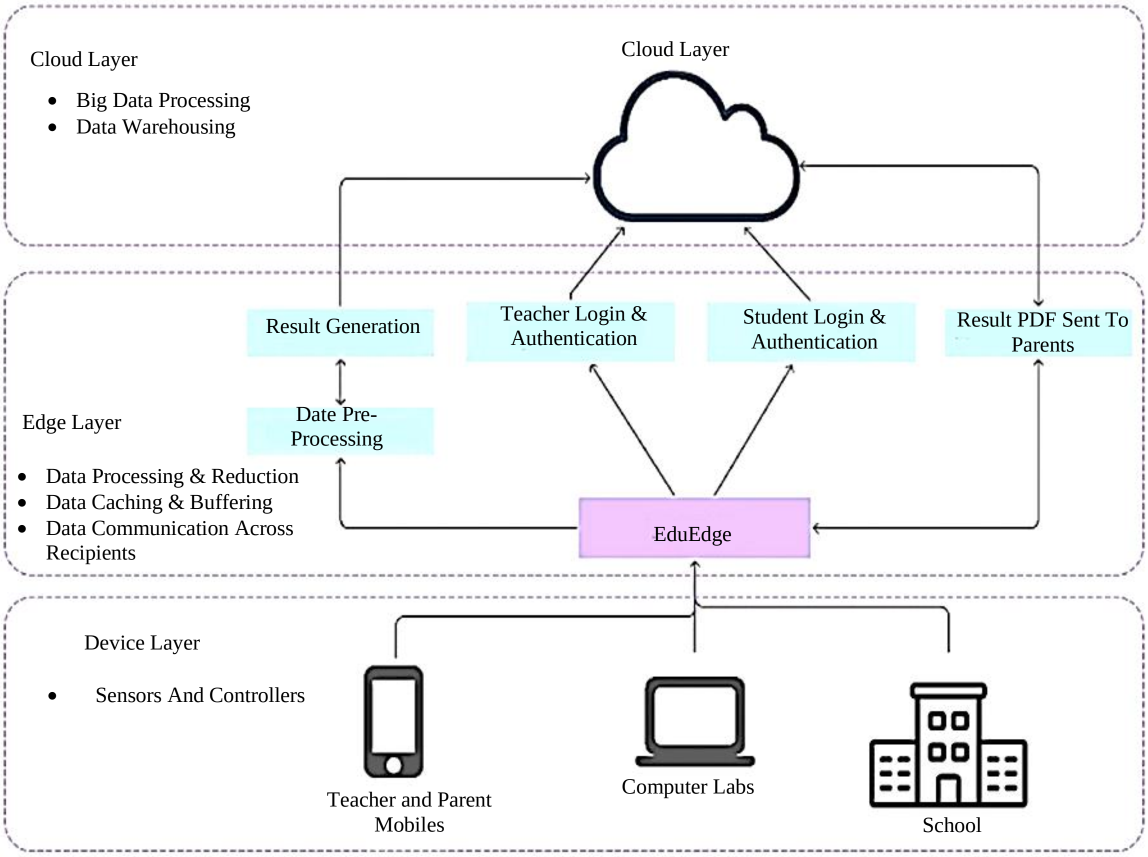

Figure 4. EduEdge framework.

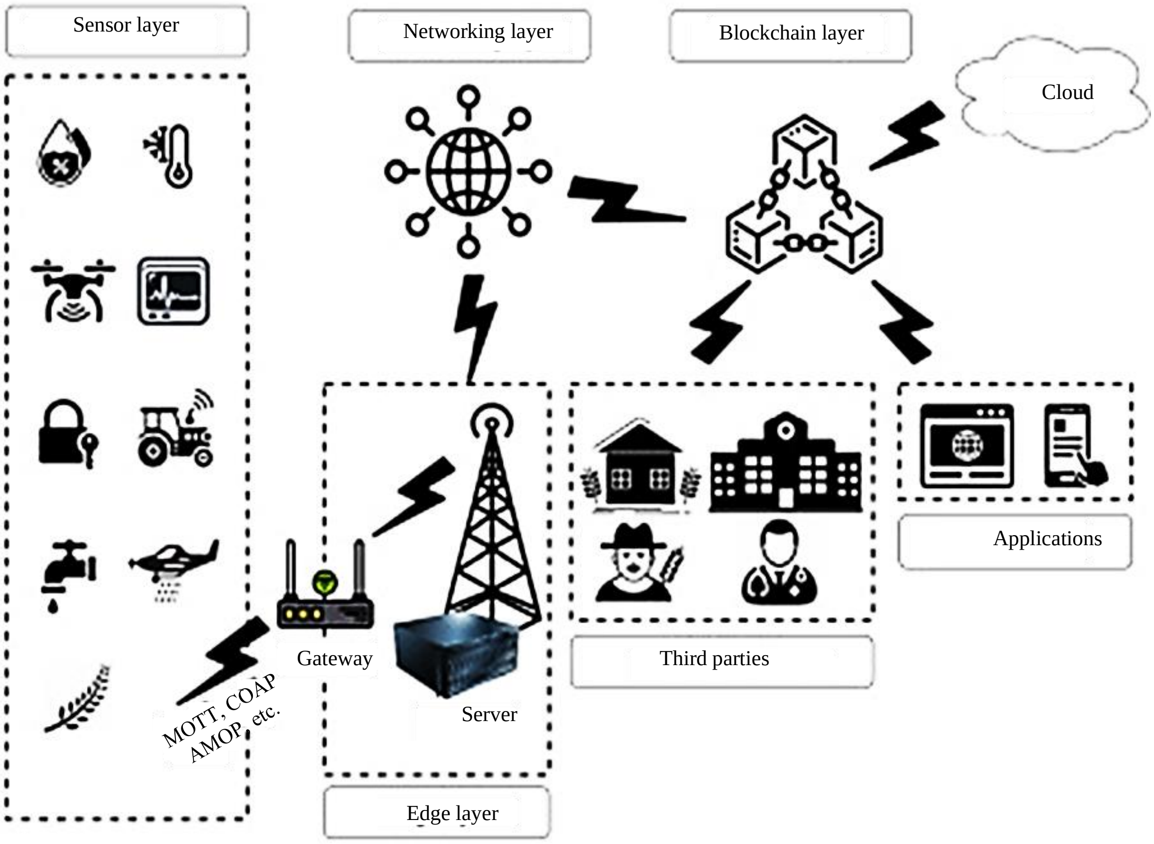

Figure 5. Proposed algorithm

The use of devices like mobile phones and Raspberry Pi enables schools to harness existing technology while minimizing additional expenditure on new hardware. Moreover, these devices can operate seamlessly in various environments, allowing for flexibility in how and where educational data is accessed [14].

Benefits of Serverless Edge Computing Architecture

One of the most significant innovative aspects of implementing EduEdge is the transition from traditional edge computing to a serverless architecture. This change introduces multiple advantages, including cost reduction, enhanced performance, and scalability.

Cost Efficiency

A conventional edge computing approach typically necessitates substantial investment in physical infrastructure, encompassing servers and network management tools. A serverless architecture enables schools to forgo the necessity of dedicated infrastructure. By employing platforms like AWS Lambda or Google Cloud Functions, educational institutions can significantly decrease initial capital expenditures, opting for a pay-as-you-go model instead. This adaptability is especially advantageous for educational institutions that may function under constrained resources [15].

Performance Enhancement

By leveraging serverless platforms, tasks such as data preprocessing, result generation, and user authentication can be offloaded from edge devices to the cloud. This not only optimizes the processing power at the edge but also allows more complex computations and data management functions to be performed in a more powerful, centralized cloud environment. As a result, the overall responsiveness of the EduEdge application improves significantly, leading to a better user experience for teachers and parents alike [16].

Moreover, these serverless solutions automatically scale according to load. When a large number of parents enter the school premises simultaneously, the serverless architecture can handle these spikes in demand without any need for manual intervention or resource allocation, maintaining smooth operations and timely delivery of results.

Effortless Scalability

Scalability is a critical component for any educational institution looking to innovate. With serverless architecture, EduEdge can effortlessly scale its operations. Whether it is adding new users, integrating additional features, or accommodating a growing student body, the serverless model allows the application to adapt to changing needs instantaneously.

Additionally, serverless computing allows for the integration of advanced technologies, such as machine learning and big data analytics. Schools can analyze trends regarding student performance, attendance, and other metrics without the overhead of managing infrastructure. This capability equips educational administrators with data-driven insights to improve teaching methodologies and parental engagement [17].

Ensuring Data Security and Privacy

The security and privacy of student data in the EduEdge application must be paramount. Serverless architectures generally incorporate stringent security standards and compliance controls, including encrypted data transmission and storage. Utilizing services from reputable cloud providers enables educational institutions to enforce stringent authentication and authorization protocols, ensuring that only authorized individuals can access critical data.

Furthermore, edge devices can incorporate local security protocols, including biometric authentication on mobile devices. This establishes an extra layer of security prior to the data being processed in the cloud [18].

Transforming Parental Engagement

The prompt provision of results to parents upon school entry is essential. This feature cultivates a sense of community and engagement among parents, prompting them to actively participate in their child's education. Instant access to academic outcomes facilitates prompt exchanges between parents and teachers, fostering a cooperative approach to student development. By optimizing communication via the EduEdge platform, educational institutions may foster enhanced relationships with families. Parents can obtain real-time updates on grades, attendance, and behavioral reports, facilitating more informed decision-making over their children's education [19].

The distinction between cloud and serverless architecture is rooted in their emphasis. Cloud computing is mostly utilized for the storage, management, and processing of data via centralized servers, whereas serverless architecture facilitates application hosting without necessitating attention to infrastructure or server-side configurations. Edge computing, conversely, facilitates data processing and other tasks in proximity to IoT devices, hence enabling rapid, real-time replies and alleviating server congestion.

By integrating both technologies via serverless edge computing, EduEdge may leverage both strategies. This integration mitigates numerous disadvantages, improves scalability, and guarantees superior performance while providing a smooth experience [20].

IMPACT OF EDUEDGE APP

Primarily the EduEdge app is designed for teachers to use whole technological infrastructure as per requirements and gain something out of the whole process of:

- Assembling data

- Handling it, and
- Creating students results.
- Sending it to authentic parents only
- Face real issues amongst parents
- Guide students and parents for future

For parents the following benefits exist:

- Get genuine, verified results
- On time results generation and distribution

For school administration, following points are noticeable:

- Effective data management
- Effective infrastructure management
- Secrecy of results and data

This app is bound to make positive changes in lives of parents, students, teachers and school management personnel in big way.

CONCLUSION

The paper is a revision to existing knowledge of serverless computing and edge computing. Unique initiative of disbursing results in PDF format before parent–teacher meeting is worth studying. It also means that there will be discretion while sending the results and not publicly showing the extreme cases as well. Parents will get lesser time to compare their wards results amongst each other.

REFERENCES

1. Raith P, Nastic S, Dustdar S. Serverless edge computing—where we are and what lies ahead. IEEE Internet Computing. 2023; 27 (3): 50–64.
2. Gadepalli PK, Peach G, Cherkasova L, Aitken R, Parmer G. Challenges and opportunities for efficient serverless computing at the edge. In: 2019 38th Symposium on Reliable Distributed Systems (SRDS), Lyon, France, October 1–4, 2019. pp. 261–2615.
3. Ferry N, Dautov R, Song H. Towards a model-based serverless platform for the cloud-edge-IoT continuum. In: 2022 22nd IEEE International Symposium on Cluster, Cloud and Internet Computing (CCGrid), Taormina, Italy, May 16–19, 2022. pp. 851–858.
4. Kofi Group. Serverless Architecture Explained in 10 Minutes. [Online]. Kofi Group. 2021. Available at https://www.kofi-group.com/serverless-architecture-explained-in-10-minutes/
5. Mohanan R. What Is Edge Computing? Components, Examples, and Best Practices. [Online]. Spiceworks Inc. 2022. Available at https://www.spiceworks.com/tech/edge-computing/articles/what-is-edge-computing/
6. Khan LU, Yaqoob I, Tran NH, Kazmi SA, Dang TN, Hong CS. Edge-computing-enabled smart cities: a comprehensive survey. IEEE Internet Things J. 2020; 7 (10): 10200–10232.
7. Jeon H, Shin S, Cho C, Yoon S. Deep reinforcement learning for QoS-aware package caching in serverless edge computing. In: 2021 IEEE Global Communications Conference (GLOBECOM), Madrid, Spain, December 7–11, 2021. pp. 1–6.
8. Samea F, Azam F, Rashid M, Anwar MW, Haider Butt W, Muzaffar AW. A model-driven framework for data-driven applications in serverless cloud computing. PLoS One. 2020; 15 (8): e0237317.
9. Mämmelä A, Riekki J, Kiviranta M. Loose coupling: an invisible thread in the history of technology. IEEE Access. 2023; 11: 59456–59482.
10. Machen A, Wang S, Leung KK, Ko BJ, Salonidis T. Live service migration in mobile edge clouds. IEEE Wireless Commun. 2017; 25 (1): 140–147.
11. Abbas N, Zhang Y, Taherkordi A, Skeie T. Mobile edge computing: a survey. IEEE Internet Things J. 2017; 5 (1): 450–465.

12. Hu S, Huang S, Huang J, Su J. Blockchain and edge computing technology enabling organic agricultural supply chain: a framework solution to trust crisis. Computers Indus Eng. 2021; 153: 107079.
13. Dinh HT, Lee C, Niyato D, Wang P. A survey of mobile cloud computing: architecture, applications, and approaches. Wireless Commun Mobile Comput. 2013; 13 (18): 1587–1611.
14. Mao Y, You C, Zhang J, Huang K, Letaief KB. A survey on mobile edge computing: the communication perspective. IEEE Commun Surv Tutorials. 2017; 19 (4): 2322–2358.
15. Abbas N, Zhang Y, Taherkordi A, Skeie T. Mobile edge computing: a survey. IEEE Internet Things J. 2017; 5 (1): 450–465.
16. Singh R, Singh SK, Kumar S, Gill SS. SDN-Aided edge computing-enabled AI for IoT and smart cities. In: Sahoo KS, Solanki A, Mishra SK, Sahoo B, Nayyar A, editors. SDN-Supported Edge-Cloud Interplay for Next Generation Internet of Things. New York, NY, USA: Chapman &Hall/CRC Press; 2022. pp. 41–70..
17. Jeon H, Shin S, Cho C, Yoon S. Deep reinforcement learning for QoS-aware package caching in serverless edge computing. In: 2021 IEEE Global Communications Conference (GLOBECOM), Madrid, Spain, December 7–11, 2021. pp. 1–6.
18. Othman M, Madani SA, Khan SU. A survey of mobile cloud computing application models. IEEE Commun Surv Tutorials. 2013; 16 (1): 393–413.
19. Luo Q, Hu S, Li C, Li G, Shi W. Resource scheduling in edge computing: a survey. IEEE Commun Surv Tutorials. 2021; 23 (4): 2131–2165.
20. Douch S, Abid MR, Zine-Dine K, Bouzidi D, Benhaddou D. Edge computing technology enablers: a systematic lecture study. IEEE Access. 2022; 10: 69264–69302.

