RETRACTED: Assisting Smart Construction With Reliable Edge Computing Technology

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Although smart construction tools are already assisting the construction sector, still major reforms are considerably seen in the coming years with Artificial Intelligence of Things (AIoT). The purpose of this work was to develop a down-to-earth reliable edge-computing design and plan, which can be utilized to bolster savvy development situations with high quality of service. The number of devices connected to industrial processes is growing in tandem with the advancement of sophisticated technologies and the use of the AIoT. Big data are created as gadgets grow more integrated and need more computing power. However, as the amount of big data generated grows, processing and analytical issues arise. Cloud computing technologies are now being used to solve processing and analytical challenges. However, by using edge computing technologies, greater emphasis is placed on executing calculations as near to the device as feasible. As a result of these facts, this article suggests the arrangement plan, which depends on the most recent cloud and computer program designing approaches and advances, and gives flexibility, interoperability, and adjustment to construction companies' particular needs.

Keywords: smart construction, artificial intelligence of things, reliable edge computing, quality of service, qos, big data

INTRODUCTION

Fundamental aspects influencing the uninterrupted functionality of the Internet within the future era of the internet, with millions and billions of tools, will be: 1) the big, rapid, and diversified information obtained by them and their consumers, 2) the population boom of tools and their expert systems, and 3) need for huge, flexible infrastructure, and services to access and extract knowledge from these huge datasets to aid in making critical, data-driven judgments. Now, a key roadblock to the adoption of sophisticated AIoT applications in the construction industry is their unacceptably low quality of service, which limits real-time processing capabilities. Several reviews of past AIoT implementations in the construction industry have been published in recent years (Avizienis et al., 2004; Braun et al., 2015).

Within the last 5 years, artificial intelligence (AI) has made great progress, and it has managed to establish a footing within construction firms, from concept to construction. The use of constructively alternative analyses to enhance the precision of estimated costs, precise deadlines, and decrease on-site risks is the possible use of AI in the design and planning stage (Bonomi et al., 2012; Kim et al., 2013; and Khodadadi et al., 2015). Furthermore, better productivity, enhanced work procedures, and a lower risk of accidents on construction sites are also advantages of AI in the construction stage.

Indeed, stringent quality of service criteria, i.e., dependability requirements, are required for such applications to realize their commercial value. To continuously analyze data from cameras, sensors, robotics, smartphones, and smart apps, for example, requires extensive networking, processing, and memory resources; in addition, control loops and feedback for signage and actuators are available. Our strategy will be based on the existing cloud service design along with reliability of solutions in general. Cloud computing, according to Mell et al (Dave et al., 2016) is an architecture that allows universally requisite accessibility to a group of computing resources over the internet that is shared, such as servers, networks, applications, storing, and services, those can be established and maintained with no difficulty.

In response to slowing growth, the need for investment and research in AI technology is being investigated (Avizienis et al., 2004; Braun et al., 2015; and Dave et al., 2016). The goal was to simplify operations and boost efficiency. Avoiding cost overruns, enhancing site security, and effectively managing projects are all advantages of AI for the construction sector (Foster et al., 2008; Bai et al., 2012; Jin et al., 2014; Prasad et al., 2015; Chen et al., 2016). The following AI sectors of big data and analytics, robotics, automation, data integration, and wearable technology have already experienced significant growth (Wang et al., 2007; Golparvar-Fard et al., 2012).

RELATED WORKS—SMART CONSTRUCTION AND EDGE COMPUTING

A collection of cyber-physical systems (CPSs) uses real-time monitoring to prevent the breakdown of temporary (Bonomi et al., 2012) structures. A cloud-premised dataset and mobile app are part of their approach. It has an impact on the issue of crane-to-immobile-object collisions, which they are attempting to reduce (Khodadadi et al., 2015). A natural-world computation, a network of anti-collision systems that cautions of an impending collision and applies appropriate precautionary methods, might be their answer. The works show methods for construction site safety that use various monitoring technologies to prevent accidents between construction equipment and pedestrians. Their approach is based on the premise of tags and warning devices that use radio frequency identification as well as communication protocol and interfaces.

AI is increasingly used at construction sites, and the future success of the project depends heavily on the efficient use of these technologies. Several communication software models and supply management availabilities are presented to help with the development process (Wang et al., 2007; Bai et al., 2012). Golparvar-Fard et al (2012) state that material handling has a substantial impact on the development process; as a result, they may provide a software model prototype for efficiently handling building materials with minimal human participation Villari et al (2016) provide web-premised offerings that may combine radiofrequency identification technology with smart devices to boost the efficiency of information and knowledge exchange on building sites. Mell and Grance (2012), Swain et al (2015), Jegen -Perrin et al (2016), Li et al (2021a), and Li et al (2021b) looked at methods for real-time data, task management, site and monitoring, and exchange using a multi-tier computer architecture in their research.

FIGURE 1 | Reliable edge-computing technology and smart AIoT construction.
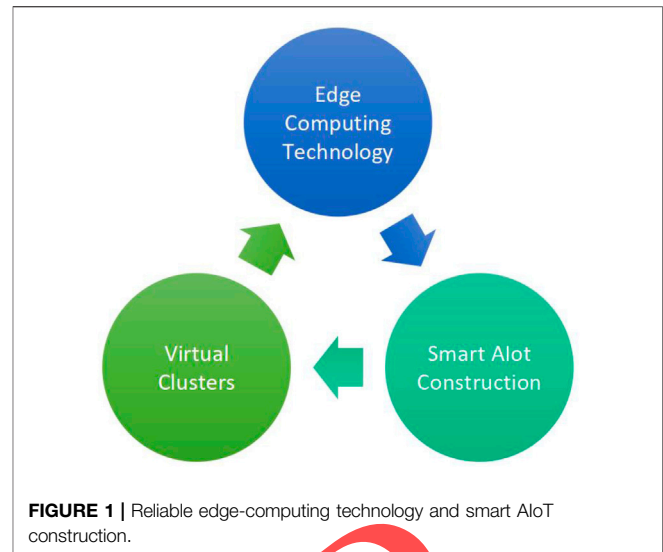
Next, NVivo was used to perform content analysis to analyze word frequency, concepts, and technology to identify the main topics of tweets about AI applications in the construction industry. The reasons for this choice are:

i.   AI is beginning to be recognized by some of Australia's top construction businesses. These businesses are effectively utilizing AI in their initiatives to save money and time.
ii. A national AI strategy and roadmap are being developed in Australia. To summarize, the development of AI in cities and industries is being carefully planned to prevent becoming simply organic.
iii. In Australia, social media is widely used and has evolved into a source of information for conveying the common view of AI in the construction business.

The lack of communication on construction sites is a common source of accidents, and it should also create a slew of serious on-site issues and delays.

Several studies specialize in the utilization of varied AIoT devices in construction. Avizienis et al (2004) discussed how the Internet of Things (IoT) and associated protocols can help to improve the development management system. Le et al (2014) and Roman et al (2018) described a tower crane safety monitoring system powered by AIoT that successfully monitors the safety of the tower production process. The majority of AIoT apps developed so far have been built to operate natively or on Web browsers, with no measures in place to reduce application/system downtime or data loss.

APPLIED METHODOLOGY

Methodology

The recognized test is to characterize a bunch of edge computing technologies as shown in **Figure 1** that can be utilized to oversee smart AIoT construction. Inside the shrewd conditions, different

savvy applications are sent to help computerization. The essential objective of the services for edge management was to add to higher quality of service, in contrast, with existing cloud frameworks and hence likewise to have the option to meet rigid trustworthiness necessities of each expected brilliant application.

The current work adopts a hierarchical strategy. In light of edge and haze figuring definitions (Chae, 2009), leaving innovation surveys (Chae and Yoshida, 2010; Yi et al., 2015), the distinguished specialized necessities of the possible applications, and experience acquired over cutting edge-distributed computing and programming projects, a sufficient calculated methodology for edge registering in development is ready. It characterizes the vital administrations that can be utilized to acquire high quality of service. Following the engineering and plan, two praiseworthy edge-processing applications were created to show the feasibility of the methodology and the potential advantages while meeting the expected quality of service. The applications that have been chosen to show the methodology are connected with video correspondences and documents of the executives, which are agents for different functionalities required inside well-informed development conditions.

Necessities

Brilliant frameworks in the development area must be planned as dependable. Framework reliability addresses the framework's capacity to convey administration that can be sensibly trusted. From a framework disappointment viewpoint, the reliability can be additionally characterized as the frameworks capacity to stay away from disappointments that are successive or serious, and longer blackout lengths than it is ok with the client (Beach et al., 2013; Datta et al., 2016), for instance, to perform security and business basic activities.

At the point when the key trustworthiness prerequisites are not fulfilled, extreme results are inescapable. For example, this can cause extra monetary expenses, compromised well-being at the building site, development process delays, loss of notoriety, and numerous different repercussions. Overall, giving the necessary steadfastness to AIoT building locales, where time-basic applications are utilized, certain trustworthiness credits must be tended to and fulfilled consistently.

Approaches and Methods for Cloud and Edge Computing

Cloud computing is widely utilized today owing to features like seamless scalability, configuration, and pay-per-use (Stankovski and Petcu, 2014). In the recent decade, it has been extensively explored, developed, and utilized in a variety of fields. Past initiatives have been supplemented by the new generation of edges and cloud computing projects, including SWITCH, which focuses on system software for ENTICE, AIoT, and Big Data that focuses on innovative cloud computing storage solutions. Advanced novel techniques have evolved, such as osmotic computing (Shi et al., 2016a). They recommend building apps out of microservices, and they are carried out at the edge network

systems. Contrary to popular belief, cloud computing is still a centralized computing architecture; new computing concepts decentralize computing by extending processing capability to the network edge. Cloud computing concentrates on processing operations inside this network, among end devices and cloud computing data centers (Prasad et al., 2015). Edge computing, on the other hand, brings processes even nearer to data resources, allowing any devices on to the edge to process data (Kim et al., 2013). Although edge and cloud computing are distinct computer tactics, they have comparable aims, and hence edge and cloud computing may be thought of as the two sides of a single coin.

There are currently data-centric technologies (Chae, 2009; Chae and Yoshida, 2010) available that enable near-data computing and significant AIoT compatibility. At the network edge, decentralized computing technologies bring services closer to users. Their objectives include reducing delays, lowering data transport and processing costs, and increasing scalability. Additionally, it is feasible to turn edge devices into virtualization platforms (Ren and Wu, 2014; Shi et al., 2016b). Container-based virtualization, for example, may be utilized to create edge-computing architectures. A container, in general, includes the application data code, all essential info libraries, and, if necessary, the data code. As a result, both functionality and data are included in a container instance.

## Modern Software Tools and Techniques

Parallel to the advancement of virtualization technology, software engineering methodologies and tools have also made significant strides in recent years. Rapid extreme programming, application development, behavior-driven development, test-driven development, and other modern software development and engineering approaches are only a few examples. Component-based software engineering, in general, facilitates such advancement. It encourages closer collaboration among development, business, and IT operations teams.

Modifying the Edge Computing Technology

Edge compute clusters (Raspberry PIs, microservers, routers, and more computational capabilities close to the environment that is smart) as well as public and private clouds are two types of infrastructure for computation that might be utilized to execute AIoT applications (that is, data center computing capacity). The initial stage in this procedure is for a smart application administrator to examine their edge-computing requirements.

Figure 2 shows a layered edge-computing architecture that divides services into three levels. Because apps are built up of software modules, they may be used at any stage of development. The first stage of the first would operate on AIoT devices in the field, while the second would run on edge-computing nodes, and the third on the most suited public cloud from the virtual bunches indefinitely. Various AIoT devices, such as video-camera-fitted headsets, might function on batteries and send data to the cloud regularly.

Due to their high networking resource requirements, edge computing must be used for time-critical software applications. Relying on the circumstance, the intelligent environment

FIGURE 2 | Layered architecture for reliable edge-computing technology and smart AIoT construction.
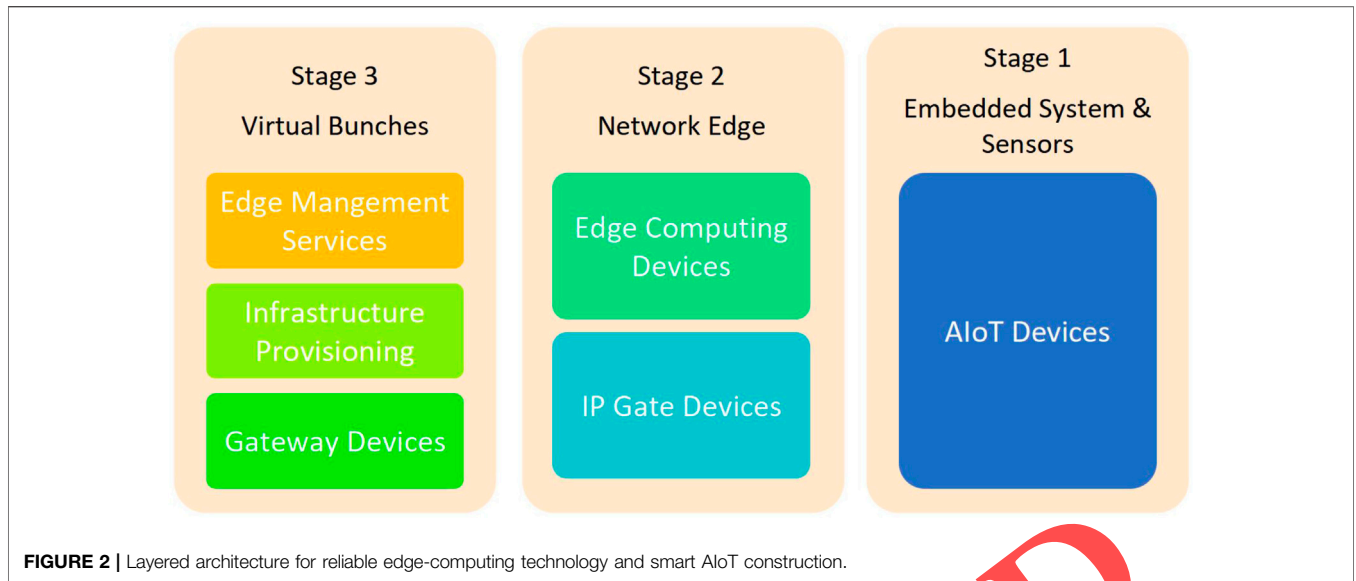
TABLE 1 | Open-source Web communication applications.

<! --Col Count:5-->	Google Meet	Microsoft Teams	Jio Meet	Zoom
Chat	Y	N	N	Y
Videoconference	Y	Y	Y	Y
Screen-sharing	N	Y	Y	Y
Encryption	Y	Y	N	Y
Record	N	N	Y	Y

operator can determine how many edge-computing devices are required to ensure that smart applications run reliably. In total, three high-performance microservers, for example, located near a medium-sized intelligent construction atmospheric environment, may be sufficient to provide good quality of service and dependency. Furthermore, sections of the applications with no time-critical needs can be placed in a dataset center, lowering operational expenses.

The infrastructure of high standard flexibility enabled by the ENTICE and SWITCH services fundamentally implies that the system may operate AIoT applications without the requirement for ongoing management. The Kubernetes-premised orchestrator can swiftly stop and start containers servicing specific AIoT units throughout the entire range of computing, such as in the dataset center, at the edge, and even in transportable AIoT device-integrated computer systems (on which an operating system and an orchestrator are installed and running). As a result, this is a fully complete system capable of running, updating, extending, building, deleting, and managing software services in real-time.

The orchestrator that has been built may be utilized to effectively expand containers horizontally as consumption grows, allowing for excellent service availability. Of course, this translates to increased operation safety near the smart construction environment. To guarantee dependable operation, an availability parameter can be used that specifies how many

service copies should be operating at the same time. Furthermore, as a result of the applications' rapid recovery process, the orchestrator ensures a more stable continuous delivery of services—applications are monitored closely by a collection of assets that are able to monitor elements, and an alerting trigger creates warnings so when service quality thresholds (e.g., jitter, latency, and bandwidth) are exceeded.

Edge Computing

Edge computing can be made up of a variety of gateway routers, devices, tiny servers, and small data centers with energy consumption ranging from 1–5 kW. All of these computer systems have an operating system in common. Core OS, RancherOS, and nearly any Linux-based systems are examples of operating systems that can effortlessly handle Docker containers. An IP gateway is a specialized device that connects AIoT devices to the Internet. IP gateways such as the TA900e or Cisco-ASA are examples of IP gateways, whereas AIoT devices and sensors include video communications, cellphones, temperature, air quality, and humidity transmitters, among others. Naturally, a system operator would be required to set up such a system and regularly monitor it using the monitoring components. The study did not focus on the forms of communication (wired and wireless) between the AIoT and the software services running at the network edge. This is an aspect about which the intended architecture is agnostic.

The AIoT devices that have been deployed can broadcast video, sensor data, and audio in real-time. Computing devices that run container-based services then interact and analyze their data directly.

In time-critical scenarios, such as probable collisions or accidents, when an immediate response to events is required, on-site data processing may be required. Furthermore, edge processing enables more efficient data processing in the cloud at reduced prices. The edge-processed data is then forwarded to network gateways, which transfer it to the most appropriate virtual data center entity (bunches).

Communication

Efficient communication and a range of signal solutions are necessitated for the success of any construction operation on one or many constructional projects. Communication through video may require for every construction project's success to be enhanced with several time-consuming functions, such as real-time video analysis to detect security and safety issues, augmented reality environments to increase cooperation and project collaboration, and construction site delays and blunders.

Construction businesses, site teams, surveyors, architects, engineers, and other site employees need to communicate often; therefore, videoconferencing eliminates the need for face-to-face meetings. As a result, face-to-face discussions may be held at any moment at a lower cost, and interaction across office-to-office, site-to-site, and project work-to-project work teams is easier. In addition to meetings, videoconferencing participants can use to discuss a video from the worksite and resolve potential on-site issues, regardless of their geographic location. This type of communication might lead to improved cooperation, faster delivery of solutions, and lower manufacturing costs. As a result, it serves as an example of a critical application.

Open-source software can be utilized to create an edge-computing application. Google Meet, Microsoft Teams, Jio Meet, and Zoom were all viewed as open-source video conferencing apps. **Table 1** compares and contrasts their functions.

The Construction Process Is Being Documented

Documentation is a regular problem in various sectors, and it also performs an important role in the building phase. Although this is not a significant issue for minor building projects, some recent firms are attempting to solve it. Delays and data loss are likely in larger projects; thus, documentation is vital. New AIoT devices,

such as radiofrequency identification sensor data, video surveillance, and tags, may assist record the entire process using new formats and methodologies, all of which are Big Data problems (veracity of data, variety, volume, and velocity). In such circumstances, using cloud-premised solutions may be able to overcome the obstacles.

This application is time-critical because it must run to avoid any delays, and everything is performed in real-time. The overall purpose of this application was to provide a file-sharing mechanism among building process participants with a high level of service quality.

CONCLUSION

The innovation of this study, in comparison to other current methods used for construction automation outlined in **Section 2**, is the innovative edge-computing architecture and creation of a reliable AIoT construction system. Artificial intelligence (AI) is a powerful instrument with the potential to transform and disrupt the construction sector. In total, two AIoT applications with strong quality of service requirements are used to showcase the methodology, which is based on the created design. This revolutionary design can accommodate a variety of smart applications for a variety of building project demands and sizes. Furthermore, software services, such as analytic services like data mining, machine learning, and simulations, may be created using containers and used successfully in the current edge-computing architecture. As a result, deploying cloud environments adjacent to construction sites might provide seamless construction site administration and communication, reducing costs and increasing dependability. The current state of knowledge about emerging construction technologies and their application areas is insufficient.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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