ICEAIST-24
International Conference on Exploring AI, IOT, Science & Technology-24
ESP Journal of Engineering Technology Advancements / ISSN:2583-2646

*Original Article*

# A Security SystemofE-Exams Using an IoTand Fog Layer Computing Environment

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***Abstract:*** *The IoT-Fog-Cloud architecture is presented in this study to provide security considerations in distributing E-exams, which face a number of security difficulties, including fine-grained access control and E-exam security preservation. Additionally, the suggested framework encourages bringing services closer to the students. Additionally, by offloading a portion of the encryption cost to fog servers, this paper increases the efficiency of E-exam data analysis, decreases the encryption burden in terms of computation cost on user devices, and offers fine-grained access control to E-exam content through encryption using various cryptographic techniques. The two primary components that the IoT-fog-cloud framework takes into account are the layer processes and the layer components. The FGNs, cloud data centres, and GFNs are among the layer components that need to be merged. Since distribution procedures aid students in lowering latency, improving response times, and maintaining confidentiality and privacy, layer methods can yield a number of advantages. In conclusion, this study demonstrates that the suggested IoT-Fog-Cloud framework may accomplish data privacy, precise access control, resistance to collusion, and enforceability to guarantee safe practices while implementing the suggested framework.*

***Keywords:*** *Internet of Things (IoTs), E-Exams, Fog Computing, Security System, E-Learning.*

## INTRODUCTION

Fog computing, a highly virtualized platform with a dispersed hierarchical structure, facilitates data processing and enhanced adaptability between cloud servers and end users.

[1]. Stated differently, it is a popular type of cloud computing that offers significant computational capacity for data storage, software application sharing, physical resource sharing, and effective end-user services for Internet of Things and terminal devices. It is compatible with a wide range of applications, including grid systems, e-healthcare, smart homes, smart cities, and smart learning.

[2].The three major layers of the FC architecture are a device/end layer, one or more layers of fog nodes, and at least one cloud datacenter (cloud layer), as shown in Figure 1.

The layer closest to end users is called the end layer. It is made up of two kinds of IoT devices: first, mobile devices (like cameras and cell phones), which are portable and have limited bandwidth, computational power, and storage; and second, fixed devices (like RFIDs). These Internet of Things gadgets have the ability to collect unprocessed data and send it to the fog layer [3].

**Fog layer:**

This works well for processing data, keeping track of completed queries, and routinely uploading data reports to the cloud. The middle layer consists of fog nodes and devices, including bridges, routers, laptops, dedicated fog servers, and similar access points with increased processing capability [4]. These devices are attached to the cloud server and can transfer inquiries to cloud centers.

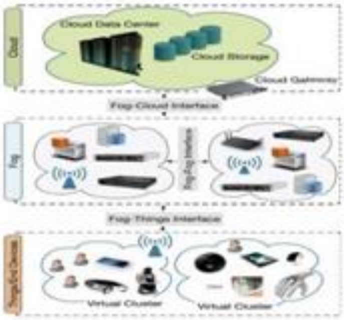


*Figure 1: Architecture of Fog Computing*

**Cloud layer:**

This is made up of multiple data centres and computers that can store enormous amounts of data and provide intricate summaries.People can access and store large amounts of data on the cloud at any time and from any location. Item uses virtualization technology to protect the privacy of separate IoT data and applications, enabling these to manage numerous users' needs on their own. The cloud facilitates reporting from various FCnodes and conducts a global analysis of the data provided by FCnodes to improve Internet of Things applications including network soptimization, smart energy distribution, and health state monitoring.[5].

Fog computing can be used to address over-the-top (OT) limitations such as latency restrictions, network bandwidth restrictions, and resource-constrained devices. With the help of the IoT-fog-cloud architecture, we can set some restrictions.First off, by pooling the transmission of E-exam data, fog nodes enable intermediaries to lower communication overhead without necessitating the acquisition of new skills for extensive Internet of Things applications.Neither the cloud nor the fog nodes can be fully trusted because the user is unable to independently calculate the result because of the low processing power of his devices. For the user, it becomes quite important whether the result is accurate or not.Second, the Internet of Things device can do complex computing operations that it cannot complete on its own with the assistance of the fog nodes' computational power.However, this method always leaves all sensitive information vulnerable to fog nodes that may have been compromised by hackers. Third, there is a serious risk to personal privacy in the big data era from safe E-examination analysis using machine learning and data mining algorithms.Although de-identification is commonly used to prevent hackers from linking the processed data to an individual's identity, the anonymity of the data is still readily jeopardised.

## THEROLEOFCLOUDANDFOGCOMPUTINGIN SMARTLEARNING

Intelligent settings and technology must be combined in order to build smart learning apps and e-learning.Given the great potential that FC models offer for intelligent learning, educators and learners may anticipate advantages from the effective sharing of instructional materials in multicultural contexts.FC is required to transform centralised computing into network-based, consistent streaming, which is necessary to bring computer services, applications, and data processing closer to end users. FC is easily accessible by end users and is locked to the cloud. Digital data can be generated from knowledge by means of links to the Internet of Things.Consequently, FC employing massive IoT data analytics offers more reliable, practical insights by empowering devices to make intelligent judgements on their own without human assistance.Big data-related data and knowledge reviews should soon make it possible to solve a variety of real-world problems.

Through education, smart learning seeks to improve learners' quality of life. It provides seamless, personalized, and contextualised instruction to advance learners' growth and foster their capacity for problem-solving in intelligent settings. Administration, control, and analysis as well as the transfer of resources, services, and learning data may all be enhanced by the fog.Smart learning environments can enable real-time communication, position awareness, large-scale sensor networks, support for flux, and more through the features of FC. Additionally, FC makes computing technology smarter through the five essential intelligence capabilities of auditability, awareness, analysis, alternatives, and actions. The application of FC in the development of electronic tests or smart learning environments can support intelligent activities at every level.

**Awareness:**

Learning takes happening everywhere and at any time. Innovations in fields like FC, design recognition, information mining, learning research, and other technologies can be used to gather data about the traits, conditions, locations, and statuses of understudy.Organisations can return this data from students' devices to intelligent learning frameworks so they can do further research.[19].

**Options:**

By using learning to stream or monitor work processes, audit tactics for learning programmes can be improved spontaneously or through human agency; that is, a decision will initiate a learning activity. The fog can take action by connecting to relevant cycle apps. With the ability to transfer certain apps to devices for activity execution, these cycle applications can be changed to a variety of settings and enhance students' related learning by providing them with access to previous or external data.

**Auditability:**

A learning action needs to be intelligently perceived, regardless of whether it is carried out correctly.It's critical to manage the learning cycle and increase its productivity in astute learningFor the purpose of evaluating and developing learning objectives, hazy workers in astute learning must grasp, adhere to, and interpret information on learning methods at each level.

Developments in FC bring students and the administration closer.Specifically, FC frequently moves data from the cloud to a company.It can increase the way learning information investigations are presented, lower the cost of clients' devices' encryption by shifting some of the encryption costs to security personnel, and enable fine-grained management over learning content by splintering exams and courses using various cryptographic techniques. A review of several IoT applications that, as Figure 2 illustrates, can profit from FC is provided in this section.

Healthcare and Activity Tracking: FC offers significant benefits for medical care. In the healthcare industry; it makes real-time processing and case communication possible. Furthermore, a robust network connection is required for the intercommunication of a large number of healthcare apps for external storage, processing, and medical record retrieval from the cloud; nevertheless, FC can handle issues with network connectivity and traffic.[23].

**AugmentedReality(AR):**

By using cloud servers and fog technology, FC can play a significant role in the AR space and support a variety of IoT applications.

**Fog Computing Uses in IoT Support**

Connected Cars: It is anticipated that all state-of-the-art automobiles will be able to "speak" with neighboring vehicles over the Internet in the upcoming years. FC will become the standard function of autumnInternet-associated vehicles, facilitating an elevated level ofcontinuouscommunication.

## PROPOSEDIOT-FOG CLOUDFRAMEWORK

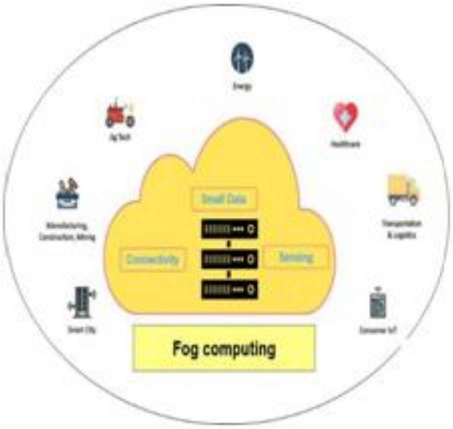
**FrameworkOverview**

In general, the proposed framework depends onIoT-basedFCtoenhancetheendpointsecurity,monitoring, andcomputationofIoTdevicesthatstudents use to receive e-exams, such as laptops,smart phones,andtablets.

The Internet of Things (IoT) device layer is represented by the devices at the bottom of Figure 4. These devices can be deployed in a designated area, such as on students' portable devices in educational institutions. Each device is utilised to receive one electronic exam, and the answers from the students are sent to an aggregation point at the edge of the FC layer, which is the middle layer.

The lowest-level energy-constrained devices are in the FClayer. These devices are not suitable for significant computing processes and can only respond to questions collected through the FC nodes at higher layers, as shown in Figure 4. Also, the fog layer includes four types of nodes: fog gateway nodes(FGNs) andtemporaryfogstoragenodes(TFSNs).

Since portable devices can be utilised in untrusted or unfamiliar locations (such students' homes) and e-examan answers can be sent over anonymous WAN networks, viruses have the potential to attack or take control of them.Sends the student's electronic exam to the best nodes along the edge between the cloud layer and the FC layer.



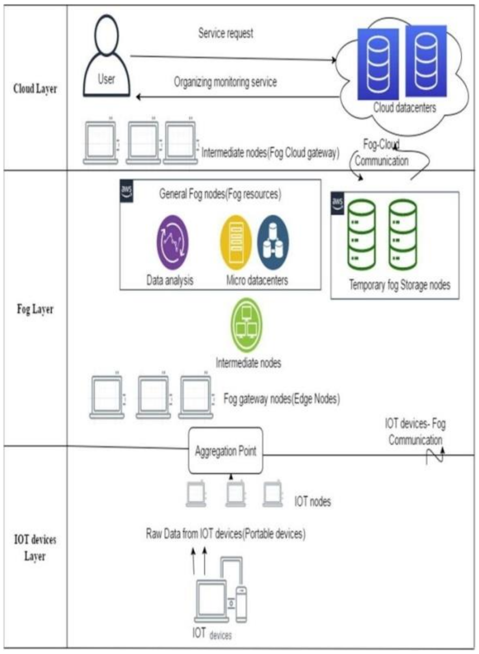

Cloud Layer
Service request
User
Organizing monitoring service
Cloud datacenters
Intermediate nodes(Fog Cloud gateway)
Fog-Cloud Communication
General Fog nodes(Fog resources)
Data analysis
Micro datacenters
Temporary fog Storage nodes
Fog Layer
Intermediate nodes
Fog gateway nodes(Edge Nodes)
IOT devices- Fog Communication
Aggregation Point
IOT nodes
IOT devices Layer
Raw Data from IOT devices(Portable devices)
IOT devices

*Figure 2: Fog Computing*

Specific nodes in the fog-like microdatacenters, which are arranged hierarchically between the fog layer and the IoT device layer.How a student submits a request for monitoring to the cloud layer is shown in Figure 4, which subsequently.Operationally, the fog-cloud node is the gateway. Next, as illustrated in Figure 4, the student sends his request for e-exam security from the gateway to more intermediate fog nodes and subsequently to other IoT device nodes in the bottom layer.

Fog nodes arrange the monitoring service in the existing framework so that only the devices required to approve the student's request are allowed access.This monitoring service releases the sources of nodes that are not directly involved in the monitoring service and stops the spread of data.The suggested framework employs a variety of encryption algorithms to identify potential attacks and implement security measures to ensure the security of e-exam responses supplied over the fog-cloud computing system. Security is used to keep an eye on the answers and validate them with the worried students. To enumerate the suggested framework's monitoring steps: In order to ensure that there are requirements for multi-broadcasting for monitoring requests and identifying the appropriate network and devices for students' demands, cryptography is initially utilised during the organisation of security procedures. Second, by monitoring transmission and processing and adhering to security protocols to reduce latency and power consumption, cryptography is utilised to protect privacy and preserve e-examan answers.

**Elements of the IoT–Fog–Cloud Framework**

The IoT-fog-cloud framework provides an integrated platform with two primary components: layer processes and layer components.

**Layer Components**

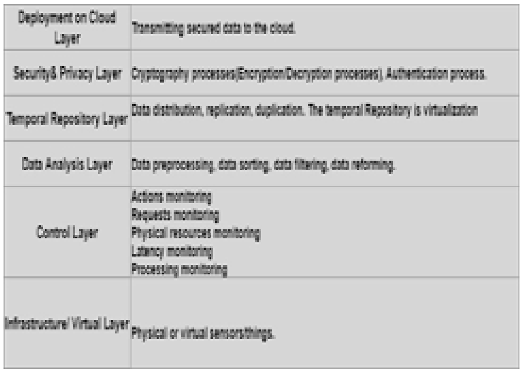
The IoT, fog, and cloud framework's constituent parts—IoT devices, FGNs, general fog nodes (GFNs), and cloud datacenters—are covered in detail in this section.

As the physical components that receive the e-examinations, laptops, tablets, and smartphones are examples of IoT devices, also known as portable gadgets.The limited energy, computation, processing, and resource capacities of these IoT devices allow them to generate student responses to e-exams as raw data. IoT devices are able to connect to edge nodes through communication protocols like Bluetooth thanks to the IOT-fog-cloud framework.

Distributed computing, which entails configuring the IoT device environment to carry out the desired activities and applications, is facilitated by FGNs.Students can utilise FGNs to send requests for fog resources to be processed by IoT devices, validate their answers, and receive service results that are affordable for them. Subsequently, FGNs gather electronic exam responses and carry out preparation, analysis, sorting, and identification of findings that are not adequately prepared, while integrating the information with other computer operations. Furthermore, FGNs maintain instantaneous communications and assimilate the information into available fog nodes.

In order to manage the IoT-fog-cloud framework, GFNs can perform a variety of computational operations using diverse hardware resources such processing devices, memory, repositories, microdatacentres, and bandwidths.This has three purposes:

The purpose of intermediate nodes is to help the necessary IoT devices' back-end applications and enable their connectivity with GFNs.Stated differently, they streamline the pre-exam processing procedures by linking resources to fulfil necessary duties.Additionally, they



| | |
|---|---|
| Deployment on Cloud Layer | Transmitting secured data to the cloud. |
| Security& Privacy Layer | Cryptography processes(Encryption/Decryption processes), Authentication process. |
| Temporal Repository Layer | Data distribution, replication, duplication. The temporal Repository is virtualization |
| Data Analysis Layer | Data preprocessing, data sorting, data filtering, data reforming. |
| Control Layer | Actions monitoring<br>Requests monitoring<br>Physical resources monitoring<br>Latency monitoring<br>Processing monitoring |
| Infrastructure/ Virtual Layer | Physical or virtual sensors/things. |

*Figure 5: The Fog Computing Layers*

In the event that issues arise, communicate GFNs or cloud calculations to supply substitute resources. The IOT-fog-cloud architecture employs error correction to provide dependability during distributed computations and enable seamless and continuous control. It also provides privacy and security safeguards for intermediary nodes.

**Fog Organization nodes (FONs**) are made accessible through intermediary nodes, such the FON protection gateway, and are utilised for normal compute operations.FONs operate under the supervision of an intermediary mediator for distributed processing. and make resources for e-examanswersavailable.Furthermore, FONs determine the synchronous tasks relayed from multiple intermediary nodes using unique clocks.The synchronous tasks are then set up, and the intermediate nodes receive the response.Furthermore, FONsperform just one application at a time to ensure application uniformity..

TFSNs offer a repository for historical exam data acquisition and analysis.They keep all of the application meta-data, including models, performance data, requirements, and soon.If issues develop, this meta-data can help get any process finished.Furthermore, every piece of metadata, command, and procedure is source-and time-stamped and stored in a storage repository.

Cloud datacenters: If the fog layer has a comprehensive computational range of services to carry out activities, the IoT-fog-cloud structure offers more scalable resources and computation. This increases the capability of IoT devices to process and access the necessary storage on TFSNs, allowing distribution to enable simple data access and analysis.

### SoftwareProcesses

Different benefits are offered by the IoT-fog-cloud framework for processing e-examanswers, including the ability to execute distributed processes in real-time, reduce latency, provide prompt responses, maintain privacy and security, and scale, analyses, and filter data to provide services with an architecture that is highly efficient.The FC layers are described in this part. Figure 5 illustrates the six layers, which are arranged from bottom to top: cloud deployment layer, security and privacy layer, data analysis layer, infrastructure/virtual layer, control layer, and temporal repository layer.

## PROTOCOLS

To guarantee secure operations in the IOT-fog-cloud system, two protocols are required: secure control/monitoring and secure organisation. To assure data delivery, these protocols maintain cryptography keys on fog, IoT devices, and cloud nodes. The following is the insecure organisation protocol that offers encryption between entities:

Cloud is shared by all fog and IoT nodes on devices with all symmetric secret keys.Additionally, it gives each node a public key (PK) and master key (MR). A public-private pair of keys linked to a public key shared with every fog layer node is shared by the fog node with the cloud

Fog node is exchanges symmetric secret keys with the cloud; a pair of public-private keys linked to a public key shared by every fog layer node.

### Secure Organisation Protocol A

Students' emails are sent to the IOT-cloud-fog framework

- Step1: The student registers on the IOT–fog–cloud framework.
- Step2: The student obtains authentication from the cloud.
- Step3:Thecloudsendsapprovaltoprovidethestudent'sservice.
- Step4: The student discovers similarities between IoT devices and the fog layer after receiving a random number along with time as an identification for secure monitoring..
- Step5: The pupils send their identities as well as comparable data to the cloud.
- Step6: The cloud selects the appropriate gateway for the student and decides which fog node will carry out the security monitoring based on similar criteria.

- Step7: The security monitoring service receives an asymmetric cryptography key generated by the cloud, which it combines with a random value and distributes to confirm that the student and entry point are in communication.
- Step8: The cloud allows the learner to establish a remote connection with the entry point by fusing the cloud output created in step 7 with a standard resource identifier. In the IOT-fog-cloud framework, users arrange a hierarchical sequence of nodes to gain a security monitoring service.

**Students don't work in hierarchical structures to receive security monitoring services.**
The student sets up a hierarchical network topology to achieve secure monitoring.Following registration on the IOT-fog-cloud framework:

- Step 1: The student combines comparable properties (C1... Cn) in various combinations between IoT devices and the fog layer.
- Step 2: Student combines the secure monitoring service with one of the combinations of similar features, assigns them ciphertexts, and transmits them all to the gateway in the fog layer.
- Step3: In step 2, the fog layer gateway decrypts every ciphertext that is sent to it.A gateway in the fog layer obtains security monitoring if it is successful in decrypting one of the ciphertexts.Then, as the student nodes in the hierarchy branch off of parent nodes in the fog layer, the gateway sends out several broadcasts to them. Digital signatures are required to generate a cryptographic secret key and the fog layer's secure service identifier; without these, the gateway will halt the protocol.
- Step4: In order to facilitate the decoding of the ciphertexts using secret keys, intermediate nodes in the fog layer verify the digital signatures.
  - -The gateway in the fog layer acquires the service if the ciphertexts have been successfully decrypted. It then delivers the remaining ciphertexts that have not been decrypted and the associated digital signatures to the student's nodes in the hierarchy and supplies their identify. Until it reaches the IoT devices, this process is repeated; if not, the gateway terminates the communication.
- Step 5: Upon arriving at the IoT device nodes, the cipher texts are decrypted using a secret key after the nodes verify the digital signatures. The IoT device node receives the service and collaborates in reading and sending e-exam answers if one of the ciphertexts is decrypted. IoT devices therefore produce a temporary secret key that is pertinent to the security monitoring service.Within every fog layer node, they produce secret keys that are connected to a secure monitoring service.IoT devices can also make use of each node's unique ID in the fog layer.
- Step 6: Every node in the fog layer receives a message from IoT device nodes, and the student uses their ID to access the service's secret key, which they subsequently give to the IoT device nodes.
- Step 7: The student acquires identifiers for nodes in the fog layer in addition to receiving identifiers for every IoT device that will be provided by the security monitoring service. After obtaining the service, the student sends all node IDs to the cloud.
- Step 8: The cloud performs two further steps:
  - It checks to see if the student's received IoT device layer nodes and fog layer nodes are genuine or not.
  - It are creates temporary secret keys using the identifiers of the security monitoring service after storing the symmetric secret keys supplied by the IoT device nodes. The pupil receives them from the cloud thereafter.
- Step 9: The student utilises the temporary secret key to guarantee that the security monitoring service, the following protocol, is executed.

**SecureControl/Monitoring Protocol B**

The monitoring process is managed by this protocol, which begins with the extraction of raw data from IoT device nodes, gathers and forwards the data to fognoses, and finally forwards the data (after processing) to the student.

- Studentries the surveillance programme

When IoT nodes receive the raw exam data, the monitoring procedure begins as follows:

- Step 1: The monitoring service receives the student's request, decides the monitoring period, and lets the student know when it expires. This indicates that fresh exam raw data have been received.
- Step 2: The student sends the electronic exam response to the fog layer gateway, utilising a distinct signature.
- Step 3: The fog layer's gateway verifies the incoming e-examan responses as follows:
- It verifies a distinct signature that contains the student's answer to the e-exam.The process is rejected if it is erroneous; else, the actions listed below are carried out.
- -Proceed to the next phase, which is to verify if the student's service time exceeds the current time to validate the request; if not, the process is terminated.
- It establishes a default time answer for new queries and saves the runtime of the student's request.
- It detects the runtime of the student's request, creates a signature using the secret key for the monitoring service, and distributes them to the student's nodes in the hierarchical levels.
- Step 4: Utilising nodes in the fog layer, Step 3 is repeated.
- Step 5: Repeat Step 3 using the IoT device's nodes.

**IoTnodes continuously send exam data to pupils through a structured hierarchy**

- Step 1: IoTnodes continuously send exam data to students through a hierarchical structure. It obtains the IoT device node e-exam time from the internal clock and the start time of the student-operated control/monitoring service.
- Step 2: It communicates its time and gives a pseudo-random sequence foreverydatabit.
- Step 3: It connects the bits' encryption with the preceding sequence.
- Step 4: It links data bits with fog layer nodes and gives the students a unique signature to verify the data bits.
- Step 5: Data bits are multicast in an ordered hierarchy.

**A fog node gathers information to send**

Intermediate nodes called fog nodes gather data and convey it to student nodes in a structured hierarchy before sending it to the students. Fog nodes gather information for transmission:

- In accordance with repeated steps and predetermined time, fog nodes gather data from active students' nodes and store the data in a mina repository.
- Fog nodes are intermediate nodes that gather data and transmit them to students' nodes in an organised hierarchy, then send them to students.
- Fog nodes collect completed data from all students' nodes and transmit them to their parent nodes in an organized hierarchy.

**Student reaches the e-exam results processing**

The student receives a terminal report including all the interpretations from all the organized IoT device nodes from the finished completed collection.

## CONCLUSION

To sum up, it is clear that fog computing (FC) ensures easy management for end users and cloud servers while also allowing for even greater flexibility. FC is a widely available facility that enables the sharing of physical resources and high processing capabilities, making it capable of resolving complicated emerging IoT problems. As was previously said, FC has several applications in a variety of industries, such as manufacturing, healthcare, and decentralized private education, to name just a few. Through the integration of an FC, the manufacturing industry is able to benefit from an efficient examination system that facilitates smart manufacturing. –HDLFusinga CNN.

However, there are certain difficulties with FC and it is not always effective. Among the most important problems that developers encounter are those related to scalability, complexity, security, and dynamicity. That said, developers will still be able to integrate FC into IoT, which is why the IoT-fog-cloud computing framework was developed. In general, the framework that is suggested in Figure Computing with IoT aims to improve endpoint security, monitoring, and computational application extension.

As a result, the suggested framework offers a security component when sharing an exam that has a number of security issues, including fine-grained access control and exam security preservation.It emphasises the security of e-exams with a focus on the organisation of security procedures and increases the effectiveness of E-exam data analysis by utilising a variety of various cryptographic techniques.Along with monitoring, it also improves the privacy and preservation of e-exam responses by cutting down on latency and power execution.

Notably, the two primary components of the IoT fog cloud framework are the layer components and the layer processes, without which it cannot function.Layer components that need to be merged are the cloud data centres, GFNs, and FGNs. A number of advantages can be obtained using inlayer processes since distribution processes aid in the reduction of latency, improvement of reaction times, and protection of confidentiality and privacy. Specifically, two protocols need to be used to guarantee a secure organisation and improve the monitoring procedure.

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