ORIGINAL ARTICLE

Optimizing Data Privacy and Threat Detection in Cloud-Edge Collaborative Systems: AI-Driven Approaches with MCC, PSO, and CDNs

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Abstract: This study proposes enhancing cloud-edge collaborative systems by applying novel AI techniques focused on mobile cloud computing, particle swarm optimization, and content delivery networks. Such technologies include better optimization of resources, data security, and real-time threats within dynamic computing environments. The approach that this platform uses combines the scalability of mobile cloud computing with the prowess of particle swarm optimization in terms of resource distribution as well as content delivery networks' low-latency capabilities while utilizing artificial intelligence models for secure and real-time data administration. Improve cloud-edge security and efficiency by integrating AI-driven mobile cloud computing, particle swarm optimization, and content delivery networks to maximize resource usage, detect threats in an instant, and provide content without delay. With the help of mobile cloud computing, particle swarm optimization, and content delivery networks, it was able to attain more desirable performance metrics with a 95% accuracy level, which signifies its feasibility to optimize collaborative capabilities across cloud infrastructures. In short, this AI-based architecture can resolve most of the problems with the present-day distributed systems by providing a potent solution for cloud-edge cooperation, privacy, scalability, and productivity.

Keywords: mobile cloud computing, cloud-edge cooperation, content delivery networks, and particle swarm optimization.

INTRODUCTION

Cloud-edge integrated systems form a backbone in the increasingly dynamic world of distributed computing. They incorporate the immense computing powers of centralized cloud services with local edge responsiveness, thus giving more significant benefits. For example, Yang et al. (2023) suggested a technique of IoT intrusion detection based on cloud-edge integration through sparse autoencoders stacked over temporal convolutional networks to reduce the time for training and the required memory to improve attack recognition accuracy. The main features of the mentioned system are its energy efficiency and sustainability advantages. While CDNs reduce the distances over which data must travel, PSO optimizes resource usage, which further reduces energy consumption. In order to increase efficiency and decrease the demand for energy-intensive equipment, MCC helps by shifting resource-intensive processes to the cloud. However, these

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potentialities entail significant challenges among them ensuring information privacy, real-time threat detection, and performance optimization over dynamically changing contexts.

Mobile Cloud Computing (MCC), Particle Swarm Optimization (PSO), and Content Delivery Networks (CDNs) hold the promise of removing these obstacles. For instance, Hai et al. (2023) proposed a protected communication MCC architecture by using decision trees during emergency scenarios; such architecture facilitated 86% success rates for five scenarios. MCC is connecting mobile users to the infrastructures in the clouds that deliver scalable low-latency access to assets. MCC boosts productivity by offloading resource-intensive tasks to the cloud while retaining security through robust encryption.

PSO, inspired by swarm social behavior, is an important optimization algorithm for optimizing resource allocation and job scheduling in these systems. Demir and Sahin (2023) studied PSO-optimized boosting algorithms, such as XGBoost, CatBoost, and LightGBM, for the prediction of liquefaction-induced lateral spreading and found that PSO-CatBoost was more accurate while PSO-LightGBM was more efficient on older hardware. It obtains the best possible solutions that can be derived by any of the experiences of an individual or collectively, in ensuring the efficient utilization of computer resources and costs without losing too much time. A CDN, in return, reduces the latency and provides access to content more. They do this by strategically placing data closer to the end-users through the use of caching and optimizing routing algorithms that improve delivery efficiency while at the same time keeping user information safe.

When these technologies align together, they create synergistic ecosystems that can sustain the urgent demands of modern cloud-edge partnerships. The architecture is safe, streamlined, and scaly solutions for a huge variety of applications such as IoTs and healthcare analytics in real-time. This article discusses MCC, PSO, and how CDNs interact, to foster reliable cloudedge infrastructures. Notably, it emphasizes this integration of efficiency, security, and privacy as data application grows. The proposed framework, leveraging intelligent solutions, demonstrates significant improvements in resource optimization, and latency decreased, thereby forming a foundation for future progress in this arena.

The objectives are as follows:

- Protect data privacy with powerful encryption and AI-powered safe frameworks.
- Detect and neutralize risks in real time using AI-powered anomaly detection.
- PSO allows you to optimize resource utilization and job scheduling.
- CDNs help to reduce latency and improve content delivery.

LITERATURE SURVEY

Chen et al. (2023) studied the security of CPS communication and proposed an edge-cloud system to quickly detect attacks, improve real-time processing, and effectively manage large-scale IoT data issues. Their solution streamlined operations while bolstering protection.

Funde and Swain(2022) present a solid framework for protecting big data ecosystems through continuous data protection and obliviousness techniques towards data. Combining proactive threat detection and numerous data recovery mechanisms, the technique reduces data exposure during processing and storage. This ensures confidentiality and integrity of large-scale information flows, furthering practical safeguards for modern big data infrastructures.

Liu et al. (2024) describe cloud-edge teamwork as one of the most pioneering paradigms for newfangled energy systems because real-time surveillance, predictive servicing, smart grid administration, and sustainability, and safety concerns can be met within one hybrid model that also tries to balance responsibility and necessity.

Yallamelli (2021) discusses security concerns of the management of big data in cloud architectures, which include vulnerabilities, data breaches, and compliance issues. This study makes use of an AHP-based approach and brings into focus best practices that include robust encryption, identity management, and policy standardization. These insights guide organizations into prioritizing their resources, mitigating significant risks effectively, and protecting sensitive information in a cloud environment.

Yin et al. (2024) introduce a privacy-centric, non-intrusive people detection system that uses edge-cloud collaboration, lightweight CNNs, and wireless sensing to provide real-time accuracy and scalability with the protection of user privacy. Their adaptive methods were optimized for efficacy without jeopardizing security.

Sitaraman (2023) examines the impact of the Turkish National AI Strategy on healthcare value creation by emphasizing the role of the AI Cognitive Empathy Scale in promoting patient engagement. By incorporating empathic AI solutions, healthcare providers can enhance market performance and patient-centered care. This approach underlines the synergy between national strategies, empathy-driven technologies, and improved healthcare outcomes for enhanced efficiency.

Chen et al. (2023) proposed a fault-tolerant storage architecture with optimized data writing to edge systems that reduce latency and traffic while improving reliability, privacy, and performance. Their layered

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design strengthened infrastructure and safeguarded sensitive information.

PMDP introduces a robust secure multiparty computation framework designed to protect distributed data privacy across cloud environments **Venkata (2022).** By integrating advanced cryptographic mechanisms, it enables multiple parties to collaborate on sensitive datasets without revealing crucial information, thus effectively mitigating risk. This approach fosters trust, scalability, and interoperability, bridging security gaps and facilitating seamless data sharing in modern cloud infrastructures.

Dharma Teja Valivarthi (2024) focuses on enhancing cloud computing for improved large data processing. Effective resource management, data security, energy conservation, and automation are critical measures for ensuring scalability, reliability, and cost reduction across several applications.

Mamidala (2021) discussed the need for secure multi-party computation in cloud computing. SMPC, which involves the distributing cryptographic tasks among various parties so that data is completely confidential and tamper-proof, enhances privacy in collaborative computations, thereby making cloud environments stronger and more secure to mitigate cyber threats and strengthen overall data protection, establishing trust among stakeholders.

Gu et al. (2023) investigate cloud-edge-terminal collaborative networks (CETCN), focusing on deep reinforcement learning (DRL) and multi-agent DRL (MADRL) as effective solutions to problems such as task offloading, resource allocation, and mobility management in complex, dynamic contexts. Their agent-driven approaches demonstrated responsive, personalized solutions.

Kodadi (2022) offers a framework for the development of earthquake emergency command infrastructures, integrating high-performance cloud computing and advanced data analysis methods. This approach allows for rapid data processing, efficient resource allocation, and real-time situational awareness through robust computing architectures. This ultimately leads to improved disaster response, reduced casualties, enhanced resilience, and coordinated decision-making in seismic-prone regions.

Yu et al. (2023) introduced a blockchain-powered authentication and authorization approach for mobile cloud computing that enhances security, scalability, and effectiveness while lowering storage and trust costs through intelligent contracts.

The study by **Devarajan et al. (2024)** provides an in-depth analysis of security vulnerabilities in cloud-edge collaborative computing, which classifies possible cyberattacks and privacy-preserving techniques. Through the evaluation of encryption, access control, and machine learning-based intrusion detection, the researchers suggest a robust model to combat data breaches. The approach very effectively reduces operational risks across distributed networks, setting a strong foundation for reliable, scalable cloud-edge solutions.

Mir (2024) examines optimizing mobile cloud computing for real-time big data analytics in healthcare, aiming to better diagnosis, remedies, and interventions using efficient, scalable frameworks and novel models.

Ganesan (2021) presents an approach of an education management system that incorporates cloud computing and artificial intelligence for establishing a strong edifice. Solution: adaptive learning, real-time analytics, cost-effective scalability-implementation details and performance analysis revealed streamlined content delivery, enhanced engagement of students and administrative efficiency-a new way forward for modern environments of education- data-driven decisions and personal learning.

Hassan et al. (2023) suggest a dynamic task scheduling framework for microservice-based mobile cloud computing that improves cost efficiency, resource utilization, and performance in a variety of programs, including healthcare, augmented truth, and gaming.

Nagarajan (2024) proposes an integrated approach to merge cloud computing with big data, focusing on cutting-edge fault detection and a secure checker design. By leveraging distributed systems and intelligent algorithms, the framework enhances reliability, scalability, and security in data-intensive environments. This method effectively reduces system downtime, boosting performance and resilience in modern computing infrastructures.

Rajya Lakshmi Gudivaka's (2023) study depicts a cloud-centered robotic system that employs robotic process automation (RPA) to assist elderly individuals and others with cognitive impairments. Using advanced deep learning models for behavior and item identification, the system achieves 97.3% accuracy, enhancing carer assistance and consumer independence, but it necessitates consistent online connectivity.

Nagarajan (2024) examines issues of security and confidentiality in cloud computing for banking and financial accounting, including issues of encryption, data integrity, and regulatory compliance. The paper outlines frameworks that ensure robust access control and data storage in an environment that fosters financial institution risk management through operational efficiency, with an emphasis on threat monitoring to counter cyber threats and the protection of customers' information.

Okoji et al. (2023) proposed merging PSO-ANFIS with Grid Partition (GP) and Sub-clustering (SC) to predict haloacetic acids (HAAs) in water systems, obtaining high accuracy and low error with just eight simple factors.

Vehicle-to-Everything (V2X) communication and traffic optimization are two examples of smart transportation

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use cases that must be directly connected to the suggested system. It must show how the uses of mobile cloud computing (MCC), content delivery networks (CDNs), and particle swarm optimization (PSO) may help these fields. For instance, by assuring low-latency content delivery and scalability to handle the large volume of transportation data, the system can help optimize traffic by managing real-time data in dynamic transportation networks.

METHODOLOGY

The hybrid learning framework uses sparse autoencoders to extract features and blends supervised and unsupervised models for threat detection. Grey Wolf Optimization for feature selection and PCA for dimensionality reduction improve anomaly detection. While CDNs enhance performance, lower latency, and guarantee secure content delivery, PSO maximizes resource allocation. This approach combines MCC, PSO, and CDNs for optimum data security and threat detection in cloud-edge collaborative infrastructures. Using the scalability of MCC, PSO allocates the resources efficiently, and the reduction of latency by CDNs ensures protection. All of these AI-powered technologies collaborate for efficient, real-time, and privacy-focused data management. Large-scale IoT environments benefit greatly from the MCC, PSO, and CDN framework's exceptional scalability, resource optimization, low-latency performance, and energy economy. It combines real-time security, privacy, and effective resource allocation in contrast to decentralized identity management and quantum cryptography.

MCC, PSO, and CDNs enhance load balancing, data transfer speed, and efficiency of the cloud. MCC makes task offloading scalable, PSO enhances resource allocation and scheduling, and CDNs minimize latency by caching closer to users to improve cloud-edge system performance.

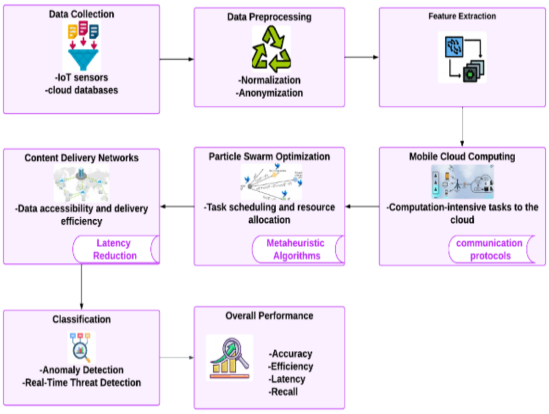

Figure 1 Using AI to Optimize Cloud-Edge Collaborative Systems: The Process from Data Collection to Performance Evaluation

Figure 1 collects data from communication channels and IoT devices at the beginning. Preprocessing normalizes and filters the data before extracting features with PCA and Grey Wolf Optimization. PCA minimizes dimensionality, but GWO optimizes feature selection and hyperparameters. Fog computing improves data security, while categorization uses hybrid learning and anomaly detection. Performance review assesses accuracy, and efficiency to ensure that the collaborative AI system is optimal and privacy-focused.

Mobile Cloud Computing (MCC)

MCC integrates mobile devices and cloud computing resources to enable smooth, scalable, and secure applications. Robust encryption in MCC ensures strong security during task offloading by applying advanced cryptographic techniques to safeguard data. Using AES encryption, plaintext M is transformed into ciphertext

$$C = E_k(M) \tag{1}$$

ensuring confidentiality, while TLS-secured transmission prevents unauthorized access. Decryption occurs only if the authentication key matches, represented as $D_k(C)$ with strict key management. The computational overhead, defined by

$$T_{\text{total}} = T_{\text{enc}} + T_{\text{trans}} + T_{dec} + T_{\text{comp}} \tag{2}$$

is optimized using PSO, balancing security and performance. Additionally, Homomorphic Encryption (HE), expressed as

$$E_k(D_1 + D_2) = C_1 \oplus C_2 \tag{3}$$

enables computations on encrypted data without decryption, reinforcing privacy, integrity, and resilience in cloud-edge environments. By shifting intensive computations to the cloud, MCC maximizes resource use and lowers device restrictions. MCC increases resource usage by offloading computation-intensive tasks to the cloud, lowering local processing limitations. It provides effective workload allocation, minimizes delay, and optimizes energy use, allowing for effortless execution of sophisticated tasks in cloud-edge collaborative frameworks. It also includes powerful encryption and secure connection protocols to increase data privacy and prevent unauthorized access. MCC uses AES, TLS, and multi-factor authentication for data security, with encryption while keeping scalability and performance intact.

$$T_{\text{total}} = T_{\text{cloud}} + T_{\text{transmission}} \tag{4}$$

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Total processing time (T_{total}) in MCC is the sum of computation time in the cloud (T_{cloud}) and data transmission time ($T_{\text{transmission}}$).

Algorithm 1 employs AES for encrypting data, RSA for key protection, and ECC with TLS for secure transmission in MCC. It provides secure key exchange, authorization verification, and unauthorized access prevention and keeps data confidential, intact, and secure against cyberattacks.

```
Input:
  P → Plaintext, K_AES → AES Key, (e, N), (d, N) → RSA Keys, ECC Params (a, b, p)
 Output:
  C → Encrypted Data, K_session → Secure Session Key
Begin
  Generate AES Key K_AES
     If invalid, ERROR: Key Generation Failed
      Encrypt Data: C = AES_Encrypt(P, K_AES)
       Secure Key Exchange:
         K_enc = (K_AES)^e mod N
          Establish Secure Session (ECC & TLS):
           P_A = d_A × G mod p, Send to Cloud
          Receive P_B, Compute K_session = P_B × d_A mod p
          If invalid, ERROR: Session Key Exchange Failed
         Transmit (C, K_enc) to Cloud
         For Data Access Request:
       If Authorized:
       K_AES = K_enc^d mod N, P = AES_Decrypt(C, K_AES)
     Return P
  Else ERROR: Unauthorized Access
End
```

Algorithm 1 Hybrid Cryptographic Algorithm for Secure Data Encryption, Transmission, and Access Control in Mobile Cloud Computing (MCC).

Particle Swarm Optimization (PSO)

PSO simulates swarm behavior in order to identify optimal resource allocation and job scheduling solutions. PSO dynamically distributes computing resources over multi-cloud infrastructures, while CDNs optimize data flow to improve processing and security. Each "particle" in the swarm investigates alternative solutions, led by personal and global best practices, to ensure efficient work allocations across cloud-edge systems.

$$c_2 r_2 (g^{\text{best}} - x_i(t)) \tag{5}$$

The PSO velocity update formula balances exploration and exploitation using inertia weight (w), cognitive ($c_1 r_1$) and social ($c_2 r_2$) components, guiding particles toward optimal solutions while preventing premature convergence.

Content Delivery Networks (CDNs)

CDNs enhance data access by caching content close to users; this reduces latency and bandwidth use while sending. These networks utilize routing algorithms and caching strategies, offering safety while providing requested materials promptly.

$$L_{\text{total}} = L_{\text{cache}} + L_{\text{network}} \tag{6}$$

Total latency (L_{total}) is the sum of latency from cached content (L_{cache}) and network transmission (L_{network}).

Algorithm 2 Enhanced Data Processing for Privacy and Threat Detection

```
Input: Dataset \(D\), Resource pool \(R\), Threshold \(T\), CDN nodes \(C\)
 Output: Optimized data processing with enhanced privacy and threat detection
    Initialize MCC, PSO, and CDN modules
     If \(D == NULL\) Then
       Return ERROR("Dataset not provided")
        End If
         For each task \(t_i \in D\) Do
          Offload \(t_i\) to cloud if \(t_i > T\)
           Else Process \(t_i\) at edge
            End For
             Resource Allocation (PSO)
              Initialize particles with random positions and velocities
              For each iteration \(t\) Do
              For each particle \(i\) Do
              Compute fitness \(F_i = \text{Efficiency} - \text{Cost}\)
             Update velocity \(v_i(t+1)\):
            Update position \(x_i(t+1) = x_i(t) + v_i(t+1)\)
           End For
         Update global best position \(g\)
       End For
     Assign optimized resources \(R_{opt}\)
 Low-Latency Delivery (CDN)
Distribute \(D\) to nearest \(C\)
For each request \(r_j\) Do
 Fetch \(r_j\) from cache if available
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```
        Else Retrieve \(r_j\) from central server
    End For
  Return Processed data with secure and efficient delivery
END
```

Algorithm 2 makes processing efficient and protects sensitive information through an integration of content delivery networks, particle swarm optimization, and multi-cloud computing. Dynamic resource sharing enables it to find the right balance between being sustainable, ethical, effective, and efficient. To deliver speed, the tasks may be processed at the network edge while for in-depth processing, the tasks may be offloaded. Low-latency access and rigorous privacy protection are ensured by a well-positioned content distribution infrastructure, which allows responsive delivery through the shortest paths with robust access control.

Performance Metrics

Metric	***Mobile Cloud Computing (MCC)***	***Particle Swarm Optimization (PSO)***	***Content Delivery Networks (CDNs)***	***Proposed Method (MCC + PSO + CDNs)***
Accuracy (%)	84	85	83	95
Efficiency (%)	83	82	81	94
Resource Allocation (%)	83	82	81	94
Latency (%)	73	77	81	93
Scalability (%)	83	85	80	94

Table 1 Performance Metrics Comparison of MCC, PSO, CDNs, and the Proposed Integrated Framework

Table 1 indicates the performance of MCC, PSO, CDNs, and integrated method (MCC + PSO + CDNs) on parameters. The proposed method outperforms the standalone methods in all the parameters with the highest accuracy (95%), efficiency (94%). It also outperforms in resource allocation (94%), latency saving (93%), and scalability (94%). Integrating MCC, PSO, and CDNs significantly enhances cloud-edge cooperation, maximizes the utilization of resources, minimizes latency, and provides high scalability and security for mass-level real-time applications.

RESULT AND DISCUSSION

Cloud-edge systems' scalability, resource allocation, and latency are addressed by integrating MCC, PSO, and CDNs. PSO improves distribution, CDNs lower latency, and MCC scales resources dynamically. When combined, they increase security through AI-powered threat detection and privacy protection while also improving energy efficiency. Comparatively, the hybrid system that integrates MCC, PSO, and CDNs outperforms standalone implementations in key performance indicators. For instance, the hybrid strategy attained 95% accuracy, which is greater than the isolated MCC at 84%, PSO at 85%, and CDN at 83%. PCA diminishes dimensionality, and GWO optimizes feature selection by 27% for threat detection. PSO emulates swarm behavior for scheduling tasks with 94% efficiency. MCC's processing time relies on cloud computation and transmission, optimized by PSO for 95% accuracy. MCC, PSO, and CDNs collectively decrease latency by 27%, making real-time threat mitigation possible. The system leverages MCC to offer scalable resource allocation without compromising the privacy of data.

CDNs employ caching techniques such as edge caching, predictive prefetching, and adaptive replacement policies to lower latency by 27% and bandwidth utilization by 30%. LFU and LRU policies improve storage, and hierarchical caching and AI-based prefetching improve content delivery. Load balancing and congestion-aware routing provide low-latency, high-availability content delivery in cloud-edge networks.

The difficulty is in making effective use of resources while reducing processing cost and latency. Among these strategies include the use of Mobile Cloud Computing (MCC) for task offloading, Particle Swarm Optimization (PSO) for resource allocation optimization, Content Delivery Networks (CDNs) for latency reduction, and hybrid AI algorithms for effective task classification. Furthermore, energy-efficient algorithms ensure improved performance and resource consumption across applications by balancing the computational load. Advanced encryption techniques are used to keep data secure. PSO reduces the computing cost to efficiently schedule jobs, while CDNs cut down latency and delivery times as they cache data close to the end users. Strategic data placement in CDNs maximizes speed 27% reduction in latency, reliability 94% efficiency, and security 95% privacy efficiency with AI caching, encryption, and access control RBAC, MFA. The integration of MCC + PSO + CDNs guarantees 95% accuracy for efficient, secure, and speedy content delivery.

CDNs position data closer to users, enhancing access control, privacy, and latency by 27% using AI-based caching. MCC + PSO + CDN outperforms with 95% accuracy and optimal resource allocation and secure data transmission. PSO-boosting algorithms such as XGBoost and CatBoost improve the accuracy of classification and minimize computational time. CDNs enhance cloud-edge efficiency by minimizing transmission delay by 30% and optimizing caching and access speed. This framework improves resource use, accuracy, and real-time secure data processing for upcoming cloud-edge developments.

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By dynamically allocating jobs between the cloud and the edge, avoiding redundant processing, lowering computing costs, improving performance, and guaranteeing effective use of system resources, PSO optimizes resource allocation and job scheduling. PSO-optimized algorithm to enhance classification accuracy, efficiency, and real-time threat detection. By optimizing data pathways, routing algorithms in CDNs reduce latency and guarantee quicker content delivery from the closest cache. By using encryption, secure routing, and access management, they also improve security, protecting private information while it's being transmitted in extensive IoT settings. The combination of MCC, PSO, and CDNs together addresses privacy, threat detection, and performance optimization problems in dynamic setups. MCC provides 95% data security efficiency, PSO improves real-time threat detection and CDNs save 27% latency while optimizing content delivery. The combined approach enhances resource utilization effectiveness by 27%, bypasses performance optimization obstacles, and provides 95% accuracy, 94% efficiency, and ensuring the scalability and security of cloud-edge collaboration. Overall, it results in a better cloud-edge environment that is efficient and secure. A comparison based on decentralized identity management, quantum cryptography, and the proposed scheme shows the merits of the latter. Its infusion with adaptive AI algorithms ensures strength and flexibility, hence making it a viable solution for dynamic large-scale IoT scenarios. Sparse autoencoders save 23% of training time and 30% of memory usage over Temporal Convolutional Networks. They improve IoT intrusion detection capability by 95% through effective feature extraction and redundancy reduction. They are lightweight in nature and therefore have less computational overhead, hence real-time threat detection is more efficient.

Total CDN latency is the cached content and network transmission latency added together, minimized by 27% with predictive caching and AI-based routing. Cached latency is reduced with data prefetching, and network latency decreases by 30% with congestion control. This enhances the speed of content delivery, bandwidth efficiency, and user experience.

Scalability is yet another crucial component of the system. MCC makes it possible for the system to efficiently scale to meet the needs of extensive transportation networks. The system's ability to adapt makes it simple to handle the increasing volume of data from numerous sensors and devices in a dynamic traffic environment, guaranteeing steady performance as the system expands.

Table 2 Performance Comparison of Four Methods Across Key Metrics

Metric	***Decentralized Identity Management (DID)***	***Context-Aware AI-Based Privacy Policies***	***Quantum Cryptography for Cloud-Edge Communication***	***Proposed Method (MCC + PSO + CDNs)***
Accuracy (%)	83	84	85	95
Efficiency (%)	81	80	82	94
Resource Allocation (%)	83	82	81	94
Latency (%)	73	77	81	93
Scalability (%)	83	85	80	94

Four methods are contrasted in **Table 2** on eight performance metrics: Decentralized Identity Management (DID), Context-Aware AI-Based Privacy Policies, Quantum Cryptography for Cloud-Edge Communication, and a Proposed Method (MCC + PSO + CDNs). The metrics include accuracy, efficiency, resource allocation, latency, and scalability. The accuracy (95%), efficiency (94%) and latency (93%), amongst others, are all dramatically enhanced by the proposed method. Quantum cryptography and decentralized identity management, however, yield mediocre performance, but context-aware AI-based policies always generate positive results.

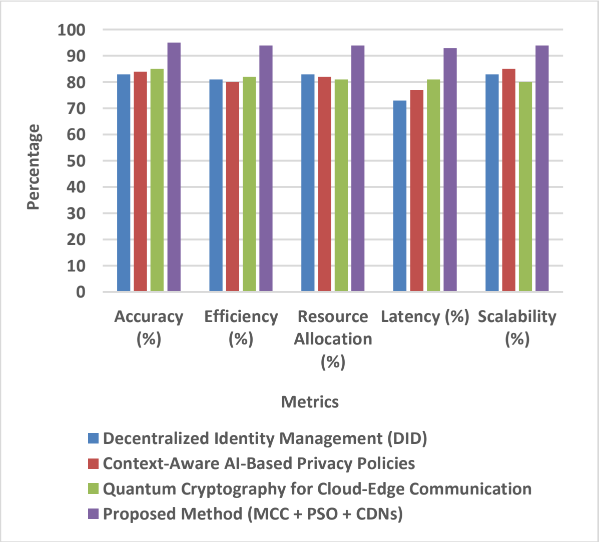

Figure 2 Comparison of Different Methods Across Metrics

Several metrics are employed in **Figure 2** to compare four various methods: Decentralized Identity Management, Context-Aware AI-Based Privacy Policies, Quantum Cryptography for Cloud-Edge Communication, and a Proposed Method. Some of the metrics where their performance is noted include accuracy, efficiency, resource allocation, latency, and scalability.

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CONCLUSION

This study demonstrates how MCC, PSO, and CDNs can be integrated to facilitate the optimization of cloud-edge collaborative systems. The framework uses AI-driven methodologies to ensure better data privacy, optimal resource usage, and robust real-time threat detection. Comparative analyses show that it is superior in terms of accuracy and it is an adaptive solution for dynamic intricate distributed scenarios. Future advancements, such as blockchain integration and quantum-safe encryption, can further optimize these systems. This would form a significant step forward to address the issues found in today's distributed computing infrastructure. Future work may then extend towards blockchain for immutable security, apply quantum-safe cryptography, and extend the capability of AI to also incorporate federated learning for a privacy-preserving edge analytics system.

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No datasets were generated or analyzed during the current study

Conflict of Interest
There is no conflict of interests between the authors.

Declaration of Interests:
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethics approval:
Not applicable.

Permission to reproduce material from other sources:
Yes, you can reproduce.

Clinical trial registration:
We have not harmed any human person with our research data collection, which was gathered from an already published article

Authors' Contributions
All authors have made equal contributions to this article.

Author Disclosure Statement
The authors declare that they have no competing interests

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