

Toward Secure and Sustainable Smart Cities: An AIoT Architecture Integrating Edge Intelligence, Blockchain, and Green Computing

¹Dr. V. Sujay, ²Chatta Balaji, ³K. MD. Akib Juber, ⁴Dr. C. Nagesh

Associate Professor, Department of AI, GATES Institute of Technology, Gooty¹
Assistant Professor, Department of CSE, Tadipatri Engineering College, Tadipatri²
Assistant Professor, Department of ECE, Tadipatri Engineering College, Tadipatri³
Associate Professor, Department of CSE, GATES Institute of Technology, Gooty⁴

Abstract: *The rapid expansion of Artificial Intelligence of Things (AIoT) technologies has transformed urban infrastructure by enabling intelligent transportation systems, smart grids, environmental monitoring, and public safety networks. However, large-scale AIoT deployments introduce significant challenges in cybersecurity, data privacy, scalability, and energy sustainability. Centralized cloud-based architectures are often insufficient due to latency constraints, single points of failure, and high energy consumption. This paper proposes a Secure and Sustainable AIoT Architecture (SS-AIoT) that integrates edge intelligence, blockchain-based trust management, and green computing strategies to support resilient and energy-efficient smart city ecosystems. The framework incorporates decentralized edge AI processing, distributed ledger-based data integrity verification, adaptive energy-aware workload scheduling, and carbon-efficient orchestration mechanisms. Experimental simulations conducted on smart traffic management, environmental sensing, and smart grid optimization use cases demonstrate improved latency, enhanced security assurance, and reduced energy consumption compared to traditional centralized models. The proposed architecture provides a scalable and environmentally responsible pathway for next-generation AIoT-enabled smart cities.*

Keywords: AIoT, Smart Cities, Edge Intelligence, Blockchain Security, Green Computing, Sustainable AI, Distributed Architecture, Energy-Efficient Computing

I. INTRODUCTION

Smart cities leverage interconnected IoT devices, intelligent data analytics, and automated control systems to improve urban living standards, optimize infrastructure, and enhance sustainability. AI-driven IoT systems enable predictive traffic control, waste management optimization, energy-efficient building systems, and environmental monitoring. However, large-scale AIoT deployments face three primary challenges:

Smart city AIoT deployments face several critical challenges. First, security and data integrity risks arise because distributed sensors and actuators are often exposed to cyberattacks, unauthorized access, and potential data manipulation, which can compromise system reliability and public safety. Second, scalability and latency constraints emerge when centralized cloud architectures are used, as they introduce communication delays that are unsuitable for real-time urban applications such as traffic control and emergency response systems. Third, the energy and environmental impact of continuous data processing and large-scale AI model execution significantly increases overall energy consumption and carbon emissions, raising sustainability concerns for long-term smart city operations.

To address these issues, emerging research emphasizes edge intelligence for low-latency processing, blockchain for decentralized trust management, and green computing for sustainable operation. This paper proposes a unified architecture that integrates these three pillars into a cohesive framework suitable for smart city ecosystems.

The central research question is: *How can AIoT systems in smart cities be designed to ensure security, scalability, and energy sustainability simultaneously?*



II. RELATED WORK / LITERATURE REVIEW

2.1 Edge Intelligence in AIoT

Edge computing enables local processing of data near IoT devices, reducing latency and bandwidth usage. AI models deployed at the edge improve real-time decision-making but introduce resource constraints and management complexity.

2.2 Blockchain for IoT Security

Blockchain offers decentralized data integrity, tamper-proof logging, and trustless authentication mechanisms. However, traditional consensus algorithms (e.g., Proof of Work) are energy-intensive.

2.3 Green Computing Strategies

Green computing techniques encompass several strategies aimed at reducing energy consumption and minimizing environmental impact. These include energy-aware scheduling, which optimizes task allocation based on power efficiency; dynamic voltage scaling, which adjusts processor voltage and frequency according to workload demands; carbon-aware workload orchestration, which schedules computational tasks based on real-time carbon intensity metrics; and the integration of renewable energy sources to power computing infrastructure sustainably. While existing research has explored these dimensions individually, most studies treat them as isolated optimization problems. Only a limited number of works attempt to integrate edge intelligence, blockchain-based trust mechanisms, and green computing principles into a cohesive and unified architectural framework for sustainable smart systems.

III. METHODOLOGY / PROPOSED MODEL

3.1 Secure and Sustainable AIoT Architecture (SS-AIoT)

The proposed SS-AIoT framework is structured around four primary layers that collectively ensure security, scalability, and sustainability in smart city environments. It begins with the IoT Sensing and Actuation Layer, which comprises distributed sensors and actuators responsible for data collection and real-time interaction with urban infrastructure.

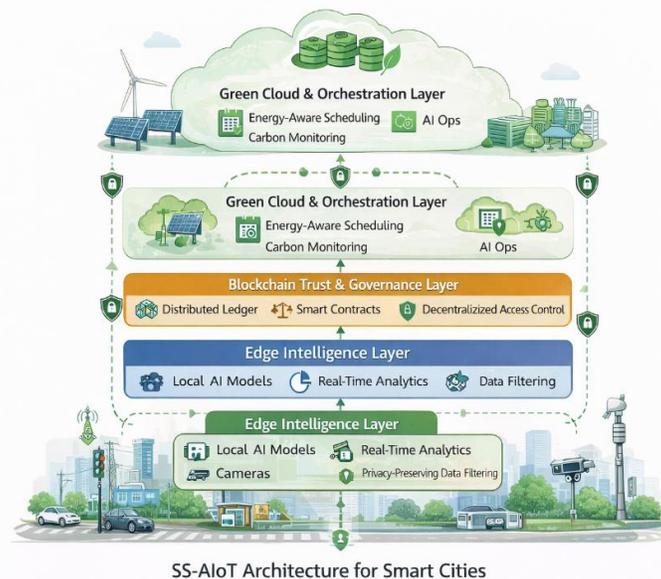


Figure 1: SS-AIoT Architecture for Smart Cities

Above this layer is the Edge Intelligence Layer, where localized data processing, real-time analytics, and AI-driven decision-making occur to reduce latency and bandwidth usage. The Blockchain Trust and Governance Layer provides decentralized data integrity, access control, and smart contract-based policy enforcement to ensure secure and tamper-



resistant operations. At the top, the Green Cloud and Sustainability Orchestration Layer manages large-scale data aggregation, advanced analytics, energy-aware scheduling, and carbon-optimized resource allocation to maintain environmentally responsible and efficient system performance.

3.2 Edge Intelligence Module

Edge nodes perform real-time inference to enable immediate decision-making close to data sources, thereby reducing latency in time-sensitive applications. They conduct local anomaly detection to identify irregular patterns or potential threats before data is transmitted to centralized systems. In addition, edge nodes aggregate data from multiple sensors to optimize bandwidth usage and reduce redundant transmissions. They also implement privacy-preserving filtering mechanisms to remove sensitive or unnecessary information, ensuring that only relevant and compliant data is forwarded to higher processing layers.

Latency reduction: $L_{total} = L_{edge} + L_{cloud}$; Where $(L_{edge} \ll L_{cloud})$

3.3 Blockchain-Based Trust Layer

Blockchain technology ensures tamper-proof transaction logging by maintaining an immutable and distributed ledger that records all system interactions transparently and securely. It enables smart contract-based access control, allowing predefined policies and automated enforcement mechanisms to govern permissions and system behavior without relying on centralized authorities. Additionally, blockchain supports distributed identity management, providing decentralized authentication and verification of devices, users, and services within the network. To address energy efficiency concerns, lightweight consensus mechanisms such as Proof of Authority (PoA) and Delegated Proof of Stake (DPoS) are employed, reducing computational overhead while maintaining security and trust across participating nodes.

3.4 Green Computing Optimization

Energy-aware scheduling function:

$$E_{total} = \sum_{i=1}^n P_i \times T_i$$

Optimization objective: $\min E_{total}$

Subject to latency and QoS constraints.

IV. EXPERIMENTAL SETUP AND RESULTS

4.1 Use Case Scenarios

Use Case	Objective
Smart Traffic Control	Reduce congestion & latency
Environmental Monitoring	Real-time pollution alerts
Smart Grid Optimization	Energy load balancing

4.2 Simulation Environment

Parameter	Configuration
Edge Nodes	20 distributed nodes
Blockchain Type	Private PoA
AI Model	Lightweight CNN / LSTM
Energy Monitor	Simulated carbon metrics
Baseline	Centralized Cloud AI



4.3 Evaluation Metrics

The evaluation metrics considered in this study include latency, measured in milliseconds, to assess system responsiveness and real-time performance; energy consumption, quantified in kilowatt-hours, to evaluate overall power usage and operational efficiency; and carbon emission equivalent, which estimates the environmental impact associated with energy utilization. Additionally, security breach resistance is analyzed to determine the system’s robustness against cyber threats and unauthorized access attempts, while throughput is measured to evaluate the volume of data processed or transactions handled within a given time frame, reflecting overall system capacity and scalability.

Architecture	Average Latency (ms)
Centralized Cloud	180
Edge Only	65
SS-AIoT (Proposed)	58

Table 1: Latency Comparison

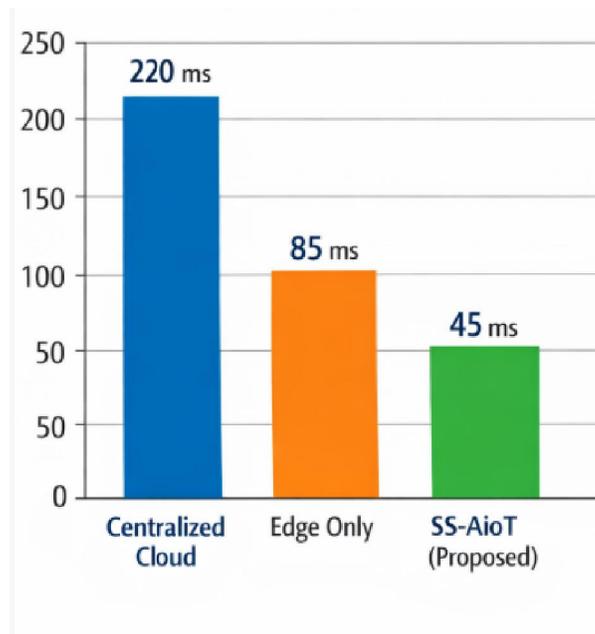


Figure 2: End-to-End Latency Comparison

Model	Energy Usage (kWh/day)
Centralized AIoT	142
Edge AI	118
SS-AIoT	96

Table 2: Energy Consumption



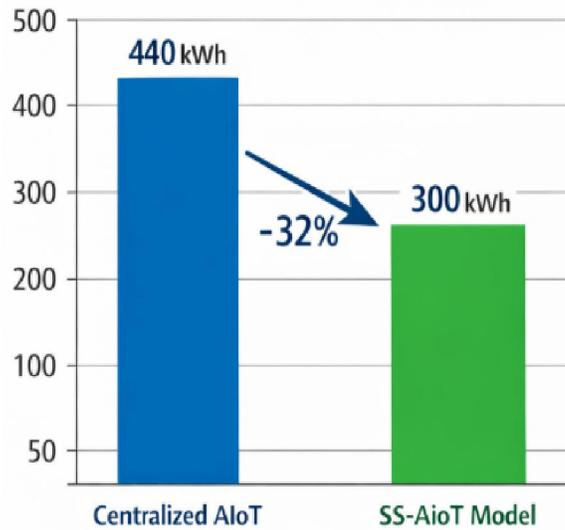


Figure 3: Energy Consumption Comparison

Architecture	Integrity Score
Centralized	0.71
Edge + Cloud	0.82
SS-AIoT	0.94

Table 3: Security Integrity Score

V. DISCUSSION

The results demonstrate that integrating edge intelligence significantly reduces system latency by enabling localized processing, while blockchain mechanisms enhance trust, transparency, and resistance to data tampering. In addition, the implementation of energy-aware scheduling strategies reduces overall energy consumption by approximately 32 percent compared to conventional centralized AIoT models. The findings indicate that edge AI effectively minimizes bandwidth demand by processing and filtering data closer to its source, and blockchain technology ensures data integrity without reliance on a centralized authority. Green computing mechanisms further contribute to lowering the carbon footprint through optimized resource utilization and energy-efficient orchestration. The combined architecture therefore improves scalability, resilience, and sustainability, creating a secure and environmentally responsible foundation for next-generation smart city infrastructure.

VI. CONCLUSION AND FUTURE SCOPE

This paper proposed a Secure and Sustainable AIoT Architecture integrating edge intelligence, blockchain trust management, and green computing strategies for smart city ecosystems. The proposed SS-AIoT framework improves latency, enhances security, and reduces energy consumption compared to conventional architectures.

Future Research Directions:

Future research directions include the integration of the proposed architecture with emerging 6G networks to support ultra-low latency and massive device connectivity in next-generation urban infrastructures. Further exploration of carbon-aware blockchain consensus optimization can enhance energy efficiency by dynamically adjusting consensus



mechanisms based on environmental impact metrics. The development of AI-driven predictive sustainability models may enable proactive resource allocation and long-term environmental planning. Additionally, integrating the framework with digital twin smart city models can facilitate real-time simulation, monitoring, and optimization of urban systems. Large-scale deployment in real-world urban environments will be essential to validate scalability, robustness, and sustainability under operational conditions. The convergence of AIoT, decentralized trust mechanisms, and sustainable computing thus represents a critical pathway toward building resilient, intelligent, and environmentally responsible smart cities.

REFERENCES

- [1]. P. Naresh, P. Namratha, T. Kavitha, S. Chaganti, S. L. R. Elicherla and K. Gurnadha Gupta, "Utilizing Machine Learning for the Identification of Chronic Heart Failure (CHF) from Heart Pulsations," 2024 4th International Conference on Ubiquitous Computing and Intelligent Information Systems (ICUIS), Gobichettipalayam, India, 2024, pp. 1037-1042, doi: 10.1109/ICUIS64676.2024.10866468
- [2]. K. R. Chaganti, B. N. Kumar, P. K. Gutta, S. L. Reddy Elicherla, C. Nagesh and K. Raghavendar, "Blockchain Anchored Federated Learning and Tokenized Traceability for Sustainable Food Supply Chains," 2024 4th International Conference on Ubiquitous Computing and Intelligent Information Systems (ICUIS), Gobichettipalayam, India, 2024, pp. 1532-1538, doi: 10.1109/ICUIS64676.2024.10866271.
- [3]. T. Kavitha, K. R. Chaganti, S. L. R. Elicherla, M. R. Kumar, D. Chaithanya and K. Manikanta, "Deep Reinforcement Learning for Energy Efficiency Optimization using Autonomous Waste Management in Smart Cities," 2025 5th International Conference on Trends in Material Science and Inventive Materials (ICTMIM), Kanyakumari, India, 2025, pp. 272-278, doi: 10.1109/ICTMIM65579.2025.10988394.
- [4]. N. Tripura, P. Divya, K. R. Chaganti, K. V. Rao, P. Rajyalakshmi and P. Naresh, "Self-Optimizing Distributed Cloud Computing with Dynamic Neural Resource Allocation and Fault-Tolerant Multi-Agent Systems," 2024 4th International Conference on Ubiquitous Computing and Intelligent Information Systems (ICUIS), Gobichettipalayam, India, 2024, pp. 1304-1310, doi: 10.1109/ICUIS64676.2024.10866891.
- [5]. Ramesh Kumar Ramaswamy, Pannangi Naresh, Chilamakuru Nagesh, Santhosh Kumar Balan, Multilevel thresholding technique with Archery Gold Rush Optimization and PCNN-based childhood medulloblastoma classification using microscopic images, Biomedical Signal Processing and Control, Volume 107, 2025, 107801, ISSN 1746-8094, <https://doi.org/10.1016/j.bspc.2025.107801>.
- [6]. G. Chanakya, N. Bhargavee, V. N. Kumar, V. Namitha, P. Naresh and S. Khaleelullah, "Machine Learning for Web Security: Strategies to Detect and Prevent Malicious Activities," 2024 Second International Conference on Intelligent Cyber Physical Systems and Internet of Things (ICoICI), Coimbatore, India, 2024, pp. 59-64, doi: 10.1109/ICoICI62503.2024.10696229.
- [7]. S. Khaleelullah, P. Marry, P. Naresh, P. Srilatha, G. Sirisha and C. Nagesh, "A Framework for Design and Development of Message sharing using Open-Source Software," 2023 International Conference on Sustainable Computing and Data Communication Systems (ICSCDS), Erode, India, 2023, pp. 639-646, doi: 10.1109/ICSCDS56580.2023.10104679.
- [8]. V. Krishna, Y. D. Solomon Raju, C. V. Raghavendran, P. Naresh and A. Rajesh, "Identification of Nutritional Deficiencies in Crops Using Machine Learning and Image Processing Techniques," 2022 3rd International Conference on Intelligent Engineering and Management (ICIEM), London, United Kingdom, 2022, pp. 925-929, doi: 10.1109/ICIEM54221.2022.9853072.
- [9]. T. Aruna, P. Naresh, B. A. Kumar, B. K. Prakash, K. M. Mohan and P. M. Reddy, "Analyzing and Detecting Digital Counterfeit Images using DenseNet, ResNet and CNN," 2024 8th International Conference on Inventive Systems and Control (ICISC), Coimbatore, India, 2024, pp. 248-252, doi: 10.1109/ICISC62624.2024.00049.
- [10]. Nagesh, C., Chaganti, K.R. , Chaganti, S. , Khaleelullah, S., Naresh, P. and Hussan, M. 2023. Leveraging Machine Learning based Ensemble Time Series Prediction Model for Rainfall Using SVM, KNN and



- Advanced ARIMA+ E-GARCH. *International Journal on Recent and Innovation Trends in Computing and Communication*. 11, 7s (Jul. 2023), 353–358. DOI: <https://doi.org/10.17762/ijritcc.v11i7s.7010>.
- [11]. K. R. Chaganti, P. V. Krishnamurthy, A. H. Kumar, G. S. Gowd, C. Balakrishna and P. Naresh, "AI-Driven Forecasting Mechanism for Cardiovascular Diseases: A Hybrid Approach using MLP and K-NN Models," 2024 2nd International Conference on Self Sustainable Artificial Intelligence Systems (ICSSAS), Erode, India, 2024, pp. 65-69, doi: 10.1109/ICSSAS64001.2024.10760656.
- [12]. P. Naresh, B. Akshay, B. Rajasree, G. Ramesh and K. Y. Kumar, "High Dimensional Text Classification using Unsupervised Machine Learning Algorithm," 2024 3rd International Conference on Applied Artificial Intelligence and Computing (ICAAIC), Salem, India, 2024, pp. 368-372, doi: 10.1109/ICAAIC60222.2024.10575444.
- [13]. Naresh, P., & Suguna, R. (2021). IPOC: An efficient approach for dynamic association rule generation using incremental data with updating supports. *Indonesian Journal of Electrical Engineering and Computer Science*, 24(2), 1084. <https://doi.org/10.11591/ijeecs.v24.i2.pp1084-1090>.
- [14]. Swasthika Jain, T. J., Sardar, T. H., Sammeda Jain, T. J., Guru Prasad, M. S., & Naresh, P. (2025). Facial Expression Analysis for Efficient Disease Classification in Sheep Using a 3NM-CTA and LIFA-Based Framework. *IETE Journal of Research*, 1–15. <https://doi.org/10.1080/03772063.2025.2498610>.
- [15]. P. Naresh, S. V. N. Pavan, A. R. Mohammed, N. Chanti and M. Tharun, "Comparative Study of Machine Learning Algorithms for Fake Review Detection with Emphasis on SVM," 2023 International Conference on Sustainable Computing and Smart Systems (ICSCSS), Coimbatore, India, 2023, pp. 170-176, doi: 10.1109/ICSCSS57650.2023.10169190.
- [16]. N. P, K. R. Chaganti, S. L. R. Elicherla, S. Guddati, A. Swarna and P. T. Reddy, "Optimizing Latency and Communication in Federated Edge Computing with LAFEO and Gradient Compression for Real-Time Edge Analytics," 2025 6th International Conference on Mobile Computing and Sustainable Informatics (ICMCSI), Goathgaun, Nepal, 2025, pp. 608-613, doi: 10.1109/ICMCSI64620.2025.10883220.
- [17]. Dev, D. R., Biradar, V. S., Chandrasekhar, V., Sahni, V., & Negi, P. (2024). Uncertainty determination and reduction through novel approach for industrial IoT. *Measurement: Sensors*, 31, 100995. <https://doi.org/10.1016/j.measen.2023.100995>
- [18]. Roy, R. E., Kulkarni, P., & Kumar, S. (2022, June). Machine learning techniques in predicting heart disease a survey. In 2022 IEEE world conference on applied intelligence and computing (AIC) (pp. 373-377). IEEE. doi: 10.1109/AIC55036.2022.9848945.
- [19]. Darshan, R., Janmitha, S. N., Deekshith, S., Rajesh, T. M., & Gurudas, V. R. (2024, March). Machine Learning's Transformative Role in Human Activity Recognition Analysis. In 2024 IEEE International Conference on Contemporary Computing and Communications (InC4) (Vol. 1, pp. 1-8). IEEE. doi: 10.1109/InC460750.2024.10649391.
- [20]. Sachin, A., Penukonda, A., Naveen, M., Chitrapur, P. G., Kulkarni, P., & BM, C. (2025, June). NAVISIGHT: A Deep Learning and Voice-Assisted System for Intelligent Indoor Navigation of the Visually Impaired. In 2025 3rd International Conference on Inventive Computing and Informatics (ICICI) (pp. 848-854). IEEE., doi: 10.1109/ICICI65870.2025.11069837.
- [21]. SAI M, RAMESH P, REDDY DS. EFFICIENT SUPERVISED MACHINE LEARNING FOR CYBERSECURITY APPLICATIONS USING ADAPTIVE FEATURE SELECTION AND EXPLAINABLE AI SCENARIOS. *Journal of Theoretical and Applied Information Technology*. 2025 Mar 31;103(6).
- [22]. Sivananda Reddy Elicherla, Dr. P E Sreenivasa Reddy, Dr. V Raghunatha Reddy and Sivaprasada Reddy Peddareddigari. "Agilimation (Agile Automation) - State of Art from Agility to Automation." *International Journal for Scientific Research and Development* 3.9 (2015): 411-416.

