MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
ISSN: 1053-7899
Vol. 36 Issue 1, 2026, Pages: 3853-3855

SCALABLE EVENT DRIVEN ANALYTICS FOR HETEROGENEOUS IOT STREAMS IN SMART INFRASTRUCTURE SYSTEMS

Dr. G. Kalaiarasi,
Assistant Professor,
Vignans Foundation for Science, Technology and Research, (Deemed to be University), kalaiibe@gmail.com
SVK. Deepikapriya,
Assistant Professor, Department of ECE,
Kgisl institute of technology, Coimbatore, India
svkdeepika@gmail.com
Nithya. C,
Assistant Professor, Department of Computer Science and Business Systems
Knowledge Institute of Technology, India
nithya.acet@gmail.com
Dr S Subasree,
Dean & HoD, Department of Cyber Security,
Sri Shakthi Institute of Engineering and Technology, Coimbatore, India
drssubasree@gmail.com
Dr T Jayaprakash
Professor in Physics (S&H), Department of Science and Humanities,
Nehru Institute of Technology Coimbatore, India
nitjayaprakash@nehrucolleges.com
Rajasekar. M
Associate Professor, Department of Computer Science and Engineering
VSB college of engineering technical campus, Coimbatore, India
rajasekarcsevsbcetc@gmail.com

Abstract
This article is a critical analysis of scalable event-driven analytics to heterogeneous IoT streams in smart infrastructure systems. It deals with architectural approaches, data integration issues, and scalability, and focuses on real-time analytics to improve decision-making and operational performance. The key limitations and future research directions are also indicated in the article.

Keywords: IoT, Event-Driven Analytics, Smart Infrastructure

1. Introduction

Smart infrastructure, such as urban infrastructure, transport networks, and energy systems, is based on connected digital technologies that enhance the efficiency of operations and sustainability and overall service delivery in contemporary settings (CIO, 2024). The systems are based on the Internet of Things (IoT), in which sensors and devices collect and share data in urban environments at all times. The swift development of the IoT has resulted in the creation of huge heterogeneous streams of data from various sources, including sensors, networks and user-generated inputs, which have become more complicated to deal with in terms of data management (Corral-Plaza *et al.,* 2020).

Real-time analytics is essential in facilitating the timely and data-driven decision-making, and it is applicable in applications like traffic control, energy optimisation, and the safety of a populace (Chauhan *et al.,* 2021). The event-based analytics, such as stream and complex event processing, allow the systems to respond in real-time to changes in streaming data. The IoT data has a high volume, velocity, and variability, making scalability a problem that demands sophisticated architectures and effective processing engines (Nadkarni, 2026). The purpose of this article is to critically analyse scalable event-driven analytics solutions to heterogeneous Internet of Things streams management in smart infrastructure systems.

2. Event-Driven Architectures in IoT Systems

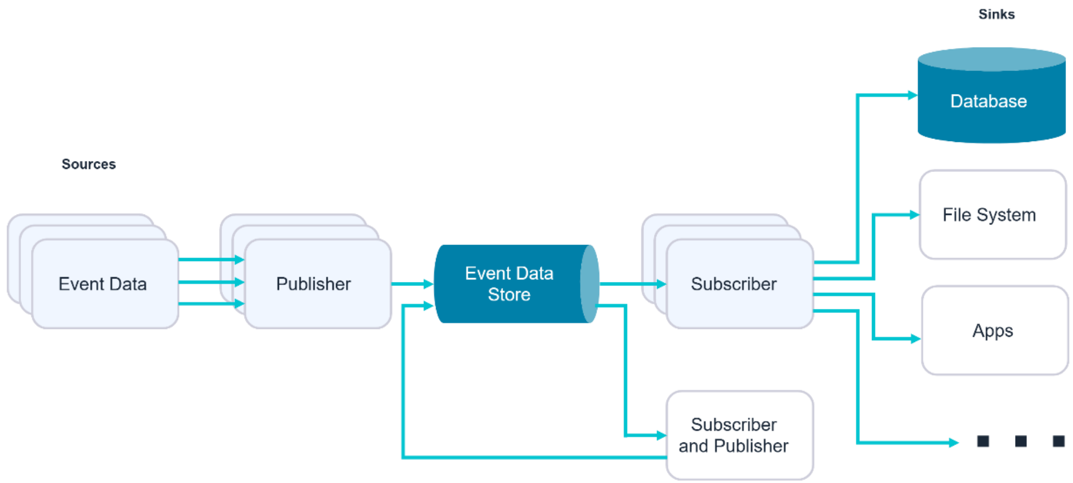

Figure one: Event-driven architecture (EDA)
Source: Amazon, 2025

EDA is a system design that is based on the concept that components in the system react to system state changes via asynchronous communication. As compared to batch processing, where data is processed at predetermined time intervals, the event-driven models process data in real time, therefore allowing immediate response (Amazon, 2025). EDA is compatible with traffic monitoring, energy optimisation, and predictive maintenance since real-time processing of data and automated decision-making can be achieved with its help (Cabane and Farias, 2024). EDA offers scalability, high responsiveness and low latency by real-time event processing. It introduces complexity; there is the risk of overloading of events and problems with integrating systems at a distance.

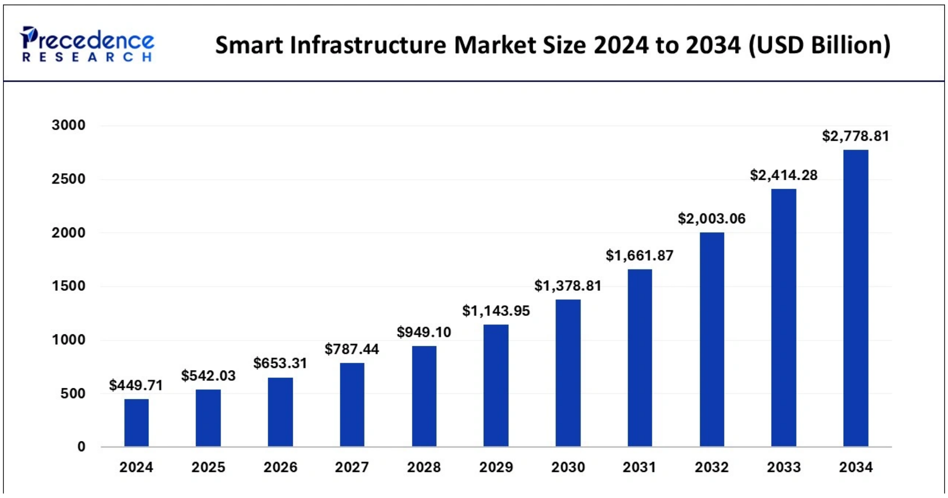

Figure two: "Smart Infrastructure Market"
Source: Precedence research, 2025

3. Handling Heterogeneous IoT Data Streams

The IoT settings produce categorised, semi-structured, and unstructured data from various sensors and devices. Such devices are based on various communication protocols, including MQTT, CoAP, and HTTP, generating data with dissimilar formats and formats, and this complexity adds complexity to the system (Gutierrez *et al.,* 2025). There is an issue of incompatible standards and protocols between platforms that makes integration difficult. The open standards and middleware solutions promote data translation, whereas APIs and semantic frameworks promote interoperability and effective data integration across systems. The heterogeneous data in the IoT tend to be noisy, have missing values and be inconsistent, which have implications on reliability. Incorrect analytics and faulty decision-making of smart infrastructure systems can arise with poor data quality (Sullivan and Lin, 2021; Moldstud, 2024).

4. Scalability Problems and Solutions

IoT systems produce big data, which has high velocity, volume and variety of data, making it difficult to scale the processing and storage of this data. With continuous conduction of data to centralised systems, bandwidth is constrained, and latency is also experienced, particularly in applications that are real-time (Manduva, 2023). Edge and fog computing also help in minimising latency since they are able to process data nearer to the source compared to cloud computing, which depends on centralised data centres (Dallaf, 2025). Distributed architecture facilitates load balancing, decentralisation of processing and enhances the responsiveness and scalability of the system. Apache Kafka and Apache Flink are stream processing systems that are used to handle real-time data in a scalable system (Batista Jr *et al.,* 2026). The combination of AI and machine learning stimulates the adaptable allocation of resources and effective analytics in dynamic IoT settings.

5. Security and Privacy Requirement

IoT systems receive immense volumes of sensitive information on infrastructure like smart grids and surveillance systems, posing a serious privacy risk. The unauthorised access, the leakage of data and the unencrypted transmissions may disclose the personal and operational information. The issue of constant data gathering by means of sensors creates the problem of surveillance and information abuse, especially when users do not know their data habits (Polat and Sodah, 2019).

IoT systems that are event-driven are based on distributed systems, which makes them more susceptible to cyberattacks. Devices are prone to malware and botnet attacks like the Mirai against weak authentication, insecure APIs, and default credentials. Moreover, the absence of standardisation and non-uniform environments makes the security management difficult and expands attack surfaces (Emily and Oliver, 2020; Trabelsi *et al.,* 2023).

To mitigate these risks, there is a need to have strong security. Encryption is used to guarantee data confidentiality in the transmission process, whereas strong authentication and access control are used to guarantee unauthorised access. New solutions like blockchain can be used to improve trust and data integrity in distributed systems. Moreover, secure device management, routine updates, and standardised security structures can also enhance resilience to cyber threats to a great extent (Sun *et al.,* 2025).

6. Discussion

The existing solutions to scalable event-driven analytics in IoT systems prove to be very promising but still ineffective due to the complexities of the architecture and operation of the system. With centralised, massive heterogeneous data streams are difficult to process efficiently, resulting in latency and bottlenecks, whereas distributed edge-based solutions are more responsive at the expense of management and coordination issues. Despite the fact that edge computing improves real-time decision-making, challenges like resource limitations, interoperability, and heterogeneity of systems still affect the optimal performance of the systems (Ashwini *et al.,* 2025).

Scalability, latency and security have a very important trade-off. As the decentralised processing minimises the latency and network congestion, the application of more sophisticated security protocols like encryption and federated learning raises the computation cost and the response time. There is a lack of scalability of cloud-based models that address the demands of the time-sensitive needs of applications, and this demonstrates the necessity of hybrid architectures (Abkenar *et al.,* 2022).

Even with improvements, there exist a number of research gaps. The unified frameworks which combine scalability, interoperability, and security in the heterogeneous IoT environment are lacking. Some of the current systems tend to be based on disjointed solutions, and cross-platform integration becomes a challenge. There are no data synchronisation, standardisation, or effective resource allocation problems to implement large-scale deployment (Vahabi and Fotouhi, 2025).

The trends of the future show that the analytics of AI and self-driving infrastructure systems will change. It is anticipated that the combination of artificial intelligence and machine learning at the edge will facilitate the adaptive decision-making process, predictive analytics, and effective resource management. The new technologies, like 5G or blockchain and the integration of edge and cloud computing will help improve the scalability of systems and their security, as well as their real-time work, contributing to the development of intelligent and self-monitoring smart infrastructure systems (Hamdan *et al.,* 2020).

MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
ISSN: 1053-7899
Vol. 36 Issue 1, 2026, Pages: 3853-3855

7. Conclusion

The scalable event-driven analytics is particularly important in handling heterogeneous data of IoT in smart infrastructure systems. In this article, the authors showed that event-driven architectures support real-time processing and deal with the complexity of processing diverse data streams and scaling the system. The discussion has highlighted the need to combine edge and cloud computing to achieve a balance in performance and efficiency. Such obstacles as data interoperability, data security risks, and the complexity of the system still play a crucial role. Notwithstanding these problems, there are openings that exist in the emerging technologies, such as AI-based analytics and decentralised architectures. The scalable, secure and adaptive solutions are important in improving the decision making, operational efficiency and supporting future development of intelligent and resilient smart infrastructure systems.

8. Recommendations

A hybrid edge-cloud architecture needs to be adopted to support IoT systems in terms of scalability and interoperability. A low-latency processing built through edge computing is combined with scalability and storage through cloud capability that forms a balanced and efficient system design. The governments and agencies, including the National Institute of Standards and Technology, state the necessity of standardised data models and taxonomies to enhance interoperability in heterogeneous IoT settings (Naveen and Kounte, 2019).

It is important to invest in AI-based analytics systems since machine learning would advance adaptive decision-making and effective resource management in dynamic infrastructures. In addition, the security frameworks require enhancement in terms of encryption, authentication, and lightweight cryptographic solutions to ensure that the resource-constrained IoT devices are secured (Gușiță *et al.,* 2025).

Lastly, additional studies must be conducted in the future with the aim of coming up with a single framework, which combine scalability, interoperability, and security. The emergence of international standardisation efforts, including the International Telecommunication Union, emphasises the need to have a coordinated approach at the global level to enable reliable, secure and scalable smart infrastructure systems (Calderini and Giannaccari, 2006).

References

Abkenar, F.S., Ramezani, P., Iranmanesh, S., Murali, S., Chulerttiyawong, D., Wan, X., Jamalipour, A. and Raad, R., 2022. A survey on mobility of edge computing networks in IoT: State-of-the-art, architectures, and challenges. *IEEE Communications Surveys & Tutorials*, *24*(4), pp.2329-2365.

Amazon, 2025. *What is EDA (Event-Driven Architecture)?* Available at: https://aws.amazon.com/what-is/eda// [Accessed on: 18th March 2026]

Ashwini, N., Dava, S., Phanindra, A.R., Ranjith kumar, G., Rajkumar, K.V. and Sravanthi, N., 2025. ThreatFedChainAI: an adaptive edge blockchain architecture for big data-driven threat analytics in IoT networks. *Scientific Reports*.

Batista Jr, E.P., Santos, A., Peixoto, M., Figueiredo, G. and Prazeres, C., 2026. Edge AI for SD-IoT: A Systematic Review on Scalability and Latency. *IoT*, *7*(1), p.23.

Cabane, H. and Farias, K., 2024. On the impact of event-driven architecture on performance: An exploratory study. *Future Generation Computer Systems*, *153*, pp.52-69.

Calderini, M. and Giannaccari, A., 2006. Standardisation in the ICT sector: The (complex) interface between antitrust and intellectual property. *Econ. Innov. New Techn.*, *15*(6), pp.543-567.

Chauhan, G.S., Jadon, R. and Awotunde, J.B., 2021. Smart IoT analytics: Leveraging device management platforms and real-time data integration with self-organizing maps for enhanced decision-making. *International Journal of Applied Science, Engineering, and Management*, *15*(2).

CIO, 2024. *The role of IoT in shaping smart cities*. Available at: https://www.cio.com/article/3543891/the-role-of-iot-in-shaping-smart-cities.html [Accessed on: 18th March 2026]

Corral-Plaza, D., Medina-Bulo, I., Ortiz, G. and Boubeta-Puig, J., 2020. A stream processing architecture for heterogeneous data sources in the Internet of Things. *Computer Standards & Interfaces*, *70*, p.103426.

Dallaf, A.A.A., 2025. Edge computing in IoT networks: Enhancing efficiency, reducing latency, and improving scalability. *International journal of advanced network, monitoring and controls*, *10*(1), pp.103-115.

Emily, H. and Oliver, B., 2020. Event-driven architectures in modern systems: designing scalable, resilient, and real-time solutions. *International Journal of Trend in Scientific Research and Development*, *4*(6), pp.1958-1976.

Gușiță, B., Anton, A.A., Stângaciu, C.S., Stănescu, D., Găină, L.I. and Micea, M.V., 2025. Securing IoT edge: a survey on lightweight cryptography, anonymous routing and communication protocol enhancements: B. Gușiță et al. *International Journal of Information Security*, *24*(3), p.149.

Gutierrez, R., Villegas-Ch, W. and Govea, J., 2025. Modular middleware for IoT: scalability, interoperability and energy efficiency in smart campus. *Frontiers in Communications and Networks*, *6*, p.1672617.

Hamdan, S., Ayyash, M. and Almajali, S., 2020. Edge-computing architectures for internet of things applications: A survey. *Sensors*, *20*(22), p.6441.

Manduva, V.C., 2023. AI-Driven Edge Computing in the Cloud Era: Challenges and Opportunities. *International Journal of Scientific Research and Management*.

Moldstud, 2024. *Achieving Data Integration in Enterprise IoT Solutions*. Available at: https://moldstud.com/articles/p-achieving-data-integration-in-enterprise-iot-solutions [Accessed on: 18th March 2026]

Nadkarni, S., 2026. Smart City as a Catalyst for Social Innovation: The Case of Dubai. In *Tech-Enabled Urbanism and Entrepreneurship for Inclusive Cities* (pp. 231-251). Singapore: Springer Nature Singapore.

Naveen, S. and Kounte, M.R., 2019, December. Key technologies and challenges in IoT edge computing. In *2019 Third international conference on I-SMAC (IoT in social, mobile, analytics and cloud)(I-SMAC)* (pp. 61-65). IEEE.

Polat, G. and Sodah, F., 2019. Security issues in iot: Challenges and countermeasures. *Isaca journal*, pp.1-7.

Sullivan, H. and Lin, M., 2021. Cloud-centric iot data processing: A multi-platform approach using aws, azure, and snowflake. *International Journal of AI, BigData, Computational and Management Studies*, *2*(1), pp.12-23.

Sun, P., Wan, Y., Wu, Z., Fang, Z. and Li, Q., 2025. A survey on privacy and security issues in IoT-based environments: Technologies, protection measures and future directions. *Computers & security*, *148*, p.104097.

Trabelsi, N., Politowski, C. and El Boussaidi, G., 2023, May. Event driven architecture: An exploratory study on the gap between academia and industry. In *2023 IEEE/ACM 5th International Workshop on Software Engineering Research and Practices for the IoT (SERP4IoT)* (pp. 25-32). IEEE.

Vahabi, M. and Fotouhi, H., 2025. Federated learning at the edge in Industrial Internet of Things: A review. *Sustainable Computing: Informatics and Systems*, *46*, p.101087.

Precedence research, 2025. *Smart Infrastructure Market Set for Transformative Growth Driven by Urbanization and Innovation*. https://www.precedenceresearch.com/smart-infrastructure-market