Digital platforms and cloud computing for smart cities: a review

William Christopher Immanuel[1], Anitha Juliette Albert[2], Limsa Joshi Jerald Jobitham[3], Roselene Rebecca Selvaraj[4], Benita Sharon Ruban[1], Bennet Vini Robin[1], Andria Morais Allen[1]
[1]Department of Electrical and Electronics Engineering, Loyola-ICAM College of Engineering and Technology, Chennai, India
[2]Department of Electronics and Communication Engineering, Loyola-ICAM College of Engineering and Technology, Chennai, India
[3]Department of Computer Science and Engineering, Loyola-ICAM College of Engineering and Technology, Chennai, India
[4]Senior Content Marketer, Joy Technologies, Pacifica Tech Park, Chennai, India

Article Info

Article history:

Received Sep 24, 2024
Revised Jun 29, 2025
Accepted Aug 6, 2025

Keywords:

Cloud computing
Digital platforms
IoT solutions
Quality of life
Smart cities
Sustainable development

ABSTRACT

The rapid urbanization of the modern world initiated the emergence of digital cities, where advanced technologies converge to optimize urban living and address the limitations of a rapidly growing population. Central to this transformation are digital platforms and cloud computing. These interconnected technologies aid in shaping the future of urban landscapes, fostering sustainability, efficiency, and improved quality of life. Digital platforms serve as the backbone of smart cities, enabling seamless integration and management of various urban services and systems. One significant application of digital platforms in smart cities is the implementation of intelligent transportation systems (ITS). By integrating real-time traffic data, public transit information, and ride-sharing services, these platforms facilitate efficient transportation management, reduce congestion, and decrease carbon emissions. Cloud computing serves as a key enabler for managing the massive data flows generated by smart city infrastructures. The scalability and flexibility offered by cloud-based solutions allow cities to manage their resources efficiently and access computing power on demand without the need for extensive physical infrastructure. Cloud computing enhances smart city development by enabling collaborative data access and interaction among diverse stakeholders, from government agencies to private firms and residents.

Corresponding Author:

William Christopher Immanuel
Department of Electrical and Electronics Engineering
Loyola-ICAM College of Engineering and Technology
Chennai, India
Email: iwchristop@gmail.com

1. INTRODUCTION

The roots of smart cities trace back to the 1960s and 1970s, when the U.S. Community Analysis Bureau pioneered data-driven approaches, such as aerial photography, databases, and cluster analysis to improve service delivery, disaster relief, and poverty intervention. This opened the door for the development of the first wave of smart cities. In an effort to showcase technology's influence on daily life, tech companies developed the idea of early smart cities. With time, this developed into the second wave of smart cities, which looked at how additional breakthroughs and smart technologies may support integrated urban solutions. The third wave of smart cities then moved decision-making away from tech companies and municipal officials and towards a public participation approach that encouraged social inclusion and community involvement. The concept of "smart cities" is gaining popularity worldwide to address issues related to urbanization, environmental sustainability, and economic growth [1]. As more people live in cities and technology develops, these investments will become more and more crucial [2]. Governments and business organizations have invested a significant amount of money in smart city projects in recent years. Figure 1 categorizes the application domains relevant to smart cities. As smart city initiatives advance, the demand for detailed research into their current state and practical uses continues to grow. Smart cities incorporate the internet of things (IoT) technology alongside software platforms, user-centric interfaces, and data communication infrastructures to provide innovative solutions for the general public. To improve sector efficiency and promote societal and economic well-being, data from these devices is stored either on servers or in the cloud. These support the development of innovative applications to enhance the general standard of living for their populace in several areas, such as government services, utilities, healthcare, transportation, and entertainment [3]. As per reference [4], smart cities are characterized by these attributes:

– Sensors make sense of their surroundings and Sensing data is sent from networked devices to the internet.
– Users who are on the move have access to information at all time and from any location. Through their social network, users can share the information they find.
– Information is viewed by people on mobile gadgets and also in street displays as the physical environment has been updated.

The efficiency of urban operations and services, along with competitiveness, impacts the quality of life. Smart, sustainable city is a feasible and effective solution that leverages information and communication technologies (ICTs) to meet the needs of current and future generations in economic, social, and environmental dimensions [5]. The goal of smart cities is to enhance people's ability to use modern ICT effectively [6]. A smart city is a system that effectively addresses public issues, promotes sustainable development, and maximizes human and social capital by interacting with natural and economic resources through technology-based innovations and solutions [7]. In addition to offering a range of advanced services in energy, transportation, healthcare, and other sectors, it provides a higher standard of living [8].

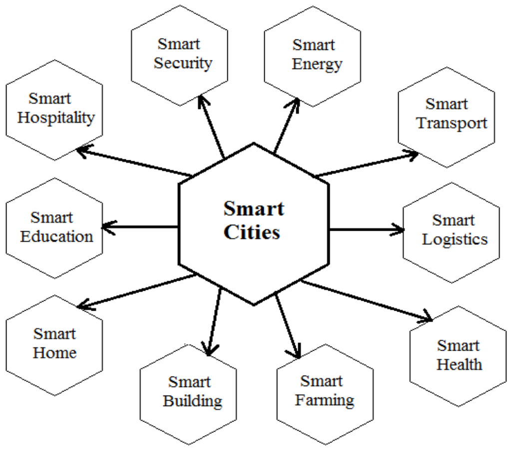

Figure 1. Application domains related to smart cities

2. DIGITAL PLATFORMS: BUILDING THE FOUNDATION OF SMART CITIES

A smart city, according to the authors [9], is an urban setting that makes use of ICT and other pertinent technologies to improve the quality of services (QoS) that its residents get and the efficiency of regular city operations [10]. The primary goal of the initial smart cities was to improve their residents' quality of life (QoL) by adjusting supply and demand in several functional areas [11]. Urbanization has led to an increase in demands for QoL. To meet these needs, modern smart cities have a special emphasis on sustainability, efficient energy management, intelligent mobility, accessible healthcare, and effective governance [12].

2.1. Integrating urban services through digital platforms

There has been an increasing amount of research on the big data phenomena using volume, velocity, and other sorts of data [13], [14]. Compared to the huge data gathered by alternative means, the majority of this data is made up of unstructured requirements [15]. Distributed fault-tolerant databases like SQL are capable of collecting and storing large volumes of unstructured data in cloud computing environments or data centers, enhancing individual services or applications [16]. However, big data analytics (BDA) is still in its infancy as it relates to smart media and may therefore hold promise for improving services in smart cities [17].

2.2. Data aggregation and analysis for informed decision-making

Digital data must be gathered and analyzed to make decisions that will benefit the public. To pinpoint issues, gauge advancement, and decide wisely how to distribute resources, cities must place a high priority on data gathering, analysis, and sharing. Analyzing data can help cities recognise their problems and create solutions. To minimize congestion, data can be utilized to identify areas of high traffic and create intelligent transportation solutions. The data flow in smart cities [18] can be easily understood by the following Figure 2.

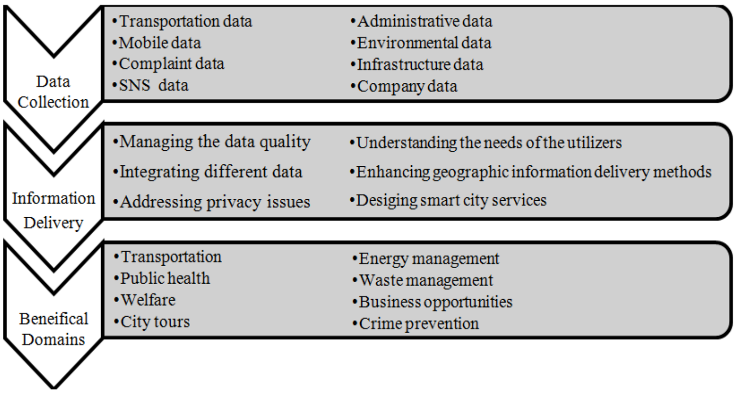

Figure 2. Data flow in smart cities

2.3. Case study: intelligent transportation systems (ITS) revolution

A sustainable resource environment, improved quality of life, and the potential to save lives are all possible with the intelligent components that smart cities integrate. To elevate the intelligence of smart cities, technologies like drones, robotics, AI, and IoT are crucial for advancing connectivity, optimizing energy use, and enhancing service quality. As a result, cooperative drones and the IoT are essential to many smart-city applications, including those related to weather monitoring, energy conservation, disaster mitigation, transportation, agriculture, safety and security, and environmental protection. An overview of some of the newer ideas for enhancing the intelligence of smart cities through the use of IoT and collaborative drones [18]. Alsamhi *et al.* [19] provide comprehensive explanations of how these techniques are used in ITSs, cybersecurity, smart grid energy-efficient utilization, efficient use of unmanned aerial vehicles (UAVs) for 5G and beyond 5G (B5G) communications, and smart healthcare systems within smart cities.

3. CLOUD COMPUTING: ENABLING DATA-DRIVEN URBAN EVOLUTION

As cloud computing and smart cities grow in popularity, companies and consumers are beginning to recognize the value of smart city cloud service platforms. Cloud systems can store data that is collected by thousands of smart devices in smart cities, hence enabling data sharing. The data exchange required for various systems is facilitated by this. The success of cloud computing in terms of cost-effectiveness, global scalability, performance, dependability and security has made it a necessary component of smart city technology these days. All data can become more complex in an inefficient cloud system, even while an efficient cloud system will make everything more accessible [20].

3.1. Empowering data management and analysis

One key component of upcoming smart city application ecosystems is the smart city operating system (SCOS). Specifically adapted for city scale, the SCOS is aimed to mimic a contemporary computer operating system, offering uniform abstractions for underlying resources and administration duties. Figure 3 illustrates an ecosystem of cloud-based smart city applications designed to tackle the inherent complexity of these settings. In a smart city, several providers (transport, electricity, and water) oversee diverse infrastructures that are maintained by these providers to cater to a variety of stakeholders. These providers provide extremely dynamic settings in which applications function [21].

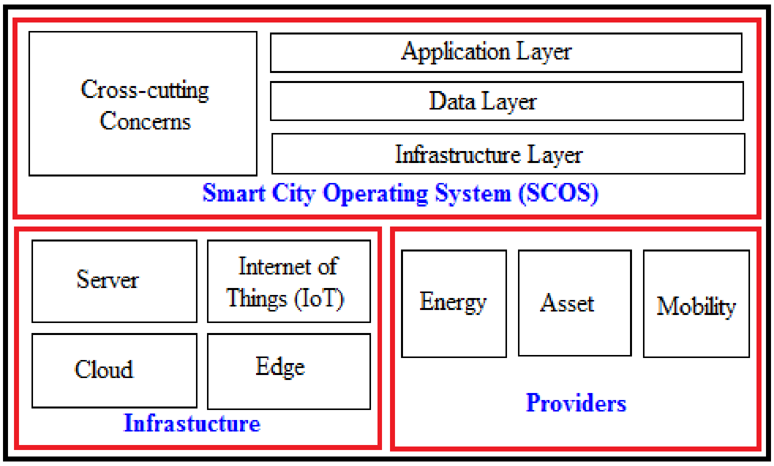

Figure 3. A cloud-based ecosystem for smart city application

3.2. Scalability and flexibility in resource management

A wider ecosystem of smart city applications is supported by the SCOS, which is a good foundation for addressing the difficulties as shown in Figure 4. To create a base that facilitates effortless expansion and exceptional scalability, the design adhered to the micro-service architecture approach. An extensible and evolving system can be achieved with this method, which permits a clear division of responsibilities and acts as a flexible framework for interaction between SCOS components to create new synergies.

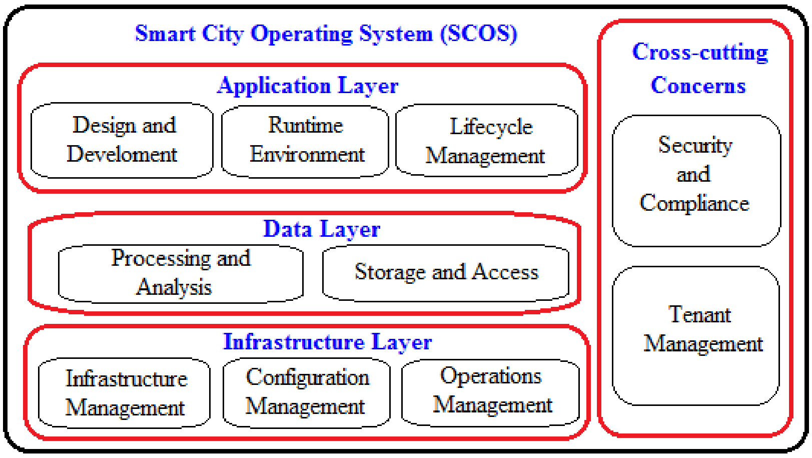

Figure 4. Smart city operating system (SCOS)

3.3. Collaborative opportunities and stakeholder engagement

One of the most important lessons to be drawn from smart cities is collaboration. Partnerships and cooperation between many stakeholders, such as governmental bodies, businesses, and individuals, are essential to the success of smart city projects. Projects must be collaboratively designed to be scalable and sustainable and to guarantee that all parties are working towards the same objectives [22]. Innovative approaches to the problems that cities face can be developed through collaborations between public and private sector entities.

4. IOT SOLUTIONS: INTERCONNECTING URBAN LIFE

A “smart city” is an urban platform that makes use of ICT and related technologies to improve regular municipal operations and increase citizen QoS. Improving the QoL for citizens by modifying supply and demand in multiple functional areas was the main objective of the first smart cities.

4.1. The IoT revolution and ITS impact on urban living

The seed idea of a smart city, which was previously theoretical, became more tangible with the advent of IoT. The goal of smart cities is to offer their residents better healthcare, security, convenience, and intelligence. Or, to put it another way, their goal is to raise the standard of living. Technology such as the IoT has the potential to be the greatest disruptive force in human history [23], [24]. IoT represents a more sophisticated version of conventional networks, enabling seamless connectivity among numerous interconnected objects. Figure 5 indicates that the IoT provides essential components for a smart city.

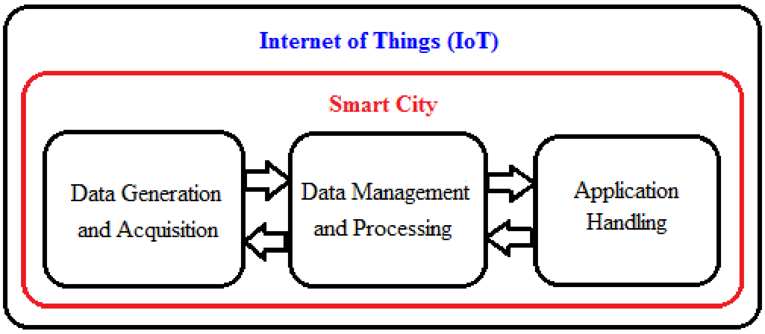

Figure 5. Role of IoT in smart city

4.2. Environmental monitoring for healthier cities

UAVs hold significant potential to benefit society and support a wide range of applications in smart cities. In order to control civic security, transport traffic, monitor pollution, monitor the environment, and deliver goods, among other tasks, UAVs can be utilized [25]. The most recent technological and physical advancements for the smart environmental monitoring and assessment technologies (SEMAT) project are presented in a new community participation paradigm for the creation of affordable environmental monitoring devices [26]. Figure 6. shows examples of IoT-based environmental monitoring applications.

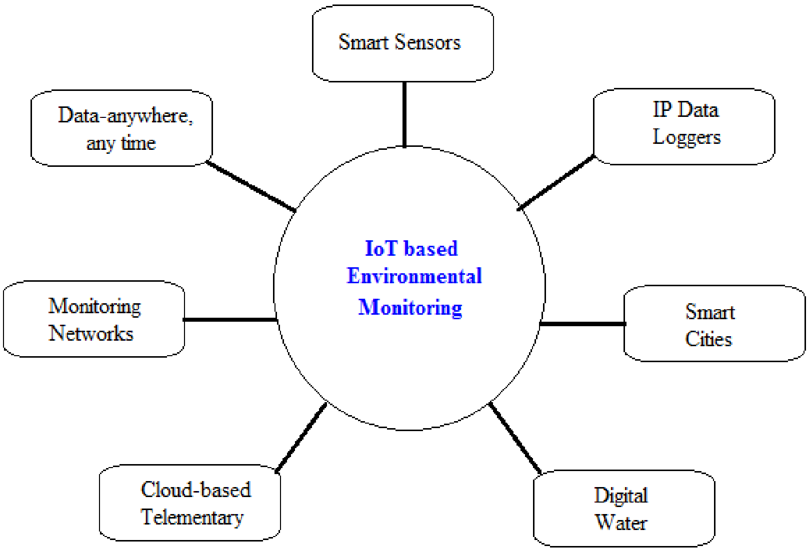

Figure 6. IoT based environmental monitoring applications

4.3. Enhancing public services through IoT innovation

Managing waste is a common part of smart city programs. Sensor-equipped bins that are cloud-connected not only alert the appropriate authorities when they need to be emptied, but they also utilize artificial intelligence (AI) to calculate the most fuel-efficient path. For the electricity grid to monitor and regulate the supply of electrical power and to provide efficient demand-side management, load and energy consumption forecasting is crucial. The authors of [27] have carried it out, determining load up to 24 hours ahead of time using consumer data gathered in a smart grid.

5. SUSTAINABLE DEVELOPMENT AND QUALITY OF LIFE

When compared to the ecology of a traditional city, smart cities have multiple benefits [28] (in terms of value):

- Achieving climate goals: the goal of a smart city is to minimize its carbon footprint and facilitate the development and application of new technologies that promote cleaner living. It centres on smart energy management, intelligent mobility, and effective city administration.
- Financial value: by 2025, the market for smart city projects is expected to reach USD 1 trillion [29]. This offers governments and private businesses alike a significant financial incentive to actively participate in the development of technologies that enable the growth of smart cities.
- Impact on society: the main goals of the smart city initiative are to raise the standard of living for city dwellers and support the creation of an inclusive society that values diversity and affords everyone equal opportunities. With their ability to make life easier and enable citizen-city interactions, information and communication technologies are essential to the delivery of public services in smart city environments.

5.1. Advancements in citizen well-being and comfort

AI and IoT are being used extensively in two key areas of health: disease diagnosis and health monitoring, and activity recognition and fall detection. To monitor a bridge's health using vibration data in a cloud environment, Syed *et al.* [30] use a clustering technique to identify anomalous behaviour groups in accelerometer measurements taken from a bridge, they employ clustering. Using IoT devices for energy management, comfort control, and building environment control is the second-way AI may be used to IoT infrastructure. Utilizing heat flow and electric power data within a building, Prihatmanto *et al.* [31] and Sarmadi *et al.* [32] forecast future energy needs to more effectively control energy usage.

5.2. Addressing data ethics and privacy concerns

An integral part of smart cities is the online operation of vital city infrastructures; any disruption in this regard would cause inhabitants daily inconveniences as well as endanger their safety and possessions. As a result, security is a key issue in smart cities. Smart cities face growing threats from malicious cyberattacks in this day and age when cyberwarfare and cybercrime have become tools in global politics. In this case, data transported over the network must be encrypted. Energy consumption and environmental sensor data collected from a building can reveal information about occupancy [33] and possibly personal identities [34]. Use the standard attack incident taxonomy [35] recommended by the computer emergency response team (CERT), which was founded by DARPA, to give a uniform framework and vocabulary for talking about security threats while discussing IoT for smart cities.

6. CONCLUSION

An overview of digital platforms, cloud computing, and IoT solutions for smart cities is provided in this paper. A case study on the revolution of intelligent transport systems is presented, along with a detailed discussion of the modern smart city transformation, the role of technology in urbanization, the integration of urban services through digital platforms, data aggregation and analysis for informed decision-making, cloud computing: enabling data-driven urban evolution, and IoT solutions: connecting urban life, sustainable development, and quality of life. Potential avenues for future research include devising approaches to surmount the obstacles related to implementation of smart cities and calculating and contrasting the advantages and disadvantages of such projects. In conclusion, digital platforms, cloud computing, and IoT technologies may be critical to gathering important data and facilitating decision-making for applications related to smart cities.

FUNDING INFORMATION

Authors state no funding involved.

AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
William Christopher Immanuel	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Anitha Juliette Albert	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓	
Limsa Joshi Jerald Jobitham	✓	✓		✓	✓	✓	✓	✓	✓		✓	✓	✓	
Roselene Rebecca Selvaraj				✓	✓	✓	✓	✓			✓			
Benita Sharon Ruban				✓	✓	✓	✓			✓	✓			
Bennet Vini Robin				✓	✓	✓	✓			✓	✓			
Andria Morais Allen					✓	✓	✓							

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

DATA AVAILABILITY

Data availability is not applicable to this paper as no new data were created or analyzed in this study.

REFERENCES

[1] J. S. Gracias, G. S. Parnell, E. Specking, E. A. Pohl, and R. Buchanan, “Smart cities—A structured literature review,” *Smart Cities*, vol. 6, no. 4, pp. 1719–1743, 2023, doi: 10.3390/smartcities6040080.

[2] E. Ismagilova, L. Hughes, Y. K. Dwivedi, and K. R. Raman, “Smart cities: advances in research—An information systems perspective,” *International Journal of Information Management*, vol. 47, pp. 88–100, 2019, doi: 10.1016/j.ijinfomgt.2019.01.004.

[3] U. Ghosh, D. Das, P. Chatterjee, and S. Shetty, “Quantum-enabled blockchain for data processing and management in smart cities,” in *2023 IEEE 24th International Symposium on a World of Wireless, Mobile and Multimedia Networks (WoWMoM), Boston, MA, USA*, 2023, pp. 425-430, doi: 10.1109/WoWMoM57956.2023.00075.

[4] G. Xiong, N. Anwar, P. Ye, X. Chen, H. Zhao, Y. Lv, F. Zhu, H. Zhang, X. Zhou, and R. W. Liu, “Cyber–physical–social systems for smart city,” in *Cyber-Physical-Human Systems: Fundamentals and Applications, IEEE*, 2023, pp. 511–542, doi: 10.1002/9781119857433.ch19.

[5] D. K. Singh, R. Sobti, A. Jain, P. K. Malik, and D.-N. Le, “LoRa-based intelligent soil and weather condition monitoring with Internet of Things for precision agriculture in smart cities,” *IET Communications*, vol. 16, pp. 604–618, 2022, doi: 10.1049/cmu2.12352.

[6] Z. Ullah, F. Al-Turjman, L. Mostarda, and R. Gagliardi, “Applications of artificial intelligence and machine learning in smart cities,” *Computer Communications*, vol. 154, pp. 313–323, 2020, doi: 10.1016/j.comcom.2020.02.069.

[7] H. Huang, W. Kong, S. Zhou, Z. Zheng, and S. Guo, “A survey of state-of-the-art on blockchains: Theories, modelings, and tools,” *ACM Computing Surveys*, vol. 54, no. 2, pp. 1–42, Mar. 2022, doi: 10.1145/3441692.

[8] R. E. Lopes, D. Raposo, R. Martins, and S. Sargento, “Time-sensitive smart cities: addressing smart city challenges with TSN,” in *IEEE Access*, vol. 13, pp. 10459-10480, 2025, doi: 10.1109/ACCESS.2025.3528257.

[9] C. Lim, K.-J. Kim, and P. P. Maglio, “Smart cities with big data: reference models, challenges, and considerations,” *Cities*, vol. 82, pp. 86–99, 2018, doi: 10.1016/j.cities.2018.04.011.

[10] M. F. Shi, W. Shi, and A. Zhang, “A new smart city index based on urban origin theory,” *Urban Informatics*, vol. 3, p. 32, 2024, doi: 10.1007/s44212-024-00065-5.

[11] B. N. Silva, M. Khan, and K. Han, “Towards sustainable smart cities: a review of trends, architectures, components, and open challenges in smart cities,” *Sustainable Cities and Society*, vol. 38, pp. 697–713, 2018, doi: 10.1016/j.scs.2018.01.053.

[12] P. Brous, M. Janssen, and P. Herder, “The dual effects of the internet of things (IoT): a systematic review of the benefits and risks of IoT adoption by organizations,” *International Journal of Information Management*, vol. 51, p. 101952, 2020, doi: 10.1016/j.ijinfomgt.2019.05.008.

[13] J. T. de Souza, A. C. de Francisco, C. M. Piekarski, and G. F. de Prado, “Data mining and machine learning to promote smart cities: A systematic review from 2000 to 2018,” *Sustainability*, vol. 11, no. 4, p. 1077, 2019, doi: 10.3390/su11041077.

[14] H. M. Kim, S. Sabri, and A. Kent, “Smart cities as a platform for technological and social innovation in productivity, sustainability, and livability: a conceptual framework,” *Smart Cities for Technological and Social Innovation*, pp. 9–28, 2021, doi: 10.1016/B978-0-12-818886-6.00002-2.

[15] M. Lom and O. Pribyl, “Smart city model based on systems theory,” *International Journal of Information Management*, vol. 56, p. 102092, 2021, doi: 10.1016/j.ijinfomgt.2020.102092.

[16] M. I. Pramanik, R. Y. K. Lau, M. S. Hossain *et al*., “Privacy preserving big data analytics: a critical analysis of state-of-the-art,” *Wiley Interdisciplinary Reviews: Data Mining and Knowledge Discovery*, vol. 11, p. e1387, 2021, doi: 10.1002/widm.1387.

[17] L. Leenen and T. A. Meyer, "Artificial intelligence and big data analytics in support of cyber defense," in *Research Anthology on Artificial Intelligence Applications in Security*, 2019.
[18] Y. Hajjaji, W. Boulila, I. R. Farah, I. Romdhani, and A. Hussain, "Big data and IoT-based applications in smart environments: a systematic review," *Computer Science Review*, vol. 39, p. 100318, 2021, doi: 10.1016/j.cosrev.2020.100318.
[19] S. H. Alsamhi, O. Ma, M. S. Ansari and F. A. Almalki, "Survey on collaborative smart drones and internet of things for improving smartness of smart cities," in *IEEE Access*, vol. 7, pp. 128125-128152, 2019, doi: 10.1109/ACCESS.2019.2934998.
[20] W. Wen, C. Zhang, and Q. Ye, "Beyond barriers: constructing the cloud migration complexity index for China's digital transformation," *Journal of Theoretical and Applied Electronic Commerce Research*, vol. 19, no. 3, pp. 2239–2268, 2024, doi: 10.3390/jtaer19030109.
[21] M. Dener, "The role of cloud computing in smart cities," *The Eurasia Proceedings of Science, Technology, Engineering & Mathematics (EPSTEM)*, vol. 7, pp. 39–43, 2019.
[22] J. Hajlaoui, Z. Trifa, and Z. Brahmi, "Model based migration of cloud systems: review and roadmap," in *Computational Science and Its Applications – ICCSA 2022*, vol. 13375, doi: 10.1007/978-3-031-10522-7_18.
[23] M. Talebkhah, A. Sali, M. Marjani, M. Gordan, S. J. Hashim and F. Z. Rokhani, "Edge computing: architecture, applications and future perspectives," *2020 IEEE 2nd International Conference on Artificial Intelligence in Engineering and Technology (IICAIET)*, Kota Kinabalu, Malaysia, 2020, pp. 1-6, doi: 10.1109/IICAIET49801.2020.9257824.
[24] G. Javadzadeh and A. M. Rahmani, "Fog computing applications in smart cities: a systematic survey," *Wireless Network.*, vol. 26, pp. 1433–1457, 2020, doi: 10.1007/s11276-019-02208-y.
[25] N. Mohamed, J. Al-Jaroodi, I. Jawhar, A. Idries, and F. Mohammed, "Unmanned aerial vehicles applications in future smart cities," *Technological Forecasting and Social Change*, vol. 153, p. 119293, 2020, doi: 10.1016/j.techfore.2018.05.004.
[26] J. Trevathan and R. Johnstone, "Smart environmental monitoring and assessment technologies (SEMAT)—A new paradigm for low-cost, remote aquatic environmental monitoring," *Sensors*, vol. 18, no. 7, p. 2248, 2018, doi: 10.3390/s18072248.
[27] S. A. A. Elmustafa and E. Y. Mujtaba, "Internet of things in smart environment: concept, applications, challenges, and future directions," *World Science News*, vol. 134, no. 1, pp. 1–51, 2019.
[28] D. Rutqvist, D. Kleyko and F. Blomstedt, "An automated machine learning approach for smart waste management systems," in *IEEE Transactions on Industrial Informatics*, vol. 16, no. 1, pp. 384-392, Jan. 2020, doi: 10.1109/TII.2019.2915572.
[29] G. E. Okereke, M. C. Bali, C. N. Okwueze, *et al*., "K-means clustering of electricity consumers using time-domain features from smart meter data," *Journal of Electrical Systems and Information Technology*, vol. 10, p. 2, 2023, doi: 10.1186/s43067-023-00068-3.
[30] A. S. Syed, D. Sierra-Sosa, A. Kumar, and A. Elmaghraby, "IoT in smart cities: a survey of technologies, practices and challenges," *Smart Cities*, vol. 4, no. 2, pp. 429–475, 2021, doi: 10.3390/smartcities4020024.
[31] A. S. Prihatmanto, R. Andrian, W. D. Sunindyo, and R. Sutriadi, "Transforming public services: a systematic review of smart government frameworks, architectures, and implementation challenges," *IEEE Access*, vol. 12, pp. 135799–135810, 2024, doi: 10.1109/ACCESS.2024.3450907.
[32] H. Sarmadi, A. Entezami, M. Salar and C. De Michele, "Bridge health monitoring in environmental variability by new clustering and threshold estimation methods," *Journal of Civil Structural Health Monitoring*, vol. 11, pp. 629–644, 2021, doi: 10.1007/s13349-021-00472-1.
[33] D. Fährmann, F. Boutros, P. Kubon, *et al*., "Ubiquitous multi-occupant detection in smart environments," *Neural Computing and Applications*, vol. 36, pp. 2941–2960, 2024, doi: 10.1007/s00521-023-09162-z.
[34] M. Jacoby, S. Y. Tan, G. Henze and S. Sarkar, "A high-fidelity residential building occupancy detection dataset," *Scientific Data*, vol. 8, p. 280, 2021, doi: 10.1038/s41597-021-01055-x.
[35] J. D. Howard and T. A. Longstaff, "A common language for computer security incidents", Albuquerque, NM, USA: Univ. of North Texas Libraries, 1998. [Online]. Available: https://digital.library.unt.edu/ark:/67531/metadc706351/.

BIOGRAPHIES OF AUTHORS

William Christopher Immanuel is the vice principal and professor of Electrical and Electronics Engineering at LICET, Chennai, with 19 years of teaching, 10 years of research, and 2 years of industry experience. He holds a Ph.D. from Anna University and has published/presented 60 technical papers in reputed journals, book chapters, and IEEE conferences. His research interests include power converter topologies and renewable energy systems. He can be contacted at email: iwchristop@gmail.com.

Anitha Juliette Albert professor in electronics and communication engineering, has 16 years of teaching and 3 years of industry experience. With a Ph.D. from Anna University for her work on asynchronous VLSI architectures, her research focuses on low-power VLSI design. She can be contacted at email: anideni2002@gmail.com.

Limsa Joshi Jerald Jobitham an academician in Computer Science and Engineering, holds B.E. and M.E. degrees with distinction from Anna University. With 10 years of teaching experience, she specializes in cloud computing, IoT and product development, and has published five technical papers in reputed journals and conferences. She can be contacted at email: limsajoshi@licet.ac.in.

Roselene Rebecca Selvaraj senior content marketer at joy technologies, brings 11 years of teaching experience in various Engineering colleges and 2.9 years in the industry. She specializes in SEO, content writing, and leveraging AI tools, while also focusing on training and upskilling individuals. She can be contacted at email: rebecca.eagleswings@gmail.com.

Benita Sharon Ruban has completed her bachelor's degree in Electrical and Electronics Engineering at Loyola-ICAM College of Engineering and Technology (LICET) and is currently working as an Engineer Trainee at Renault Nissan Technology and Business Centre India (RNTBCI). She can be contacted at email: benitasharon.24ee@licet.ac.in.

Bennet Vini Robin has completed her bachelor's degree in Electrical and Electronics Engineering at Loyola ICAM College of Engineering and Technology (LICET)and is currently working as an Engineer Trainee at Vestas Wind Technology India Private Limited. She can be contacted at email: bennetvini.24ee@licet.ac.in.

Andria Morais Allen has completed her bachelor's degree in Electrical and Electronics Engineering at Loyola ICAM College of Engineering and Technology (LICET), Anna University, Chennai. She can be contacted at email: andriamorais.24ee@licet.ac.in.