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IoT-Powered Parking Management Systems: Architectures, Enabling Technologies, and Future Pathways

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Abstract: The rapid growth of urbanization and vehicular ownership has intensified parking challenges in modern cities, leading to congestion, environmental pollution, and inefficient land use. Internet of Things (IoT)-powered parking management systems have emerged as a transformative solution, integrating sensors, communication networks, cloud-edge computing, artificial intelligence, and blockchain technologies to provide real-time, secure, and user-centric parking services. This paper critically examines the multi-layered architecture of IoT-enabled parking, covering perception, network, processing, application, and security layers, while highlighting enabling technologies and their deployment guidelines. A systematic review of literature from 2015 to 2025 traces the evolution from basic sensor-based models to advanced AI-driven and blockchain-secured frameworks. Based on identified gaps, a Hybrid Cloud-Edge IoT Model with Blockchain Integration is proposed, incorporating digital twins for predictive maintenance and AI-based demand forecasting. The model addresses key challenges of latency, trust, and interoperability while enhancing operational efficiency and inclusivity. Future pathways emphasize integration with autonomous vehicles, sustainable pricing strategies, and digital twin city planning. The study underscores both technological and policy implications, positioning IoT-powered parking as not merely a mobility solution but a critical enabler of resilient, inclusive, and sustainable smart city ecosystems.

Keywords: IoT-powered parking, Smart cities, Cloud-edge computing, Blockchain integration, Digital twins.

INTRODUCTION

Searching for a parking place in today's crowded metropolitan environments may take time and effort. As a result of the development of Internet of Things

(IoT) technology, however, intelligent parking management systems are becoming more popular as a potential solution to this persistent urban problem. This piece will examine the advantages and disadvantages of integrating the Internet of Things

IoT in smart parking management.

The complexity of city traffic is increasing daily, particularly after [COVID-19](#), when everyone appears to be out on the road. Urbanization is growing, and the complexity of city traffic is developing constantly. Only some have easy access to public transportation, and parking a personal car is considerably more difficult (and expensive) than public transportation. Urbanization has dramatically increased the demand for mobility services, with private vehicles remaining the most common mode of transport worldwide. This growth has placed immense strain on urban infrastructure, particularly in parking management. Studies estimate that 20–30% of urban traffic congestion results from drivers searching for available parking spaces, wasting fuel and contributing to environmental pollution (Shoup, 2017). The World Health Organization (2021) warns that traffic-induced air pollution has become one of the leading environmental health risks in cities. Conventional parking management systems, such as manual allocation and ticket-based approaches, lack efficiency and fail to meet the real-time needs of growing urban populations. Consequently, smart city initiatives are increasingly adopting Internet of Things (IoT)-enabled solutions to improve urban sustainability. IoT technologies allow real-time monitoring, dynamic allocation, and predictive analytics, thereby reducing congestion, improving resource utilization, and supporting greener cities (Al-Turjman & Malekloo, 2019).

The concept of smart cities emphasizes leveraging digital technologies to optimize resource utilization and enhance quality of life. Within this framework, smart parking systems have emerged as a critical component of intelligent transportation networks. Smart parking integrates IoT devices such as wireless sensors, RFID tags, and camera systems to detect vehicle presence and availability in real time (Geng & Cassandras, 2015). By transmitting data through cloud and edge platforms, these systems provide drivers with instant information on parking availability, reducing search times and improving urban mobility efficiency. Moreover, IoT-enabled parking supports flexible payment mechanisms, including mobile applications and blockchain-based microtransactions, improving user convenience (Anagnostopoulos, 2018). The integration of IoT in parking not only reduces urban congestion but also aligns with global sustainability goals by lowering carbon footprints and promoting smarter urban planning. Thus, smart parking stands as a cornerstone of sustainable and digitally connected urban ecosystems.

The Internet of Things (IoT) has transformed multiple domains, including healthcare,

manufacturing, and logistics, and urban transportation is no exception. IoT's fundamental capability lies in connecting physical devices with data-driven intelligence through sensors, communication protocols, and cloud infrastructures (Perera et al., 2015). In parking management, IoT enables automated detection, monitoring, and predictive analytics, which are essential for efficient space utilization. Real-time data generated from IoT sensors helps traffic controllers optimize routes, while predictive algorithms guide drivers to available spaces, reducing traffic congestion (Ahmed et al., 2020). The adaptability of IoT technologies allows integration with other smart city services, such as electric vehicle charging infrastructure, ride-sharing platforms, and intelligent traffic management. This cross-functional integration positions IoT-enabled parking systems as a central component in urban mobility solutions. Consequently, the deployment of IoT in parking not only addresses immediate challenges but also contributes to long-term urban resilience and sustainability.

The successful implementation of IoT-powered parking management systems relies on several enabling technologies. Wireless communication protocols such as Zigbee, Bluetooth Low Energy (BLE), Wi-Fi, and 5G play pivotal roles in transmitting real-time parking data (Hassija et al., 2019). Low-power wide-area networks (LPWANs), including LoRaWAN and NB-IoT, extend coverage for large-scale deployments while ensuring energy efficiency. Cloud computing and edge computing frameworks further enhance data processing capabilities, enabling predictive analytics and real-time decision-making. Artificial intelligence (AI) and machine learning algorithms allow pattern recognition, demand forecasting, and dynamic pricing models (Almotairi et al., 2021). Blockchain technology has also gained traction in ensuring secure, transparent, and decentralized parking transactions. The combination of these technologies provides a robust foundation for scalable, efficient, and user-friendly smart parking ecosystems. Therefore, IoT-enabled parking is not merely a standalone system but a convergence point for multiple cutting-edge digital innovations.

Beyond technological advancements, IoT-powered parking management systems hold significant societal and policy implications. Governments worldwide are prioritizing smart mobility solutions to reduce urban congestion, enhance environmental sustainability, and improve citizen well-being (European Commission, 2020). By enabling efficient land use and minimizing vehicle idling, smart parking supports broader climate action goals. Additionally, IoT-based systems provide municipalities with valuable data insights for urban planning and

infrastructure investments. However, issues of privacy, cybersecurity, and interoperability present challenges that require robust policy frameworks (Roman et al., 2018). From a societal perspective, smart parking improves accessibility for differently abled individuals and fosters inclusivity in urban mobility. The alignment of IoT-powered parking with United Nations' Sustainable Development Goals (SDGs), particularly SDG 11 on sustainable cities, highlights its global relevance. Thus, IoT-enabled parking is not only a technological solution but also a policy instrument for shaping resilient and inclusive urban futures.

REVIEW OF LITERATURE

IoT Foundations and Early Developments (2015–2017)

The literature on IoT-powered parking systems began with early explorations of sensor-based urban infrastructure. Geng and Cassandras (2015) developed one of the first smart parking models that combined wireless sensors with dynamic allocation algorithms, significantly reducing search times for drivers. Similarly, Perera et al. (2015) provided a broader context-aware IoT framework, demonstrating how intelligent systems can support data-driven decision-making in urban environments. Shoup (2017) highlighted that nearly 30% of urban congestion results from parking searches, underscoring the necessity of efficient systems. These foundational works laid the conceptual and practical groundwork for smart parking, emphasizing IoT's potential to address inefficiencies in urban mobility. They collectively show that parking management is not an isolated problem but closely tied to sustainable transport and air quality. Importantly, these studies framed IoT parking as a cornerstone for future smart city planning. Their insights continue to influence architectural models and policy discourse in mobility management.

Security, Scalability, and Policy Implications (2018–2020)

From 2018 onward, turned toward security, scalability, and policy integration of IoT systems. Anagnostopoulos (2018) introduced blockchain for secure and transparent parking transactions, signaling a move toward decentralized architectures. Roman et al. (2018) examined IoT vulnerabilities, stressing the risks of data breaches in public infrastructures. Al-Turjman and Malekloo (2019) highlighted the scalability challenges of deploying IoT-enabled parking at city-wide levels, pointing to communication protocols as key enablers. Hassija et al. (2019) reinforced this by categorizing protocols like Zigbee, Wi-Fi, and LoRaWAN, emphasizing energy efficiency and cost-effectiveness in large deployments. Meanwhile, Ahmed et al. (2020) advanced predictive models that integrate IoT data

with mobile applications for real-time availability. The European Commission (2020) also recognized IoT-enabled parking as vital for sustainable mobility strategies across Europe. Together, these studies establish that IoT-powered parking requires robust governance, technical interoperability, and secure infrastructures to fulfill its transformative potential.

Artificial Intelligence and Advanced Analytics (2021–2022)

Recent research highlights the integration of artificial intelligence (AI) and advanced analytics into IoT parking systems. Almotairi et al. (2021) applied machine learning algorithms for dynamic pricing, demonstrating how predictive analytics balance demand and supply while reducing congestion. The World Health Organization (2021) linked traffic-related air pollution to public health, indirectly supporting smart parking as a mitigation tool. Nair and Pradhan (2021) focused on India, identifying barriers like infrastructure limitations and governance challenges that hinder large-scale adoption. Zhang et al. (2022) advanced the field by proposing edge-computing-enabled architectures, which reduce latency compared to cloud-only solutions and improve responsiveness in real-time parking management. Gupta and Chauhan (2022) further examined blockchain-based transactions in parking, highlighting transparency and fraud reduction benefits. The United Nations (2022) projected that 68% of the global population will live in urban areas by 2050, creating an urgent need for scalable and resilient smart parking solutions worldwide.

Barriers, Risks, and Societal Challenges (2023–2024)

Emerging research between 2023 and 2024 broadened the scope of smart parking literature to consider adoption barriers, cybersecurity risks, and societal implications. Singh and Kaur (2023) identified high costs, interoperability issues, and low public acceptance as major challenges in smart parking adoption. Li et al. (2023) integrated AI-driven image recognition with IoT sensors, improving accuracy in parking detection and addressing sensor limitations. Chen and Wu (2024) focused on cybersecurity, revealing vulnerabilities in IoT communication channels and proposing blockchain-based authentication as a countermeasure. Patel and Sharma (2024) shifted attention to developing countries, suggesting that LPWAN and mobile-based applications offer cost-effective solutions where advanced infrastructure is lacking. These contributions show that while technological progress is rapid, the societal and contextual factors remain critical. Adoption depends not only on cutting-edge technology but also on governance, inclusivity, and affordability across

diverse urban environments.

Future Pathways and Emerging Innovations (2025 and beyond)

The most recent scholarship points toward futuristic pathways for IoT-powered parking systems. Khan et al. (2025) proposed digital twin frameworks, enabling virtual replicas of parking infrastructures to optimize predictive maintenance and integration with autonomous vehicles. These innovations align with broader trends in smart cities, where digital twins and AI-driven models enhance resilience and adaptability. Literature increasingly recognizes the convergence of IoT with other technologies such as blockchain, AI, and edge computing, which together create intelligent, self-sustaining ecosystems (Chen & Wu, 2024; Zhang et al., 2022). Scholars also highlight sustainability and inclusivity, linking smart parking to UN Sustainable Development Goal 11 on sustainable cities (United Nations, 2022). By integrating predictive analytics, decentralized transactions, and digital twins, future systems promise not only operational efficiency but also societal resilience. Thus, research from 2015 to 2025 reflects an evolution from conceptual frameworks to cutting-edge, multi-technology ecosystems shaping the future of urban mobility.

Research Objectives

1. To critically analyze the multi-layered architecture of IoT-powered parking management systems.

2. To evaluate enabling technologies and their practical deployment guidelines
3. To propose and assess a hybrid IoT model

System Architecture of IoT-Powered Parking

The architecture of IoT-powered parking management systems is typically designed as a multi-layered framework, where each layer plays a distinct yet interconnected role in ensuring efficiency, scalability, and reliability. At the base is the Perception Layer, consisting of IoT-enabled devices such as ultrasonic sensors, RFID tags, magnetic detectors, and computer vision cameras. These devices are responsible for sensing and detecting the real-time status of parking slots, such as whether they are occupied, vacant, or reserved (Li et al., 2023).

Above these layers sits the Processing Layer, where cloud and edge computing infrastructures analyze incoming data streams. This layer leverages machine learning algorithms to recognize patterns, predict demand, and optimize parking allocation in real time (Almotairi et al., 2021). The processed insights are then presented through the Application Layer, where end-users—typically drivers—interact with parking services via mobile applications or web-based dashboards. Features such as navigation assistance, slot reservation, digital payments, and dynamic pricing models improve the overall user experience while promoting efficient utilization of parking resources. Overlaying all these layers is the Security Layer, which serves as a cross-cutting safeguard.

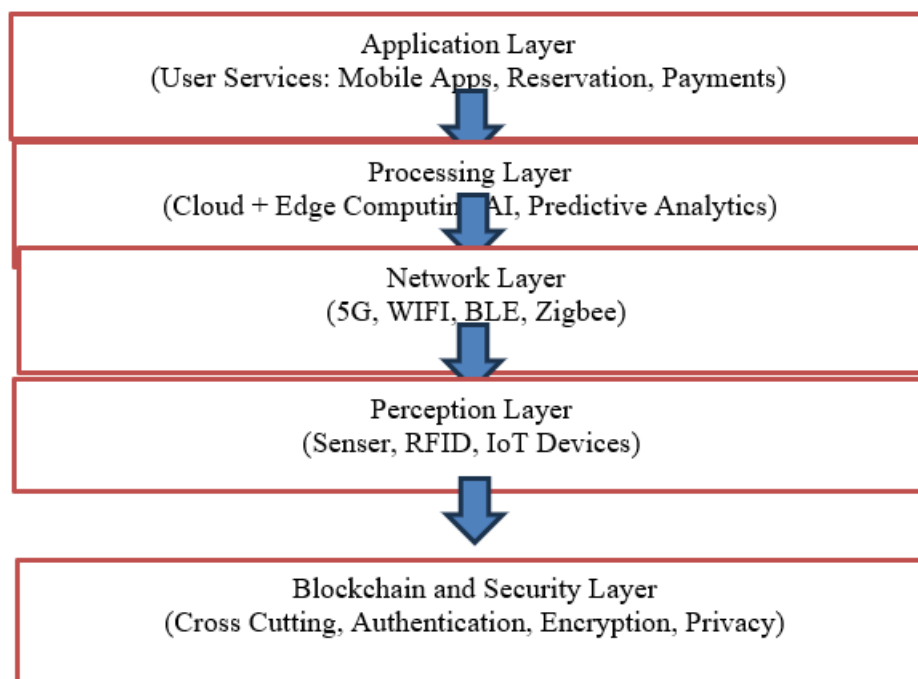
Proposed Model for IoT-Powered Parking Management

Based on the literature and identified gaps, we propose a **Hybrid Cloud-Edge IoT Parking Model with Blockchain Integration**, which combines efficiency, scalability, and security.

- **Hybrid Cloud-Edge Infrastructure:** Edge nodes near parking lots handle latency-sensitive tasks (e.g., slot detection, user navigation), while cloud servers manage large-scale analytics, predictive modeling, and storage.
- **AI-Driven Prediction:** Machine learning models forecast peak parking demand, recommend dynamic pricing, and optimize space utilization.
- **Blockchain Layer:** Ensures transparency and immutability in payment processing, access control, and data sharing among stakeholders.
- **Digital Twin Integration:** A virtual replica of the parking ecosystem simulates real-time conditions, enabling predictive maintenance and policy simulation (Khan et al., 2025).
- **User-Centric Mobile Application:** Provides slot availability, reservation, guidance, and e-wallet services with multilingual support for inclusivity.

This model addresses three critical challenges: (a) reducing latency through edge computing, (b) enhancing trust through blockchain, and (c) improving planning accuracy with digital twins.

Figure 1: Proposed IoT Powered Parking Management Architecture



The challenges of implementing IoT and AI in smart parking management

Smart parking is an emerging market with immense potential. According to a recent study, the global smart parking market is expected to grow from \$3.8 billion in 2020 to [\\$5.4 billion](#) by 2025. Several challenges are causing the slow adoption rate, including:

1. Correctness of information

A key challenge is ensuring correct information is displayed to the users on the application at all times. Inaccuracy or delays in receiving the data may result in drivers traveling to different places than the designated parking spots - causing much mayhem and confusion on the roads.

2. Availability of standard IoT tools

The service providers use technological platforms like the P&E PARC and PUCRS to manage the parking process which is so extensive. These include computer clients, servers, wireless and wired telecommunications systems, hardware sensors, dynamic messaging systems, traffic management devices, and application interfaces.

The biggest obstacle to lowering the price and complexity of IoT smart parking is making it possible for all these devices from hundreds of different vendors to speak with one another and connect to a single platform.

Another problem with installing a smart parking management system is requiring numerous sensors to be online to obtain data for a single booking window. You must have a variety of routers, which looks to be a challenge.

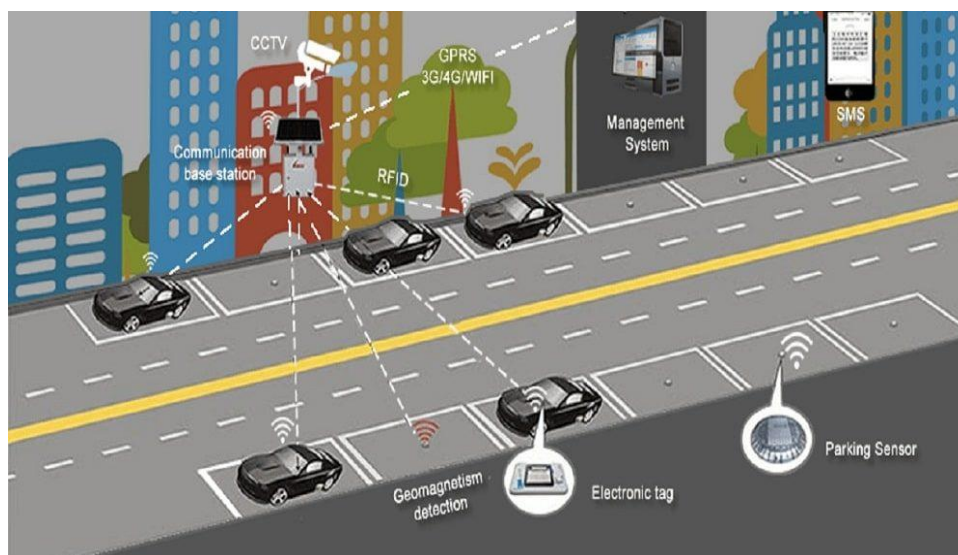
2. High cost of implementation

The capital investment required to install smart parking infrastructure can be very high. For example, a single parking space can cost upwards of \$1,000 to equip with the necessary sensors and IoT devices. When you multiply that by the number of parking spaces in a given facility, the costs can become prohibitive.

3. Data privacy

When you implement AI and IoT in the parking management system, it raises concerns about data privacy. AI processes a vast amount of collected by IoT devices to deliver effective insights. By establishing strong security and compliance measures with privacy regulations, you can protect essential information like personal details to maintain users' trust.

Benefits of Internet of Things-based parking system



Source: <https://www.transportadvancement.com/road-traffic/use-of-iot-in-making-smart-parking-systems/>

Vehicles equipped with intelligent IoT in smart parking solutions are designed to give drivers complete control over their trip, from the beginning to the conclusion, without needing to search for parking spots. The Internet of Things technology helps reduce travel time and expenditures. It also serves as the basis for collecting and analyzing data in real time. Through the Internet of Things (IoT), it is possible to link the many sensors and devices that are part of the parking ecosystem and obtain data that can be utilized to improve operations. The combination of IoT technology with [autonomous cars](#) is where the future of smart parking rests. As a result of the arrangement, people would have an easier time getting about, which would free up even more room on the roads.

Seamless Trip Management with IoT-Enabled Vehicles

Vehicles integrated with intelligent IoT technology in modern parking solutions are developed to provide drivers with complete control over their journey, from departure to arrival, eliminating the need to hunt for available parking. The use of IoT not only helps cut down travel time and expenses but also enables the continuous collection and analysis of real-time data. By connecting multiple sensors and devices within the parking ecosystem, IoT facilitates smarter operations and enhances overall efficiency. The integration of IoT with autonomous vehicles represents the next frontier in smart parking, allowing smoother mobility and creating more space on the roads.

Real-Time Parking Availability

A major advantage of IoT in smart parking systems is its ability to deliver real-time updates on available parking spaces. By equipping parking spots with sensors, municipalities can accurately track occupancy levels. This data is then communicated to drivers through mobile applications, directing them instantly to vacant spaces. Research by McKinsey indicates that access to real-time parking information can reduce the time drivers spend searching for parking by up to 43%.

Optimized Space Utilization

IoT-based parking systems not only simplify the process for drivers but also ensure more effective use of available space. Authorities can analyze parking patterns and demand trends to identify underutilized areas and implement dynamic pricing or alternative usage strategies. This proactive approach promotes fairer sharing of parking resources and helps alleviate congestion in high-traffic zones.

Positive Environmental and Traffic Benefits

Minimizing the time spent searching for parking has a direct impact on both traffic flow and environmental sustainability. Studies reveal that a significant portion of urban traffic congestion arises from drivers looking for parking. IoT technology can help ease congestion, reduce vehicle emissions, and improve air quality by making the parking process more streamlined and efficient.

Enhanced Safety and Security

IoT-enabled parking solutions also strengthen security and safety measures. Real-time monitoring allows authorities to quickly detect unauthorized vehicles or suspicious activities in parking areas. Connected surveillance systems provide valuable evidence in case of accidents or criminal incidents, contributing to safer urban environments.

Enabling Technologies: Practical Capabilities

1. Sensing and Detection Technologies

Accurate vehicle detection forms the foundation of IoT-powered parking systems. Common options include ultrasonic sensors, inductive loops, RFID tags,

infrared devices, and computer vision with AI-enabled CCTV. Low-cost magnetic or ultrasonic sensors are effective for on-street or small lots, while vision-based systems excel in complex, multi-level garages where enforcement and license plate recognition are essential (Li et al., 2023). Sensor redundancy and periodic calibration are vital to minimize false positives, maintain reliability, and adapt to environmental factors such as lighting or weather. A hybrid sensing approach enhances detection accuracy and ensures operational continuity in real-world deployments.

2. Communication Protocols and Networking

Reliable communication between sensors, gateways, and servers is critical for smart-parking efficiency. LPWAN technologies like LoRaWAN and NB-IoT are suitable for sparse deployments due to low energy use and wide coverage, while BLE and Wi-Fi enable short-range, cost-effective setups (Hassija et al., 2019). For dense urban areas requiring video transmission or ultra-low latency, 5G networks provide high throughput and network slicing for QoS. Protocol selection depends on deployment scale, data bandwidth, and energy constraints. A multi-protocol strategy often balances cost, coverage, and performance, ensuring that diverse environments can support seamless real-time data flow.

3. Computing Infrastructure and Data Platforms

The computational backbone of IoT parking systems integrates cloud and edge computing for efficient data handling. Edge servers perform real-time inference, enabling rapid responses such as gate control and slot updates, while cloud platforms handle long-term storage, analytics, and model retraining (Zhang et al., 2022). Containerization and serverless functions allow for scalability and modular upgrades, minimizing downtime. Telemetry-aware partitioning helps ensure that sensitive, personally identifiable data remains at the edge to safeguard privacy. This hybrid computing model balances responsiveness with advanced analytics, making it essential for scaling smart-parking systems across large metropolitan areas.

4. Analytics, AI, and Prediction Models

Artificial intelligence enhances IoT-parking systems by enabling demand forecasting, predictive allocation, and dynamic pricing. Supervised learning models classify occupancy states, while time-series and unsupervised models predict demand fluctuations and optimize pricing strategies (Almotairi et al., 2021; Li et al., 2023). These models require constant monitoring for drift, with retraining mechanisms to preserve accuracy.

5. Security, Privacy, and Operational Technologies

Given the financial and personal data involved, robust cybersecurity and trust infrastructures are essential. Measures include multi-factor authentication, TLS encryption for telemetry, endpoint attestation, and blockchain for transparent auditing of payments and reservations (Roman et al., 2018; Chen & Wu, 2024). Operational resilience further depends on predictive maintenance using sensor health data, over-the-air firmware updates, and remote diagnostics. These capabilities reduce downtime, extend device lifecycles, and minimize total cost of ownership (TCO), thereby ensuring long-term sustainability of smart-parking solutions.

Future Pathways

The next decade presents exciting possibilities for IoT-powered parking systems:

- **Integration with Autonomous Vehicles (AVs):** Parking systems will increasingly support AVs by guiding them directly to slots and enabling automated valet services.
- **Digital Twin Cities:** Expanding digital twin frameworks will allow simulation of traffic and parking scenarios for proactive planning (Khan et al., 2025).
- **Sustainable Parking Models:** Dynamic pricing, eco-friendly zones, and integration with electric vehicle charging stations will promote greener urban mobility.
- **Policy-Driven Growth:** Governments will adopt smart parking as a policy instrument for climate action, urban inclusivity, and congestion management (European Commission, 2020).
- **Interdisciplinary Convergence:** The fusion of IoT, AI, blockchain, and 5G will create highly adaptive, intelligent ecosystems capable of autonomous decision-making.

CONCLUSION

The evolution of IoT-powered parking management systems highlights the potential of digital innovation in resolving one of the most persistent challenges in urban mobility. By integrating multi-layered architectures—spanning sensing, communication, computation, application, and security—these systems enhance efficiency, reduce congestion, and enable sustainable urban planning. The literature (2015–2025) demonstrates a clear trajectory: from early sensor-based prototypes to AI-enhanced, blockchain-secured, and hybrid cloud-edge ecosystems. The proposed hybrid model contributes to this evolution by addressing latency, trust, and predictive planning challenges through edge computing, blockchain, and digital twins. Yet, large-scale adoption faces barriers such as high infrastructure costs, interoperability issues, and cybersecurity risks. Overcoming these requires coordinated policy frameworks, standardization, and

interdisciplinary collaboration between technologists, city planners, and policymakers. Looking forward, integration with autonomous vehicles, digital twin cities, and sustainable pricing models will redefine the role of smart parking in intelligent transportation networks. Ultimately, IoT-powered parking systems stand not just as technological solutions but as essential instruments for building inclusive, resilient, and environmentally responsible smart cities.

REFERENCES

1. Aldehim, G., Shahzad, T., Khan, M. A., Ghadi, Y. Y., Jiang, W., Mazhar, T., & Hamam, H. (2025). Balancing sustainability and security: a review of 5G and IoT in smart cities. *Digital Communications and Networks*.
2. Allanki Sanyasi Rao, D. S. M. S., Jagan, D., & Ramesh, R. Navigating the Internet of Things (IoT): Towards a Smart and Sustainable Future-Opportunities, Issues and Challenges.
3. Balaji, S., Shobana, D., Pandi, V. S., Makanyadevi, K., & Muralidharan, C. (2024, November). IoT-Powered Smart Electric Automobile Ecosystems: Using Intelligent Infrastructure and Connected Technologies for Innovative Mobility. In *2024 International Conference on Smart Technologies for Sustainable Development Goals (ICSTSDG)* (pp. 1-6). IEEE.
4. Choudekar, P., & Singh, R. (2024). Traffic management system using AIoT. *Reshaping Intelligent Business and Industry: Convergence of AI and IoT at the Cutting Edge*, 439-458.
5. Firdhous, M. F. M., Sudantha, B. H., & Hussien, N. A. (2021). A framework for IoT-enabled environment aware traffic management. *International Journal of Electrical and Computer Engineering*, 11(1), 518.
6. Kaur, R., Singh, J., Kaur, S., & Malhotra, V. (2023, December). IoT in Smart Cities: Review of IoT Architecture for Smart Cities, Applications, and Key Challenges. In *International Conference On Artificial Intelligence, Computing, IOT and Data Analytics* (pp. 497-510). Singapore: Springer Nature Singapore.
7. Khalid, S., Ahmad, I., Clark, A. E. G., Pavel, H. R., Makhdoom, I., Abolhasan, M., ... & Ziegler, S. (2023). Technological Views for IoT for Sustainable Development. In *Springer Handbook of Internet of Things* (pp. 787-804). Cham: Springer International Publishing.
8. Khanna, A., & Hassan, I. U. (2024). IoT's golden age: Pioneering societal change and economic advancements. In *Bio-Inspired Data-driven Distributed Energy in Robotics and Enabling Technologies* (pp. 77-103). CRC Press.
9. Mishra, P., & Singh, G. (2023). Energy management systems in sustainable smart cities based on the internet of energy: A technical review. *Energies*, 16(19), 6903.
10. Mohamed Firdhous, M. F., Sudantha, B. H., & Hussien, N. A. (2021). A framework for IoT-enabled environment aware traffic management. *International Journal of Electrical & Computer Engineering* (2088-8708), 11(1).
11. Mohanty, A., Mohapatra, A. G., Mohanty, S. K., & Nayak, S. (2024). Harnessing the power of IoT and big data: advancements and applications in smart environments. In *Internet of things and big data analytics-based manufacturing* (pp. 19-58). CRC Press.
12. Mustafa, Z., & Alwin, G. (2025). AI-Powered Parking Systems: Enhancing Urban Mobility Through IoT and Automation.
13. Rahaman, M. M. (2022). A Review on Internet of Things-IoT-Architecture, Technologies, Future Applications & Challenges. *International Journal of Science and Business*, 14(1), 80-92.
14. Rosário, A. T., & Dias, J. C. (2024). Exploring the landscape of smart tourism: a systematic bibliometric review of the literature of the internet of things. *Administrative Sciences*, 14(2), 22.
15. Sajwan, V., Sharma, S., Awasthi, M., Joshi, U., & Sunil, G. (2023, December). IoT and Smart Cities: Present and Future Directions. In *2023 International Conference on Power Energy, Environment & Intelligent Control (PEEIC)* (pp. 192-196). IEEE.
16. Salih, S., Abdelmaboud, A., Husain, O., Motwakel, A., Elshafie, H., Sharif, M., & Hamdan, M. (2025). IoT in urban development: insight into smart city applications, case studies, challenges, and future prospects. *PeerJ Computer Science*, 11, e2816.
17. Sharma, S., & Rishi, O. P. (2024, March). Survey on IoT Enabled Smart Tourism in India: Indian Tourism Service Dimensions. In *International Conference On Emerging Trends In Expert Applications & Security* (pp. 57-71). Singapore: Springer Nature Singapore.
18. Talaat, F. M., Shaban, W. M., ZainEldin, H., Badawy, M., & Elhosseini, M. (2025). Integrating V2X solutions in intelligent green cities: an AI-driven point exchange system approach. *Neural Computing and Applications*, 1-33.