

# IoT-Based Intelligent Logistics Systems in Smart Cities: A Review of Architectures, Optimization Techniques, and Applications

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**Abstract.** The rapid growth of urban populations and the expansion of e-commerce have significantly increased the complexity of logistics operations in modern cities. Smart city initiatives increasingly rely on Internet of Things (IoT) technologies to develop intelligent logistics systems capable of improving delivery efficiency, reducing congestion, and minimizing environmental impact. This paper presents a comprehensive review of IoT-based intelligent logistics systems within smart cities. The study examines key architectural frameworks, communication technologies, optimization techniques, and practical applications in urban logistics. Furthermore, the paper explores recent developments in artificial intelligence, data analytics, and vehicular communication technologies that enable real-time decision-making in logistics networks. The analysis highlights the integration of IoT, AI, and autonomous systems for improving route optimization, fleet management, and last-mile delivery operations. Finally, research challenges and future directions for intelligent logistics systems in smart cities are discussed.

**Keywords:** Smart Cities, Internet of Things, Intelligent Logistics, Urban Transportation, Optimization Algorithms, AI-based Logistics.

## 1 Introduction

Urbanization and the rapid expansion of digital commerce have dramatically increased the demand for efficient logistics systems within cities. Traditional logistics infrastructures are often unable to handle increasing delivery demands while maintaining sustainability and efficiency. Smart cities aim to address these challenges by integrating advanced digital technologies such as the Internet of Things (IoT), artificial intelligence (AI), and data analytics into urban infrastructure.

IoT-enabled logistics systems allow real-time monitoring of vehicles, packages, and infrastructure, thereby improving operational visibility and decision-making capabilities. These systems utilize interconnected sensors, wireless communication technologies, and cloud-based analytics platforms to optimize logistics operations. Recent studies highlight the importance of smart urban logistics

in improving delivery efficiency while reducing traffic congestion and environmental impact [1].

Intelligent logistics systems are increasingly supported by AI-based optimization techniques that enable adaptive decision-making in dynamic urban environments. These techniques allow logistics platforms to adjust delivery routes, predict demand patterns, and manage fleet operations efficiently [5]. Additionally, the integration of autonomous vehicles, intelligent transportation systems, and IoT infrastructure further enhances the capabilities of modern logistics networks.

Recent developments in IoT communication technologies, such as LiFi, hybrid wireless networks, and intelligent vehicular communication systems, have also contributed to improving data transmission and connectivity in logistics environments [3]. These technologies enable reliable communication between logistics vehicles, smart infrastructure, and control centers.

This paper provides a detailed review of IoT-based intelligent logistics systems in smart cities, focusing on architectural frameworks, optimization techniques, and real-world applications.

## 2 Related Work

The concept of smart urban logistics has received increasing attention in recent years due to its potential to address the growing challenges of urban transportation and delivery operations. A systematic literature review conducted by Chocholáč et al. analyzed research trends in smart city logistics and identified modeling and optimization as the dominant research directions [1]. Their work emphasizes the importance of digital technologies in improving urban logistics planning and decision-making.

Recent research has explored the integration of IoT, artificial intelligence, and autonomous vehicles to improve logistics efficiency in smart cities. Mohsen proposed an AI-driven framework that integrates IoT infrastructure with autonomous delivery vehicles to optimize route planning and traffic signal control in urban environments [5]. This approach demonstrates the potential of AI-based analytics for improving logistics operations.

Last-mile delivery systems represent one of the most challenging aspects of urban logistics. Moufad et al. conducted a comprehensive review of smart and sustainable last-mile delivery systems and highlighted the role of digital technologies such as IoT, digital twins, and AI-driven logistics platforms [7]. Their study suggests that integrated logistics platforms can significantly improve delivery efficiency and sustainability.

Other studies focus on evaluating smart logistics solutions using multi-criteria decision-making approaches. Tadić et al. proposed a hybrid decision-making model combining the Best-Worst Method (BWM) and CODAS technique to evaluate smart city logistics strategies [10]. The results indicate that logistics systems combining autonomous vehicles and IoT infrastructure offer the most promising solutions.

Recent work also highlights the importance of dynamic logistics management systems. Rubino et al. proposed a system dynamics model to analyze interactions between logistics operations and urban access management policies [9]. Their model demonstrates how data-driven decision support systems can help optimize urban logistics operations.

Technological advancements in IoT communication systems also play a critical role in enabling intelligent logistics platforms. Several studies have proposed LiFi-based IoT architectures for smart monitoring and vehicular communication systems [3]. Hybrid LiFi-WiFi architectures have also been explored to provide high-speed communication for intelligent transportation systems [4]. Energy-efficient LiFi transceivers have further improved communication reliability in next-generation logistics networks [11].

### 3 Methodology

This study adopts a systematic literature review (SLR) methodology to analyze the development of IoT-based intelligent logistics systems in smart cities. The primary objective of this methodology is to identify, classify, and synthesize existing research contributions related to architectural frameworks, communication infrastructures, optimization techniques, and real-world applications of IoT-enabled logistics technologies. The systematic review approach ensures that the study follows a structured, transparent, and reproducible research process while providing a comprehensive overview of current technological developments in smart city logistics.

The literature collection process was conducted using major academic databases such as IEEE Xplore, Scopus-indexed journals, Google Scholar, and open-access scientific repositories. The search strategy involved combinations of keywords including “IoT-based logistics”, “smart city logistics”, “intelligent transportation systems”, “urban delivery optimization”, and “AI-driven logistics systems”. These keywords were selected to ensure broad coverage of research related to urban logistics infrastructures supported by Internet of Things technologies.

To ensure the quality and relevance of the selected literature, only peer-reviewed journal articles and conference papers were considered. The initial search produced a large number of studies, which were then filtered using predefined inclusion and exclusion criteria. Duplicate records and studies not directly related to IoT-enabled logistics systems were removed during this stage. The remaining papers were carefully examined to extract relevant technical information regarding system design, communication frameworks, optimization algorithms, and application scenarios.

Each selected study was evaluated according to several analytical dimensions representing the key technological components of intelligent logistics systems. The first dimension focuses on system architecture and infrastructure design, where the integration of sensing devices, communication networks, and cloud-based processing platforms is examined. IoT-based logistics systems typically

consist of multiple interconnected layers including sensing, communication, data processing, and decision-support layers.

The second analytical dimension focuses on communication technologies and networking frameworks used in intelligent logistics environments. Modern logistics systems rely on heterogeneous communication technologies such as wireless sensor networks, cellular networks, WiFi, and optical wireless communication systems to enable real-time data exchange between vehicles, sensors, and control centers.

The third dimension examines optimization algorithms and intelligent decision-making techniques used to improve logistics operations. These techniques include machine learning models, artificial intelligence algorithms, and multi-criteria decision-making approaches that support route optimization, fleet management, and demand prediction in urban logistics systems.

The final analytical dimension evaluates practical implementations and application domains of IoT-enabled logistics systems in smart cities. These applications include last-mile delivery optimization, intelligent warehouse management, traffic-aware delivery routing, and real-time fleet monitoring systems.

After extracting and organizing relevant information from the selected studies, the literature was categorized into major research themes. These themes include IoT logistics architectures, communication infrastructures for smart transportation, AI-based logistics optimization techniques, and real-world smart city logistics applications. This classification allows a structured comparison of different approaches and helps identify emerging research trends and technological challenges.

Figure 1 illustrates the workflow of the systematic literature review process used in this study. The process begins with literature identification through academic databases, followed by screening and filtering of relevant publications. The selected studies are then analyzed based on architectural frameworks, communication technologies, optimization techniques, and application domains. Finally, the extracted insights are synthesized to provide a comprehensive understanding of intelligent logistics systems in smart cities.

This methodological framework ensures that the study captures the most relevant research contributions while providing a structured and reproducible approach for analyzing IoT-based logistics technologies.

## 4 Architectural Framework of IoT-Based Logistics Systems

IoT-based intelligent logistics systems typically consist of multiple interconnected layers that facilitate data collection, communication, processing, and decision-making. These architectures integrate sensors, communication networks, cloud computing platforms, and AI-based analytics systems.

The general architecture of an IoT-based logistics system can be represented as follows:

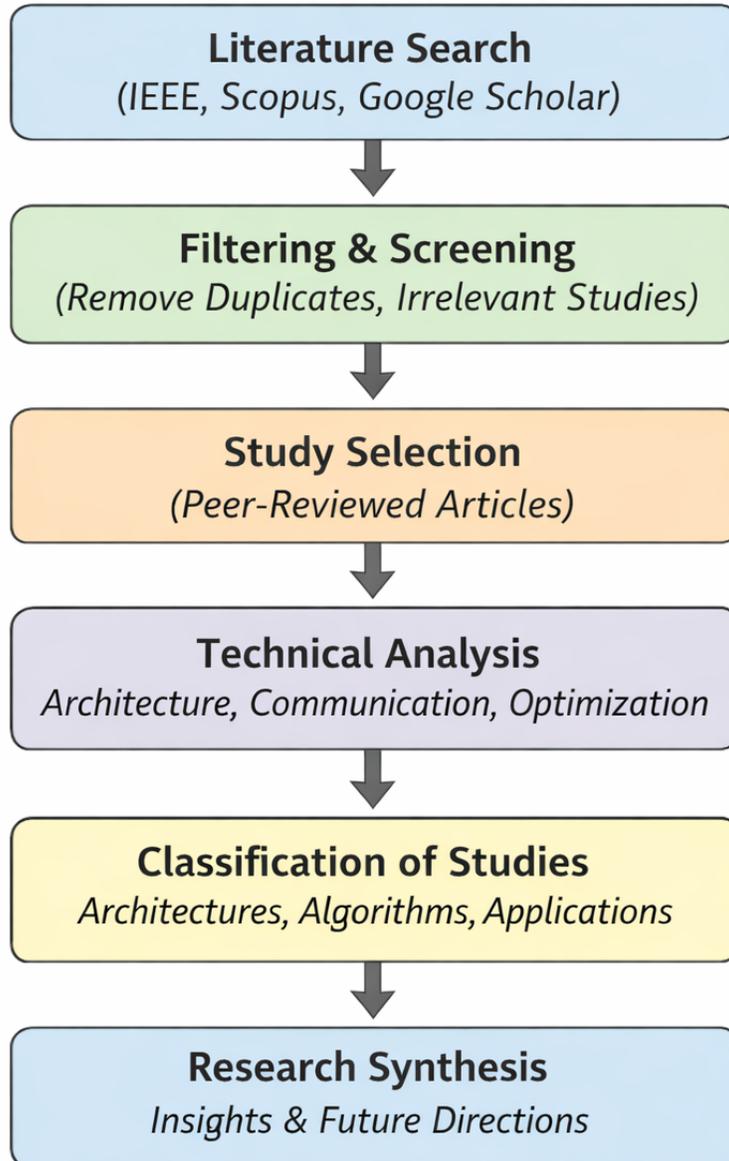


Fig. 1: Systematic Literature Review Methodology for IoT-Based Intelligent Logistics Systems

$$L = \{S, C, D, A\} \tag{1}$$

where:

- $S$  represents IoT sensing devices,
- $C$  denotes communication networks,
- $D$  represents data processing infrastructure,
- $A$  represents intelligent analytics and optimization modules.

The sensing layer consists of RFID tags, GPS sensors, and environmental monitoring devices that collect logistics-related data. The communication layer enables data transmission using wireless technologies such as WiFi, LiFi, and cellular networks.

The data processing layer utilizes cloud computing and edge computing platforms to process large volumes of logistics data. Finally, the application layer includes AI-based analytics systems responsible for route optimization, fleet management, and demand prediction.

## 5 Optimization Techniques for Intelligent Logistics

Optimization plays a critical role in intelligent logistics systems. Machine learning algorithms are widely used to improve delivery route planning, vehicle scheduling, and demand forecasting.

Recent research highlights the use of multi-criteria decision-making models to optimize network connectivity and resource allocation in heterogeneous communication networks [8]. These techniques can also be applied to logistics networks to improve operational efficiency.

Artificial intelligence techniques such as reinforcement learning and predictive analytics have also been used to enhance decision-making in logistics operations. AI-driven logistics platforms are capable of analyzing large datasets and dynamically adjusting delivery strategies in response to real-time conditions [6].

Additionally, IoT-enabled sensor networks allow real-time monitoring of logistics vehicles and delivery infrastructure. These systems enable intelligent route optimization and adaptive logistics planning.

## 6 Applications in Smart Cities

IoT-based logistics systems have been implemented in various smart city applications, including last-mile delivery, fleet management, warehouse automation, and traffic management.

AI-driven logistics systems can significantly improve last-mile delivery efficiency by dynamically adjusting delivery routes based on real-time traffic conditions. Intelligent fleet management systems also enable logistics operators to monitor vehicle performance and optimize resource utilization.

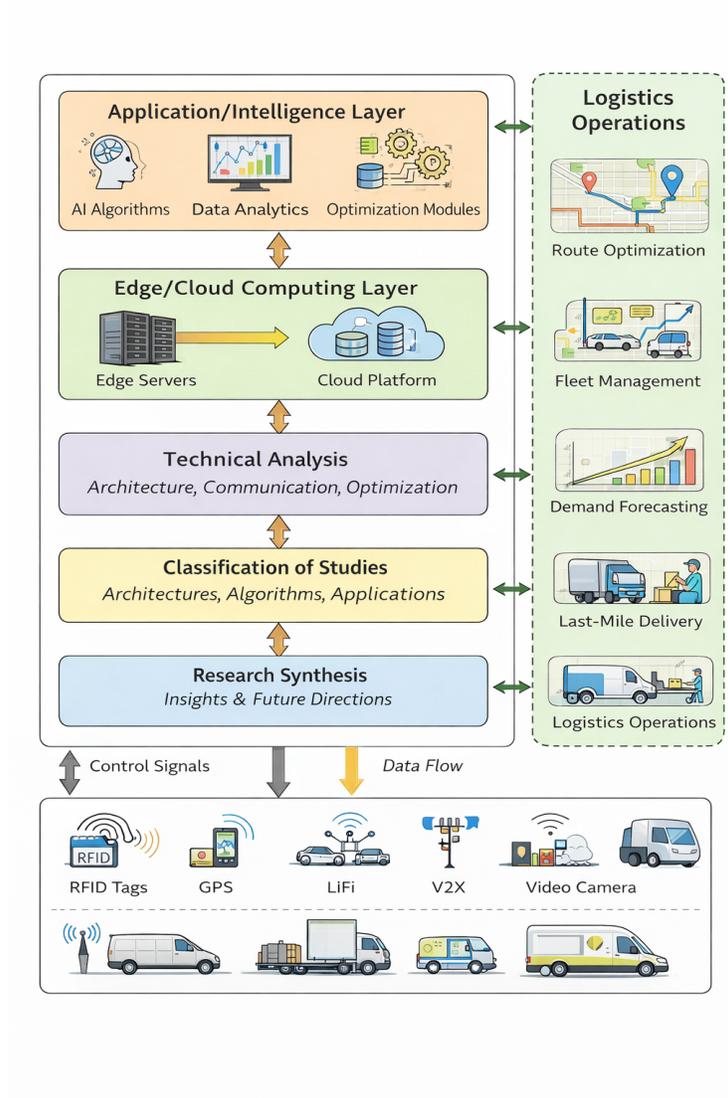


Fig. 2: Architecture of IoT-Based Intelligent Logistics System

Recent studies demonstrate the integration of AI-driven logistics platforms with mixed reality systems and knowledge graph-based decision support tools to enhance warehouse operations and logistics coordination [2]. These technologies improve operational visibility and enable collaborative decision-making across logistics stakeholders.

Furthermore, IoT-enabled intelligent transportation systems support vehicle-to-infrastructure communication, allowing logistics vehicles to interact with smart traffic signals and road infrastructure.

## 7 Results and Discussion

The analysis indicates that IoT-based logistics systems offer significant advantages in improving delivery efficiency, reducing operational costs, and minimizing environmental impact. Intelligent logistics platforms provide real-time monitoring capabilities that enable proactive decision-making in urban logistics networks.

However, several challenges remain in implementing these systems. These include data security concerns, interoperability issues among heterogeneous devices, and the need for scalable communication infrastructure.

Research also highlights the importance of integrating emerging technologies such as autonomous vehicles, digital twins, and AI-based decision support systems to further enhance logistics performance.

## 8 Conclusion

IoT-based intelligent logistics systems represent a key component of smart city infrastructure. By integrating IoT sensors, advanced communication technologies, and AI-driven analytics platforms, these systems enable efficient and sustainable logistics operations in urban environments.

The review highlights the importance of intelligent architectures, optimization techniques, and real-time decision-making capabilities in modern logistics systems. Future research should focus on improving system scalability, enhancing data security, and developing more advanced optimization algorithms for urban logistics networks.

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