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RADemics

IoT-Enabled Smart Logistics and Real-Time Tracking Systems

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IoT-Enabled Smart Logistics and Real-Time Tracking Systems

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Abstract

The rapid evolution of digital technologies has transformed traditional logistics systems into intelligent, data-driven, and interconnected supply chain ecosystems. Internet of Things (IoT)-enabled smart logistics and real-time tracking systems provide continuous visibility, automation, and optimization across logistics operations, enabling enhanced operational efficiency, reduced costs, and improved service quality. This book chapter presents a comprehensive exploration of IoT architectures, sensing technologies, communication frameworks, and data analytics methodologies applied to smart logistics environments. Layered IoT architecture models, edge-cloud hybrid computing frameworks, and interoperability mechanisms are examined to demonstrate their role in enabling scalable and resilient logistics infrastructures. Real-time tracking technologies, environmental monitoring sensors, geofencing systems, and digital twin-based tracking models are analyzed to highlight their contributions to predictive logistics management and risk mitigation. The integration of artificial intelligence, explainable AI, and advanced analytics techniques is discussed to illustrate intelligent decision support, autonomous logistics operations, and adaptive supply chain optimization. Security, privacy, and governance challenges associated with IoT-based logistics systems are also addressed to ensure trustworthy and ethical deployment. Finally, emerging trends, research gaps, and future directions are outlined to guide the development of next-generation smart logistics ecosystems aligned with Industry 4.0 and beyond.

Keywords; IoT-Enabled Smart Logistics; Real-Time Tracking Systems; Edge-Cloud Computing; Digital Twin; Explainable Artificial Intelligence; Intelligent Supply Chain Analytics.

Introduction

The digital transformation of logistics and supply chain systems has accelerated due to the convergence of Internet of Things technologies, advanced data analytics, artificial intelligence, and cyber-physical infrastructures [1]. Traditional logistics models relied heavily on manual operations, static planning, and limited real-time visibility, which constrained operational efficiency and responsiveness [2]. Modern smart logistics environments leverage interconnected devices, intelligent platforms, and automated decision-making frameworks to enable dynamic supply chain management [3]. IoT-enabled logistics systems provide continuous monitoring, data-driven insights, and autonomous operational capabilities that enhance transparency, reduce

inefficiencies, and improve service delivery across global supply chains [4]. The integration of sensing technologies, communication protocols, and intelligent analytics has reshaped logistics operations into adaptive and intelligent ecosystems capable of responding to rapidly changing market demands and operational conditions [5].

IoT-enabled smart logistics and real-time tracking systems provide critical capabilities for monitoring assets, vehicles, environmental conditions, and operational workflows across distributed supply chain networks [6]. Real-time tracking mechanisms enable precise location monitoring, condition monitoring, and performance analytics for goods in transit and storage environments [7]. These capabilities are particularly significant in cold chain logistics, high-value asset transportation, and time-sensitive delivery operations [8]. Continuous data acquisition through sensors and embedded systems enables predictive analytics and proactive decision-making, reducing risks associated with spoilage, delays, and operational disruptions [9]. The deployment of IoT technologies across warehouses, transportation systems, and distribution centers enhances operational coordination and enables integrated logistics management across multiple organizational entities [10].

The architectural design of IoT-enabled logistics systems constitutes a foundational element for achieving scalability, reliability, and interoperability [11]. Layered IoT architecture models define functional components such as perception, communication, processing, and application layers to support modular system development and deployment [12]. Edge–cloud hybrid computing architectures facilitate real-time data processing and large-scale analytics by distributing computational tasks across localized edge nodes and centralized cloud platforms [13]. Communication protocols and networking technologies such as 5G, LPWAN, and satellite networks provide robust connectivity across geographically dispersed logistics environments [14]. Middleware and interoperability frameworks enable seamless integration among heterogeneous devices, platforms, and enterprise systems, ensuring coordinated logistics operations and data-driven decision-making [15].