

Application and Practice of Internet of Things Technology in Intelligent Operation and Management of Property Services

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Abstract

In the era of the digital economy, the Internet of Things (IoT) technology has become a core driving force for the transformation and upgrading of the property service industry to achieve refined operation. Traditional property services are plagued by pain points including low operational efficiency, slow service response, difficult cost control and inadequate safety prevention and control. Through the coordinated operation of the perception layer, network layer and application layer, IoT technology can realize intelligent perception, data-driven analysis and automatic management and control across full scenarios of property services. Combined with the actual operation and management of property companies, this paper discusses application paths and practical approaches of IoT technology in core scenarios such as intelligent security, intelligent operation and maintenance of facilities and equipment, smart environmental management and intelligent customer service response. It also analyzes difficulties in technology implementation and puts forward optimization strategies. This study aims to empower property services with IoT technology, improve operational and management efficiency, cut operating costs, enhance owners' service experience, and provide practical references for the intelligent transformation of property service enterprises.

Keywords: Internet of Things Technology; Property Services; Intelligent Operation; Facility Operation and Maintenance; Intelligent Security; Service Upgrading

1. Introduction

As an important component of urban services, the operation and management level of the property service industry is directly related to owners' living experience and the harmony and stability of communities. With the continuous improvement of residents' demands for quality of

life, the traditional labor-oriented property service model can hardly meet owners' requirements for efficient, convenient, accurate and safe services. Meanwhile, enterprises are confronted with industry-wide challenges such as rising labor costs, low management efficiency and great difficulties in service standardization. Against the backdrop of the rapid development of new-generation information technologies, IoT technology, featured by "interconnection of all things, intelligent perception and data-driven operation", offers brand-new solutions for the transformation and upgrading of property services (Liu, 2018; Zeng, 2023).

As the general manager of a property company, in coordinating daily enterprise operations and formulating development strategies, I have gained an in-depth understanding of the transformative value of IoT technology for the property service industry. Integrating IoT technology into the whole process of property services covering security, operation and maintenance, customer service and environmental management can realize the shift from "passive response-oriented services" to "proactive prediction-oriented services", as well as the upgrade from "extensive labor-based management" to "data-driven refined management" (Liu, 2024). Based on practical experience of IoT technology implementation in enterprises, this paper systematically sorts out application scenarios and key practical points of IoT technology in property service operation and management, so as to provide replicable and implementable paths for intelligent transformation of property service enterprises in the industry.

2. Core Value of Empowering Property Services with IoT Technology

The Internet of Things refers to a network technology that connects any object to the Internet through information-sensing devices such as radio-frequency identification, infrared sensors, global positioning systems and laser scanners in accordance with agreed protocols for information exchange and communication, so as to realize intelligent identification, positioning, tracking, monitoring and management of objects. Its application in the field of property services is not merely the intelligent upgrade of individual devices, but the technical integration across full scenarios and whole workflows (Zhao et al., 2020). Its core value in property services is reflected in the following four aspects:

2.1. Improve Operational and Management Efficiency and Reduce Labor Costs

IoT technology enables automatic and intelligent management and control of every link in property services and replaces a large number of repetitive manual operations. For instance, intelligent security systems support 24-hour unattended monitoring; intelligent facility and equipment operation-maintenance systems automatically monitor equipment operating status; and intelligent meter-reading systems realize automatic data collection of water and electricity meters, which substantially cuts manpower input for posts such as security guards, engineering staff and meter readers. Meanwhile, centralized management via the IoT platform facilitates data exchange and instruction coordination across service scenarios, eliminates information silos among departments, boosts cross-departmental work efficiency, and lowers overall enterprise operation and management costs (Liu, 2024; Zeng, 2023).

2.2. Optimize Service Response Mechanism and Enhance Owners' Experience

In traditional property services, owners submit demands via phone calls or WeChat, which brings problems such as delayed responses and opaque processing procedures. The intelligent customer service and demand response platform built with IoT technology supports one-click submission of owners' demands, automatic work-order dispatching, whole-process tracking and completion evaluation (Song, 2024; Wang & Li, 2023). Service response time is shortened from hour-level to minute-level. Furthermore, intelligent perception by IoT devices enables proactive services. For example, upon detecting emergencies such as water leakage in owners' homes or elevator failures, the system triggers automatic alarms and pushes notifications to relevant staff for early intervention and rapid handling, greatly improving owners' service experience and satisfaction.

2.3. Strengthen Safety Prevention and Control Capabilities and Guard against Various Risks

Safety management constitutes the core work of property services, covering community security, fire control management, safety of facilities and equipment, and public environmental safety. By deploying intelligent sensing devices, IoT technology achieves real-time monitoring, automatic early warning and rapid disposal of safety risks. For example, intelligent fire-fighting systems monitor real-time data of smoke sensors, temperature sensors and gas concentration, and trigger immediate alarms while linking sprinkler and ventilation equipment once anomalies occur. Intelligent security systems adopt face recognition, vehicle recognition and abnormal behavior monitoring to effectively guard against potential safety hazards such as intrusions of outsiders, random vehicle parking and theft. The intelligent monitoring system for facilities and equipment keeps real-time track of the operating status of key equipment including elevators, water pumps and power distribution rooms, predicts equipment failures in advance, and prevents safety accidents caused by equipment shutdown (Zhao, 2023).

2.4. Realize Data-Driven Decision-Making and Improve Refined Management

The IoT platform collects real-time operational data of every link in property services, including operational data of facilities and equipment, owners' service demand data, safety prevention-and-control data and cost consumption data. Through analysis and mining of such data, property enterprises can accurately grasp community operation status, characteristics of owners' service demands and patterns of cost consumption, which provides scientific data support for formulating business strategies, adjusting service schemes, optimizing cost control and improving management systems (Wang & Li, 2023). For example, analysis on owners' service demand data helps add targeted high-frequency service items; analysis on equipment operational data optimizes equipment maintenance plans and reduces maintenance costs; analysis on property fee collection data supports differentiated collection strategies and raises the collection rate. The capability comparison of the two property service models is shown in Table 1.

Table 1. Comparison of Traditional and IoT-Enabled Property Service Models

Comparison Dimension	Traditional Property Service Model	IoT-enabled Smart Property Service Model
Operation & Management Mode	Extensive labor-based management	Data-driven refined management
Service Response Mode	Passive repair receiving, hour-level response	Proactive prediction & early warning, minute-level closed-loop handling
Safety Prevention Means	Mainly human-based defense, post-incident disposal	Human-technical-intelligent integrated defense; pre-warning and real-time monitoring
Labor Cost	Large manpower input with numerous posts	Scientific decision-making supported by multi-dimensional operational data

3. Specific Application and Practice of IoT Technology in Property Service Operation and Management

Based on the actual operation and management of property companies, IoT technology is applied in core scenarios including intelligent security, intelligent operation and maintenance of facilities and equipment, smart environmental management, intelligent customer service and smart energy consumption management (Liu, 2024; Zhao et al., 2020). Through full-link construction of “sensing device deployment + network transmission + platform management + application implementation”, the intelligent upgrade of property services is realized. The practical applications of each scenario are presented as follows:

3.1. Intelligent Security Scenario: Building an Omnidirectional and Dead-angle-free Community Security System

Community security ranks high on the priority list of property services. By deploying IoT sensing devices, an omnidirectional security system integrating “human defense, technical defense and intelligent defense” is constructed to realize the transition from “passive prevention” to “proactive early warning” (Ministry of Housing and Urban-Rural Development of the People’s Republic of China, 2022). First, face-recognition and vehicle-recognition devices are installed at community entrances and unit gates to realize intelligent access management for personnel and vehicles. Outsiders are required to register with real-name information and obtain owners’ confirmation before entry, which effectively prevents intrusions of strangers. Meanwhile, the vehicle-recognition system is linked with the community parking management system to realize automatic billing and frictionless access for vehicles and improve parking management efficiency. Second, high-definition intelligent cameras equipped with functions such as motion detection, abnormal behavior recognition and sound detection are deployed in public community areas, elevators and corridors. Once anomalies such as people climbing over walls, gatherings causing disturbances or unattended articles are detected, the system automatically pushes alarm information together with location

information to security guards' handheld terminals for on-site rapid disposal. Third, intelligent security devices such as door-window magnetic contacts, infrared sensors and gas-leakage alarms are installed in owners' homes. Owners can conduct remote control via mobile apps. In case of forced prying of doors or windows or gas leakage, the system sends alarms to both owners and the property monitoring center, and notifies community security staff to conduct on-site verification so as to safeguard owners' home safety.

3.2. Intelligent Operation and Maintenance of Facilities and Equipment: Realizing Full-life-cycle Management of Key Equipment

Facilities and equipment in property services, including elevators, water pumps, power distribution rooms, fire-fighting facilities and monitoring equipment, underpin normal community operation. The traditional operation-maintenance mode relies on regular manual inspections, which suffers from delayed inspections, late detection of failures and high maintenance costs. IoT-enabled intelligent operation and maintenance of facilities and equipment builds an intelligent management platform to realize real-time monitoring of equipment operating status, automatic failure early warning, intelligent dispatching of maintenance work-orders and full-life-cycle management (Liu & Chen, 2024; Zhang & Zhao, 2022). Firstly, elevator operation monitors, video surveillance equipment and emergency call devices are installed inside elevators to collect real-time data such as running speed, car position, door opening-closing status and fault codes. When faults such as elevator entrapment, overspeed or buffer-striking occur, the system automatically sends alarms to engineering maintenance staff and the monitoring center. Meanwhile, fault information is pushed to owners' mobile apps to inform them of fault causes and disposal progress. In addition, elevator operation data are analyzed to predict the replacement time of vulnerable components and formulate advance maintenance plans so as to reduce elevator failure rates. Secondly, temperature-humidity sensors, current-voltage monitors and pressure sensors are deployed in key facility areas such as water pump houses, power distribution rooms and fire-fighting pump houses to monitor real-time equipment operating parameters. The system triggers automatic early warnings and alerts maintenance staff for troubleshooting upon parameter anomalies, avoiding water supply suspension, power outage and failure of fire-fighting systems caused by equipment malfunctions. Thirdly, electronic archives for facilities and equipment are established to record procurement information, installation information, operational data, maintenance records and fault handling records, realizing digital full-life-cycle management of equipment and providing data support for equipment renewal and maintenance plan formulation.

3.3. Smart Environmental Management Scenario: Creating Green and Livable Community Public Environment

Community public environmental management covers cleaning, greening, waste classification and public-area disinfection. The traditional management mode depends on manual inspections and subjective judgment, resulting in insufficient refinement and untimely services. Empowered by IoT technology, environmental management achieves intelligent perception of environmental conditions, automatic triggering of service demands and precise control over service procedures (Ministry of Housing and Urban-Rural Development of the People's Republic of China, 2022). Firstly, garbage bin overflow sensors are deployed in public community areas to monitor bin filling

status in real time. When reaching the early-warning threshold, the system automatically pushes removal notifications with specific bin locations to cleaning staff's handheld terminals, realizing on-demand cleaning services, improving cleaning efficiency and preventing environmental pollution caused by overflowing garbage. Secondly, soil moisture sensors and ambient temperature-humidity sensors are installed in green belts to monitor soil moisture and environmental conditions. Based on monitored data, the system automatically judges irrigation demands of plants and links intelligent irrigation systems for on-demand watering, which guarantees plant growth while saving water resources. Meanwhile, pest and disease risks in green belts can be detected in a timely manner so that greening maintenance staff can carry out prevention and treatment to improve greening management. Thirdly, disinfection check-in devices are deployed in public areas. Cleaning staff are required to complete on-site check-ins after finishing disinfection work, and check-in information is uploaded to the IoT platform in real time. Managers can view disinfection completion status, covered areas and working hours on the platform to ensure effective implementation of disinfection work and safeguard public health in communities.

3.4. Intelligent Customer Service Scenario: Building an Efficient and Transparent Owner Demand Response System

Owner customer service serves as a core window of property services and directly affects owners' satisfaction. By building an IoT-based intelligent customer service platform and integrating online and offline service channels, closed-loop management featuring one-click demand submission, intelligent work-order dispatching and whole-process tracking is realized (Song, 2024; Wang & Li, 2023). Firstly, online owner service platforms including mobile apps and WeChat Mini Programs are developed. Owners can complete property fee payment, repair applications, complaint submission, visitor reservation and community activity registration via the platforms without visiting property service centers, realizing "handling services without going out". Secondly, intelligent dispatching and whole-process tracking of owner demands are realized. After owners submit repair requests or complaints, the system automatically assigns work-orders to corresponding staff according to demand types and locations. Staff receive and process work-orders via handheld terminals. Every step including order receiving, processing and completion is uploaded to the platform in real time, and owners can check work-order progress transparently via the platforms. Thirdly, an owner service evaluation system is established. Upon work-order completion, owners can evaluate service quality through the platform, and evaluation results are linked with staff performance assessment to urge staff to improve service quality. Moreover, by analyzing owner evaluation and demand data, weak links in services can be identified, and service procedures can be optimized in a targeted manner to lift overall service standards.

3.5. Smart Energy Consumption Management Scenario: Realizing Refined Control of Community Energy Consumption and Energy Conservation

Community energy consumption covers water, electricity, gas, public lighting and elevator operation, constituting a major component of property service costs. The traditional energy-consumption management mode adopts manual meter reading and extensive control, leading to inaccurate energy data, severe waste and difficult cost control. The smart energy-consumption management system built with IoT technology supports automatic collection, real-time monitoring,

analytical early warning and energy-saving control of energy data (W. Liu, 2018; Zeng, 2023). Firstly, intelligent remote-transmission modules are installed on metering devices such as public-area electricity meters, water meters and gas meters to realize automatic collection and real-time upload of energy-consumption data, replacing manual meter reading and improving data accuracy and timeliness. Meanwhile, the platform conducts statistical analysis on energy-consumption data of different areas and equipment, generates energy-consumption analysis reports, and accurately identifies consumption patterns and waste points in communities. Secondly, intelligent lighting controllers and human-body induction sensors are deployed for public lighting systems to realize intelligent control. For instance, human-body induction enables “lights on upon human arrival and lights off upon human departure” in stairwells and underground parking lots; street lamps in communities automatically adjust brightness according to light intensity and time, which greatly cuts energy consumption of public lighting. Thirdly, energy-saving schemes are formulated through analyzing energy-consumption data, such as upgrading high-energy-consumption equipment and sending gentle reminders to owners for unreasonable energy-use behaviors. Refined management reduces community energy consumption and further cuts property service costs.

4. Difficulties and Optimization Strategies for IoT Technology Implementation in Property Services

Although IoT technology brings remarkable value improvement to property services, property service enterprises still face multiple challenges in practical implementation, including high capital investment, difficult technology integration, insufficient staff competence and data security risks (Liu, 2024; Song, 2024). Combined with enterprise practical experience, targeted optimization strategies are put forward as follows.

4.1. Difficulty 1: Large Up-front Capital Investment, Limited Affordability of Small- and medium-sized Property Enterprises

The implementation of IoT technology requires deployment of a large number of sensing devices as well as construction of network transmission and platform management systems, which involves substantial up-front capital input. Small- and medium-sized property enterprises with limited financial strength can hardly afford high transformation costs, which becomes the primary barrier for technology implementation (Zeng, 2023).

Optimization Strategies: Adopt a phased and progressive construction mode. Priority shall be given to transformation of core and high-demand scenarios such as intelligent security and intelligent facility operation-maintenance. Cost savings and efficiency gains generated from core scenarios can be reinvested into technical upgrades for other scenarios. In addition, property enterprises may cooperate with IoT technology service providers and adopt the mode of “equipment leasing plus platform service fee” to ease up-front capital pressure. Furthermore, enterprises can apply for special subsidies by making use of government digital transformation support policies to alleviate financial burdens.

4.2. Difficulty 2: Poor System Connection, Great Challenges in Technology Integration and Data Interoperability

IoT devices and systems for different property service scenarios are mostly supplied by various vendors, resulting in inconsistent device interfaces, poor system compatibility and divergent data formats. These problems hinder data interoperability and functional coordination among systems, create “information silos”, and prevent IoT technology from giving full play to its overall value (Wang & Li, 2023).

Optimization Strategies: Formulate unified technical standards and interface specifications at the initial stage of IoT system construction, and select service providers with system integration capabilities to guarantee seamless connection of devices and systems across scenarios. Build a unified IoT management platform to integrate systems and data of intelligent security, facility operation-maintenance, smart environmental management and intelligent customer service onto one single platform for centralized management, data sharing and collaborative application. Moreover, establish a long-term mechanism for technical docking and maintenance, and sign long-term cooperation agreements with service providers to guarantee smooth system upgrade, maintenance and docking in later stages.

4.3. Difficulty 3: Shortage of Professional Technical Personnel, Inadequate Staff Competence in Operation and Management

The operation and management of IoT systems require compound talents equipped with both property service knowledge and IoT technical expertise. Most employees of traditional property enterprises are engaged in security, cleaning and engineering maintenance posts and lack capabilities to operate and manage IoT technologies. Consequently, constructed IoT systems cannot deliver full functional value, and even suffer from idle systems and unattended equipment failures.

Optimization Strategies: Establish a comprehensive staff training system and carry out position-specific IoT training. For example, staff in monitoring centers receive training on platform operation and alarm handling; engineering maintenance staff are trained for equipment monitoring and troubleshooting; customer-service staff get training on intelligent customer-service platform operation and work-order processing to improve employees’ technical operation capabilities. Meanwhile, introduce IoT professionals and set up an in-house technical operation-maintenance team responsible for daily operation, maintenance and optimization of IoT systems to underpin stable system performance. In addition, incorporate IoT system operation capabilities into employee performance assessment to encourage staff to proactively learn relevant technologies.

4.4. Difficulty 4: Prominent Data Security Risks, Vulnerability of Owner Information and Enterprise Data to Leakage

The application of IoT technology involves massive owner information (face-recognition data, identity information, household information, etc.) and enterprise operational data (energy-consumption data, financial data, service data, etc.). In the processes of data collection, transmission, storage and utilization, such data face security risks including hacker attacks, data leakage and unauthorized use, which may not only infringe owners’ privacy rights but also disrupt normal enterprise operations.

Optimization Strategies: Build a comprehensive data security protection system. In data collection, follow the “minimum necessity” principle, collect only information required for property services, clearly inform owners of purposes, modes and scope of data use, and obtain owners’ consent. In data transmission, adopt encryption technologies to guarantee transmission security. In data storage, deploy secure databases with strict access permissions and encrypted data storage to prevent unauthorized access and data theft. In data utilization, establish an approval system for data use and prohibit unauthorized data access. Meanwhile, deliver data-security training for employees to raise their awareness of data protection. Furthermore, conduct regular security inspections and vulnerability repairs for IoT systems to guard against cyber-attacks and data-security hazards in a timely manner.

5. Conclusion

As a core component of new-generation information technologies, IoT technology brings new development opportunities for the transformation and upgrading of the property service industry. Its application in property service operation and management effectively addresses pain points of traditional property services such as low efficiency, slow service response, high costs and prominent risks, and realizes the transformation of property services from “extensive labor-based management” to “intelligent refined management”. As the general manager of a property company, when formulating enterprise development strategies, we should take empowering property services with IoT technology as a core development orientation, and promote phased and scenario-based implementation of IoT technology in light of enterprise realities and owners’ service demands.

Based on practical experience of IoT technology application in enterprises, this paper explores application paths and practical approaches of IoT technology in core scenarios including intelligent security, intelligent operation and maintenance of facilities and equipment, smart environmental management, intelligent customer service and smart energy consumption management. It also puts forward optimization strategies targeting implementation difficulties concerning capital, technology, personnel and data security. Practices have proven that empowered by IoT technology, enterprises achieve significantly improved operational and management efficiency, reduced operating costs, greatly enhanced owners’ service experience and satisfaction, and further elevated brand reputation.

In the future development of property services, IoT technology will be deeply integrated with artificial intelligence, big data, cloud computing and 5G technologies to realize higher-level intelligence of property services. Property service enterprises should continuously increase R&D and technical investment, optimize IoT application schemes, improve intelligent service systems, and strengthen talent training and team building to enhance enterprises’ intelligent operation and management capabilities. Through in-depth empowerment of IoT technology, the property service industry will develop toward higher efficiency, greater convenience, better safety and higher livability, create high-quality living environments for owners, and contribute to urban services and community governance.

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