

Research on the Application of Internet of Things Technology in Water-Related Electromechanical Equipment and Smart Property Services

Zihao Ye ¹, Xihu Lin ¹, Yunde Zhou ², Zuntao Ma ³, Renjie Zhu ⁴, Lingqi Zhang ⁵, Sisi Shao ^{6,*}

¹ Rui'an Water Affairs Co., Ltd., Wenzhou Public Utilities Development Group, Rui'an 325000, China

² Rui'an Rural Water Supply Operation and Maintenance Co., Ltd., Rui'an 325200, China

³ Wenzhou Electric Power Construction Co., Ltd., Wenzhou 325000, China

⁴ Wenzhou Huachang Construction Co., Ltd., Wenzhou 325000, China

⁵ Wenzhou Xinghe Property Management Co., Ltd., Wenzhou 325000, China

⁶ Zhejiang Ruixiang Property Service Co., Ltd., Wenzhou 325200, China

*Corresponding Author

Sisi Shao

328765767@qq.com

Received: 16 September 2026 / Accepted: 22 October 2026 / Published online: 24 October 2026

Abstract

Traditional operation and maintenance of water-related electromechanical equipment and residential property services are often characterized by low operational efficiency, delayed fault responses, excessive energy consumption, and high labor costs. By integrating sensing, transmission, analysis, and intelligent control, Internet of Things (IoT) technology offers opportunities to improve equipment management and property operations. This paper outlines the technical architecture of IoT and examines its principal applications in two interconnected settings: the operation of water-related electromechanical equipment and the management of water-related facilities in residential communities. It also identifies implementation challenges, including limited equipment compatibility, data security risks, inadequate operation and maintenance systems, and insufficient integration across applications, and proposes corresponding measures. The analysis suggests that IoT-enabled systems can support real-time equipment monitoring, early fault warnings, and intelligent control, while improving the digital management of water-related property services, reducing operation and maintenance costs, and enhancing service quality. The discussion provides a practical reference for integrating smart water services with smart property management.

Keywords: Internet of Things; Water-Related Electromechanical Equipment; Smart Property Management; Equipment Operation and Maintenance; Intelligent Monitoring and Control

1. Introduction

1.1. Research Background

Against the backdrop of smart city development, smart water services and smart property management have become important components of more effective urban governance. Conventional operation and maintenance of water-related electromechanical equipment relies on manual inspections, scheduled maintenance, and repairs after failures occur. Pumping stations, pipe networks, and water pump units are geographically dispersed and operate under complex conditions. Manual monitoring makes it difficult to track equipment conditions in real time, potentially leading to abnormal water pressure, pipe leakage, equipment overload, and energy waste. These problems can compromise water supply reliability and waste water and electricity.

In residential communities, secondary water supply facilities, water supply and drainage networks, and other water-related electromechanical equipment are essential to everyday life. Conventional property-managed water services face inefficient meter reading, slow responses to faults, fragmented maintenance records, and limited control over energy consumption. These limitations make it difficult to meet the needs of modern smart communities. IoT technology can reduce information barriers in conventional operation and maintenance by supporting real-time data collection, intelligent analysis, and remote equipment control. It therefore provides a technical basis for upgrading water-related electromechanical systems and improving property services (Singh & Ahmed, 2021).

1.2. Research Significance

From a theoretical perspective, this paper proposes an integrated framework for applying IoT technology to water-related electromechanical equipment and property management. By examining the links between these settings, it contributes to discussions at the intersection of smart water services and smart property management.

From a practical perspective, IoT-enabled monitoring and control can support continuous observation of water-related equipment, identify faults and pipe leakage more promptly, and help reduce energy use and maintenance costs. These capabilities can also streamline property management workflows, accelerate fault resolution, and improve residents' experience of water services, offering practical pathways for digital transformation.

1.3. Domestic and International Research

International research and practice have explored IoT-based monitoring of water distribution networks and pumping-station equipment (Pagano et al., 2025). In settings such as Europe, North America, Japan, and South Korea, industrial IoT solutions have been used to support predictive maintenance, equipment scheduling, and energy-efficiency improvements. Such developments offer examples of how water infrastructure monitoring can be connected with intelligent property management.

Research on related applications in China is also expanding. However, existing work frequently addresses individual equipment upgrades or separate smart property applications rather than their coordinated deployment. Research on integrating water-related electromechanical equipment with

residential property water services remains comparatively fragmented. This paper addresses that integration by considering equipment management and property operations within a common application framework.

1.4. Research Content and Methods

This paper reviews the architecture of IoT technology, examines limitations of conventional operation and maintenance, analyzes major IoT application scenarios for water-related electromechanical equipment and residential property water services, and proposes strategies to address implementation challenges. It combines a literature review, scenario analysis, and problem-oriented analysis to connect technological considerations with practical management needs.

2. Relevant Concepts and IoT Technical Architecture

2.1. Core Concepts

Water-related electromechanical systems include pumping stations, water pump sets, secondary water supply equipment, pipe-network valves, water-quality monitoring devices, electrical control units, and other essential water supply and drainage facilities. Together, these systems provide the infrastructure required for reliable water supply (Menke et al., 2016; Silva et al., 2025).

Property-oriented IoT refers to the use of networked sensing devices, data platforms, and connected control systems to support the operation and maintenance of residential and industrial properties. Combined with big data and cloud computing, these technologies enable data-driven equipment management and more precise operational control (Pagano et al., 2025; Singh & Ahmed, 2021).

The integrated application of IoT in water services connects information systems used for municipal water infrastructure with those serving water facilities in residential developments. This integration can support unified monitoring, intelligent scheduling, and coordinated property-based operation and maintenance of water-related electromechanical equipment.

2.2. Four-Layer IoT Technical Architecture

The perception layer provides on-site data acquisition. Pressure, flow, temperature, and water-level sensors, together with smart water meters, collect information on equipment operating conditions, water quality, energy consumption, and pipe-network status.

The network layer supports data transmission and the delivery of control instructions through a combination of optical fiber and wireless communication. Technologies such as 5G and narrowband IoT (NB-IoT) enable communication between connected devices and management platforms.

The platform layer uses cloud-based data services to store, process, and analyze information collected from connected devices. It can support anomaly detection, early-warning models, and data-informed decisions about equipment operation and maintenance.

The application layer provides interfaces for maintenance personnel, property managers, and residents. Through dashboards and mobile applications, users can access remote monitoring, fault alerts, automatic meter reading, energy-consumption analysis, and maintenance management services.

Table 1. Four-Layer Architecture of IoT: Functions and Key Equipment

Layer	Core Function	Main Hardware and Technologies
Perception Layer	On-site data collection	Pressure, flow, and water-level sensors; smart water meters
Network Layer	Data transmission and control instructions	5G, NB-IoT, LoRa, optical fiber
Platform Layer	Data storage, analysis, and early warning	Cloud computing, big data analytics, early-warning algorithms
Application Layer	User-facing visualization and services	Monitoring dashboards, mobile apps, operation and maintenance systems

3. IoT Applications in Water-Related Electromechanical Equipment and Smart Property Management

3.1. Applications in Water-Related Electromechanical Systems

IoT technology enables continuous monitoring and intelligent control of water pump units. Sensors can collect real-time data on temperature, vibration, electrical current, and pressure. Monitoring systems can identify potential problems, such as equipment overload, and send early-warning notifications to relevant personnel. Pump operation can then be adjusted according to water demand, helping reduce energy consumption and equipment wear (Menke et al., 2016; Silva et al., 2025).

For pipe-network operation and maintenance, comparisons of flow and pressure measurements at different network nodes, combined with hydraulic models, can help locate potential leaks and shorten troubleshooting and repair times. In secondary water supply systems, IoT devices can monitor tank water levels, water quality, and supply pressure in real time. Automated water replenishment, pressure regulation, and remote fault diagnosis can help maintain a safe and stable water supply (Sadeghioon et al., 2014; Silva et al., 2025).

3.2. Applications in Residential Property Water Services

IoT-enabled smart water meters can automatically collect and transmit water-consumption data (Cominola et al., 2015). Depending on system configuration and applicable requirements, they can also support online billing, account top-ups, and remotely authorized service control or restoration. These functions can reduce the need for manual meter reading and improve the efficiency of property operations.

IoT platforms can integrate water supply and drainage pipelines, drainage pumps, firefighting water supply facilities, and other water-related equipment within residential developments (Pagano et al., 2025). Digital equipment records and visual monitoring interfaces support preventive maintenance and improve operational visibility. The platforms can also analyze household and communal water consumption, identify abnormal usage patterns, and provide evidence for water-saving upgrades and cost control. In addition, automated alerts can flag potential leaks, pipe blockages, and abnormal water pressure. A closed-loop process covering fault reporting, work-order assignment, maintenance, and verification can improve the consistency of property services.

4. Existing Problems in Practical Application

First, equipment compatibility remains a challenge. New and legacy devices often operate alongside one another, while older equipment may lack suitable interfaces for network connectivity. Differences in communication protocols and vendor specifications can create data silos, increasing the cost and complexity of system upgrades (Pagano et al., 2025).

Second, data security protections may be inadequate. Equipment operating records and residents' water-consumption data can be exposed to unauthorized access, leakage, or tampering when encryption, access controls, and data governance procedures are insufficient or inconsistently applied.

Third, operation and maintenance practices may not keep pace with technological upgrades. Conventional maintenance approaches can persist even after intelligent equipment has been installed, limiting its effective use. There may also be a shortage of professionals with expertise in both water services and IoT systems.

Fourth, integration across operational settings is often limited. Municipal water service systems and residential property water-management systems may function independently, with little data sharing or coordination of workflows. This separation makes end-to-end monitoring and joint operation and maintenance more difficult.

5. Optimization Strategies

First, organizations should standardize equipment communication and data exchange requirements. A phased upgrade strategy can prioritize critical facilities, add suitable interface modules to legacy equipment, and use common access platforms to improve interoperability and reduce data silos.

Second, organizations should establish data security measures throughout the information lifecycle. Encryption, network security controls, data backups, and role-based access permissions should be accompanied by regular security audits, incident response procedures, and clear responsibilities for protecting operational and resident data.

Third, organizations should strengthen digital operation and maintenance capabilities. Predictive monitoring should complement, rather than eliminate, professional on-site inspections. Targeted

staff training and recruitment can help build teams with expertise in both water infrastructure and IoT systems.

Finally, water service providers and property management organizations should develop interoperable coordination mechanisms or shared management platforms. Better information exchange between municipal and residential water systems can support joint monitoring, coordinated maintenance, and more effective management across organizational boundaries.

6. Conclusions and Prospects

The application of IoT technology to water-related electromechanical equipment and residential property water services offers ways to address the limitations of conventional operation and maintenance, including delayed responses, high operating costs, and fragmented management. Its main potential benefits lie in continuous equipment monitoring, earlier detection of faults, improved energy management, and more coordinated maintenance.

Nevertheless, equipment incompatibility, data security risks, shortages of appropriately trained staff, and inadequate coordination across systems can limit these benefits. Gradual equipment upgrades, stronger security governance, improved maintenance practices, and better data interoperability are therefore important. As artificial intelligence and edge computing continue to develop, IoT-enabled water and property management systems may support more accurate fault prediction, demand-responsive energy scheduling, and closer coordination between municipal infrastructure and residential services.

Author Contributions:

All authors have read and agreed to the published version of the manuscript.

Funding:

This research received no external funding.

Institutional Review Board Statement:

Not applicable.

Informed Consent Statement:

Not applicable.

Data Availability Statement:

Not applicable.

Conflict of Interest:

The authors declare no conflict of interest.

References

- Cominola, A., Giuliani, M., Piga, D., Castelletti, A., & Rizzoli, A. E. (2015). Benefits and challenges of using smart meters for advancing residential water demand modeling and management: A review. *Environmental Modelling & Software*, 72, 198–214. <https://doi.org/10.1016/j.envsoft.2015.07.012>
- Menke, R., Abraham, E., Pappas, P., & Stoianov, I. (2016). Demonstrating demand response from water distribution system through pump scheduling. *Applied Energy*, 170, 377–387. <https://doi.org/10.1016/j.apenergy.2016.02.136>
- Pagano, A., Garlisi, D., Tinnirello, I., Giuliano, F., Garbo, G., Falco, M., & Cuomo, F. (2025). A survey on massive IoT for water distribution systems: Challenges, simulation tools, and guidelines for large-scale deployment. *Ad Hoc Networks*, 168, Article 103714. <https://doi.org/10.1016/j.adhoc.2024.103714>
- Sadeghioon, A. M., Metje, N., Chapman, D. N., & Anthony, C. J. (2014). SmartPipes: Smart wireless sensor networks for leak detection in water pipelines. *Journal of Sensor and Actuator Networks*, 3(1), 64–78. <https://doi.org/10.3390/jsan3010064>
- Silva, J. B., de Oliveira, L. D., Duarte, R. M., de Rocha Souto, C., & Villanueva, J. M. M. (2025). Smart water management: An energetically autonomous IoT-based application for pressure and flow monitoring in water distribution systems. *Sensors*, 25(23), Article 7227. <https://doi.org/10.3390/s25237227>
- Singh, M., & Ahmed, S. (2021). IoT based smart water management systems: A systematic review. *Materials Today: Proceedings*, 46, 5211–5218. <https://doi.org/10.1016/j.matpr.2020.08.588>

License: Copyright (c) 2026 Author.

All articles published in this journal are licensed under the Creative Commons Attribution 4.0 International License (CC BY 4.0). This license permits unrestricted use, distribution, and reproduction in any medium, provided the original author(s) and source are properly credited. Authors retain copyright of their work, and readers are free to copy, share, adapt, and build upon the material for any purpose, including commercial use, as long as appropriate attribution is given.