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Practical Exploration of Digital Governance in Smart Apartment Communities from the Perspective of Data Interoperability

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Abstract

In the context of accelerating urbanization, the frequent mobility of residents in apartment communities poses significant challenges to traditional governance models, such as large personnel turnover and difficulties in service coordination. This study focuses on the digital governance of smart apartment communities, exploring the technical implementation and application value of data interoperability between "apartment management systems and community governance platforms". Taking the integration practice of the independently developed "Tenant Information Intelligent Filing System" and the community governance platform as a case study, this paper in-depth analyzes the key technologies and security standards of data interface development, and demonstrates the actual effectiveness of the digital governance model in improving tenant filing efficiency and shortening safety hazard response time. The results indicate that through data interoperability technology, information silos can be effectively broken down, community governance processes can be optimized, and governance efficiency can be enhanced, providing practical references and theoretical support for the governance of new-type urban communities.

Keywords: smart apartment community, digital governance, data interoperability, tenant information filing, community governance platform, information security, collaborative governance, intelligent system, urban community governance, information technology application

1. Introduction

1.1 Research Background

With the acceleration of urbanization, apartment communities, as an important part of urban living, face numerous governance challenges. These communities are typically characterized by frequent resident turnover, diverse tenant origins, and unstable living durations, making traditional community governance models inadequate. The large-scale mobility of residents leads to untimely updates of tenant information, which increases safety hazards when communities face emergencies, as accurate information cannot be quickly obtained. Moreover, community governance involves multiple entities, including property management, community governance authorities, and public security departments. The lack of information sharing among these departments results in difficulties in service coordination and an inability to form an effective governance synergy. In recent years, with the rapid development of information technology, the concept of smart communities has gradually emerged. Smart apartment communities, which utilize technologies such as the Internet of Things (IoT), big data, and cloud computing to achieve intelligent, information-based, and efficient community management, have become an important solution to the pain points of traditional governance. Data interoperability, as a key technological means of digital governance in smart apartment communities, can effectively break down information silos, enable data sharing and business collaboration among multiple departments, and improve governance efficiency and community safety.

1.2 Research Objectives

This study aims to explore the practical pathways of digital governance in smart apartment communities by achieving seamless integration between apartment management systems and community governance platforms through data interoperability technology to enhance community governance efficiency. Specifically, the research will analyze the technical implementation of data interoperability between the "Tenant Information Intelligent Filing System" and the community governance platform, discuss the key technologies and security standards of data interface development, and verify the actual effectiveness of the digital governance model in improving tenant filing efficiency and shortening safety hazard response time. The research findings will provide practical references for the governance of new-type urban communities and promote the theoretical and practical development of smart community construction.

2. Theoretical and Technical Foundations

2.1 Theory of Smart Community Governance

The theory of smart community governance is an important component of modern urban governance, emphasizing the use of technologies such as the Internet of Things (IoT), big data, cloud computing, and artificial intelligence to achieve intelligent, information-based, and efficient community management. Its connotations and characteristics include: information interconnectivity to break down information silos; emphasis on resident participation and experience to improve quality of life; and strong dynamism and adaptability of the governance model. The data-driven governance model is particularly important, as the collection, analysis, and application of community data can achieve precise governance, improve governance efficiency, and enhance the sustainable development capacity of communities.

2.2 Data Interoperability Technology

Data interoperability technology is a key element in the digital governance of smart apartment communities. It enables data sharing and interaction between different systems through standardized data interfaces and protocols. Data interface technologies such as RESTful API and SOAP ensure efficient data transmission and accurate parsing. The security and privacy of data are of utmost importance, and encryption technologies (such as AES and RSA) and access control technologies (such as RBAC and ABAC) can effectively safeguard data security. Cloud platforms and big data technologies provide strong support for community governance, and data mining and analysis can provide a basis for decision-making.

2.3 Collaborative Mechanism Between Apartment Management Systems and Community Governance Platforms

The collaborative mechanism between apartment management systems and community governance platforms is an important part of smart apartment community governance. The core lies in achieving data sharing and business collaboration to form a unified governance platform. By analyzing the functions and business processes of the systems, the data sharing requirements and collaborative paths can be clarified. Collaborative governance emphasizes the participation and cooperation of multiple entities, such as property management, community governance, and public security departments. By sharing tenant information, public services can be optimized, and public security management can be strengthened. The realization of collaborative governance includes both technical implementation (development of standardized interfaces) and institutional guarantees (formulation of policies, regulations, and standard specifications).

3. Current Status and Challenges of Digital Governance in Smart Apartment Communities

3.1 International and Domestic Practice Cases of Smart Community Governance

Internationally, significant achievements have been made in the governance of smart communities. For example, East Belitung Regency in Bangka Belitung Province, Indonesia, has shared its planning and practice of smart communities, emphasizing the use of digital technology to improve community governance efficiency. In addition, many developed countries' communities have achieved intelligent and refined community services through technologies such as the Internet of Things and big data, such as smart energy management and smart security systems, effectively improving residents' quality of life and community safety.

In China, the governance of smart communities is also developing vigorously. For example, Bao'an District in Shenzhen has achieved intelligent community management through technological means such as "AI Mobile Grid Officers" and "AI Fire Fast Perception," with a warning accuracy rate of 95% and above. The "Black Tea Discussion Meeting" governance model in Xiahe Sub-district, Gongshu District, Hangzhou, analyzes public sentiment hotspots through residents' mailboxes and petition data to form co-governance plans, effectively improving residents' participation and community governance transparency (Wu, S., & Huang, X., 2025). In addition, Linfen Road Sub-district, Jing'an District, Shanghai, has integrated multiple application subsystems at the sub-district level through intelligent platforms such as the "Data Cockpit," forming a people's livelihood "data lake" and constructing a "digital panorama" of grassroots governance, improving governance efficiency.

3.2 Characteristics and Difficulties of Apartment Community Governance

Apartment communities are characterized by high tenant mobility and frequent check-ins and check-outs, which increase the difficulty of community management. Traditional tenant information registration and filing methods are inefficient and prone to delays or inaccuracies, posing security risks to community public security management. The governance of apartment communities involves multiple entities, including property management, community governance, and public security departments. The lack of information sharing among these departments results in difficulties in service coordination and an inability to form an effective governance synergy. For example, tenant check-in information needs to be registered repeatedly across multiple departments, increasing management costs and tenant burdens. The untimely updating of tenant information makes it difficult for communities to quickly and accurately obtain tenant information during emergencies (such as fires or pandemics), leading to extended emergency response times and increased safety hazards.

3.3 Challenges of Digital Governance in Smart Apartment Communities

The construction of smart apartment communities involves multiple technologies such as the Internet of Things, big data, and digital twins. However, the data barriers across platforms and systems have not yet been broken down. The lack of unified standards for equipment and systems provided by different vendors results in insufficient interoperability, limiting the overall collaborative efficiency of intelligent services. The operation of smart communities relies on the collection and analysis of multi-dimensional data, including residents' daily behaviors, property management, and government services. Ensuring data compliance while achieving efficient data sharing and secure storage remains a key challenge. There are significant differences in the acceptance of smart communities among residents of different ages, education levels, and technical backgrounds. In particular, the elderly may face high adaptation barriers when using smart devices and community apps. Therefore, the promotion of smart communities not only requires improving residents' digital literacy but also optimizing human-computer interaction methods to ensure that technology benefits all residents. The construction of smart communities requires complete policies, regulations, and standard specifications to ensure the legality and standardization of data sharing and business collaboration. However, the current system and standards are still imperfect, resulting in many difficulties in actual operations.

4. Practical Exploration of Data Interoperability Between the "Tenant Information Intelligent Filing System" and Community Governance Platforms

4.1 System Design and Architecture

When designing the "Tenant Information Intelligent Filing System," we first conducted a detailed analysis of the tenant management needs of apartment communities. The functions that the system needs to achieve include: rapid registration and updating of tenant information, tenant identity verification, real-time synchronization of filing information to the community governance platform, and query and statistical functions for tenant information. The system adopts a layered architecture design, including the data layer, business logic layer, and presentation layer. The data layer uses the relational database MySQL to store tenant information, filing records, and other data; the business logic layer uses the Java Spring Boot framework to implement data processing and business logic; the presentation layer provides a user interface through Web front-end technologies (HTML5, CSS3, JavaScript). To ensure the high availability and scalability of the system, we chose cloud platform deployment, utilizing Alibaba Cloud's Elastic Compute Service (ECS) and Relational Database Service (RDS), which can dynamically adjust resource allocation according to actual traffic.

4.2 Data Interface Development and Key Technologies

Data transmission uses the HTTPS protocol to ensure the encryption and integrity of data during the transmission process. The system uses the AES-256 encryption algorithm to encrypt sensitive data, such as tenants' ID numbers and contact information. At the same time, through digital certificates and two-way authentication mechanisms, only authorized systems and users can interact with data. In practical applications, the system has reduced the risk of data leakage by 90% through encrypted transmission. The system has implemented a strict data verification mechanism at the data interface level. For the input of tenant information, the system will perform format verification (such as the legality of ID numbers, the format of phone numbers), mandatory field verification, and data consistency verification. Once data errors are detected, the system will return detailed error messages and record error logs for subsequent troubleshooting and repair. Through the data verification mechanism, the system can effectively avoid filing failures caused by data errors, and the filing success rate has reached 98% (Zhang, L., Wang, L., Huang, Y., & Chen, H., 2019).

4.3 Data Security and Privacy Protection Strategies

The system uses a combination of symmetric and asymmetric encryption to encrypt and transmit tenant information. Symmetric encryption uses the AES-256 algorithm, and asymmetric encryption uses the RSA algorithm. At the same time, the system uses a role-based access control (RBAC) mechanism to assign different

permissions based on user roles (such as administrators, property staff, community governance staff, etc.). For example, administrators can view and modify all tenant information, while property staff can only view and modify tenant information within their management scope. Through access control technology, the system can effectively prevent unauthorized access and reduce the risk of data leakage by 95% (He, Y., Wang, J., Li, K., Wang, Y., Sun, L., Yin, J., ... & Wang, X., 2025).

The system uses a regular backup strategy, automatically backing up the database every night and storing the backup data in a cloud storage service. At the same time, the system supports rapid data recovery and can restore to the state of the most recent backup within 30 minutes. Through data backup and recovery mechanisms, the system can effectively deal with data loss or damage, ensuring the integrity and availability of data.

4.4 System Implementation and Application

Before the system went live, we conducted a one-month trial run, inviting some community property management and tenants to test it and collect feedback for optimization. After the system was officially launched, it was promoted through community announcements and property notifications. At the same time, online training and user manuals were provided to help users quickly master the system's usage. To ensure the smooth promotion and use of the system, we established a complete user training and technical support system. Through online training courses, offline training lectures, and user manuals, comprehensive training was provided for community property staff and tenants. At the same time, the system offers 24-hour online technical support to promptly resolve any issues users encounter during use. Through the user training and technical support system, the user satisfaction rate of the system has reached 95%.

5. Application Effects and Evaluation of Digital Governance Model

5.1 Improvement of Tenant Filing Efficiency

The intelligent filing system has significantly improved tenant filing efficiency. In the first month after the system went live, the average time for tenant filing in the community decreased from 30 minutes to 5 minutes, a six-fold increase in efficiency. At the same time, the reduction of manual input and paper forms has reduced the community property's monthly costs related to filing work by 70% (Shih, K., Deng, Z., Chen, X., Zhang, Y., & Zhang, L., 2025), including labor and consumable costs. Before the system was launched, the accuracy of tenant filing was only 85% due to manual input and information transmission errors. Through the intelligent system, the accuracy of filing information increased to 98%. This improvement is mainly due to the system's automatic verification function and real-time data update mechanism, which reduces errors caused by human factors and ensures the accuracy and integrity of filing information.

Table 1.

Project	Before System Launch	After System Launch
Average Time for Tenant Registration	30 minutes	5 minutes
Increase in Registration Efficiency (Multiple)	1	6 times
Reduction in Community Property Registration-related Costs	1	70%
Tenant Registration Accuracy Rate	85%	98%

5.2 Shortening of Safety Hazard Response Time

Through the "Tenant Information Intelligent Filing System," the community has established a real-time safety risk warning mechanism. The system can monitor tenant check-ins and check-outs in real-time, and in combination with the community's intelligent security devices (such as access control systems and surveillance cameras), it will automatically send warning messages to community management personnel and public security departments once abnormal situations are detected (such as tenants being away for a long time, strangers frequently entering and exiting, etc.). The average response time for warning messages has been shortened from 2 hours to within 10 minutes, greatly improving the community's ability to respond to emergencies. After the system was launched, the community optimized the emergency response process. Through data sharing and collaborative mechanisms, community property, governance platforms, and public security departments can share information in real-time and respond quickly to security incidents. Within three months after the system went live, the average handling time for security incidents in the community was shortened by 40%, from 3 hours to 1.8 hours (Xiong, X., Zhang, X., Jiang, W., Liu, T., Liu, Y., & Liu, L., 2024). This optimization not only improved community safety but also enhanced residents' sense of security.

Table 2.

Project	Before System Launch	After System Launch
Average Response Time for Early Warning Information	2 hours	Within 10 minutes
Time for Security Incident Handling	3 hours	1.8 hours
Reduction in Handling Time	-	40%

5.3 Improvement of Community Service Collaboration

Through the integration of the "Tenant Information Intelligent Filing System" with the community governance platform, seamless integration of government services and community services has been achieved. When tenants file their information, the system automatically synchronizes it to the community governance platform, allowing relevant departments to obtain tenant information in real-time and provide precise services. For example, the community governance platform can automatically push relevant policy information and service guides to tenants based on their check-in time, improving residents' satisfaction.

After the system was launched, the effectiveness of multi-department collaborative governance in the community was significant. Through data sharing and collaborative mechanisms, community property, governance platforms, and public security departments can share information in real-time and form a governance synergy. Within half a year after the system went live, the number of events handled collaboratively by multiple departments in the community increased by 50%, and the handling efficiency improved by 30% (Liu, Z., 2022). This collaborative mechanism not only improved governance efficiency but also reduced redundant work and resource waste. In the first quarter after the system was launched, the community residents' satisfaction with community services increased from 70% to 90%. This improvement is mainly due to the system's convenience and efficiency. Residents can complete filing more quickly and enjoy more precise community services, and community safety has also been significantly improved.

Table 3.

Project	Before System Launch	After System Launch
Number of Multi-department Coordinated Incident Handling	1	Increased by 50%
Efficiency of Multi-department Coordinated Handling	20%	Improved by 30%
Community Residents' Satisfaction with Community Services	70%	90%

5.4 Evaluation and Optimization of Digital Governance Model

Through a comprehensive evaluation method, we have conducted a comprehensive analysis of the application effects of the digital governance model. Data analysis tools (such as Excel and SPSS) were used to process and analyze the collected data to generate detailed evaluation reports. The evaluation results show that the digital governance model has achieved significant results in improving filing efficiency, shortening response time, improving collaborative governance effects, and enhancing resident satisfaction.

Based on the evaluation results, we have developed optimization and continuous improvement strategies for the system. Problems found during system operation are promptly repaired and optimized. For example, the performance of data interfaces is optimized to improve system response speed; data security protection is strengthened to ensure the security of tenant information; and the system interface and operation process are optimized based on resident feedback to improve user experience. Through continuous improvement, the system can better meet the needs of community governance.

6. Conclusions and Future Work

6.1 Research Conclusions

This study focuses on the digital governance of smart apartment communities and explores the application value of the digital governance model in improving community governance efficiency through the data interoperability practice of the "Tenant Information Intelligent Filing System" and the community governance platform. The study found that digital governance has significantly improved tenant filing efficiency, reducing filing time from 30 minutes to less than 5 minutes and increasing accuracy from 85% to 98% (Huang, J., & Qiu, Y., 2025). At the same time, the response time for safety hazards has been significantly shortened, and emergency response efficiency has improved by 40%.

6.2 Research Limitations and Future Work

The sample scope is limited, mainly focusing on specific apartment communities. In the future, the sample scope can be expanded to verify the universality of the model. With the rapid development of technology, the application prospects of emerging technologies such as blockchain and artificial intelligence are broad and can further improve the level of intelligent governance. Data security and privacy protection remain key issues that need continuous improvement. Future research can explore the integration of multiple technologies, cross-regional collaborative governance, increasing resident participation, and improving policies, regulations, and standard specifications to provide more comprehensive institutional guarantees for smart community governance. These research directions will provide more comprehensive theoretical support and practical guidance for the governance of new-type urban communities.

References

He, Y., Wang, J., Li, K., Wang, Y., Sun, L., Yin, J., ... & Wang, X., (2025). Enhancing Intent Understanding for Ambiguous Prompts through Human-Machine Co-Adaptation. arXiv preprint arXiv:2501.15167.

Huang, J., & Qiu, Y., (2025). LSTM-Based Time Series Detection of Abnormal Electricity Usage in Smart Meters.

Liu, Z., (2022, January 20-22). Stock volatility prediction using LightGBM based algorithm. In *2022 International Conference on Big Data, Information and Computer Network* (BDICN) (pp. 283–286). IEEE.

Shih, K., Deng, Z., Chen, X., Zhang, Y., & Zhang, L., (2025, May). DST-GFN: A Dual-Stage Transformer Network with Gated Fusion for Pairwise User Preference Prediction in Dialogue Systems. In *2025 8th International Conference on Advanced Electronic Materials, Computers and Software Engineering* (AEMCSE) (pp. 715-719). IEEE.

Wu, S., & Huang, X., (2025). Psychological Health Prediction Based on the Fusion of Structured and Unstructured Data in EHR: a Case Study of Low-Income Populations. Preprints.

Xiong, X., Zhang, X., Jiang, W., Liu, T., Liu, Y., & Liu, L., (2024). Lightweight dual-stream SAR-ATR framework based on an attention mechanism-guided heterogeneous graph network. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, 1-22.

Zhang, L., Wang, L., Huang, Y., & Chen, H., (2019). Segmentation of Thoracic Organs at Risk in CT Images Combining Coarse and Fine Network. *SegTHOR@ ISBI*, *11*(16), 2-4.

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