# Research on Digital Management and Optimization of Municipal Infrastructure under the Background of Smart City

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**Keywords:** smart city; digital management; municipal infrastructure

**Abstract:** This paper discusses the necessity and implementation path of digital management and optimization of municipal infrastructure under the background of smart city. There are some problems in the traditional management mode, such as information lag, resource mismatch and insufficient emergency response, and the construction of smart cities provides a new way to solve these problems. Firstly, this paper constructs the digital management framework of municipal infrastructure under the background of smart city, and expounds the key technical links such as data perception, transmission, processing and application. Then, digital optimization methods such as data-driven resource integration, intelligent perception and dynamic monitoring, intelligent operation and maintenance of facilities in the whole life cycle, collaborative service model innovation, simulation deduction and planning decision support, and equal emphasis on security and privacy protection are proposed. Finally, the paper puts forward a phased promotion strategy and guarantee mechanism, including organizational guarantee, policy guarantee, financial guarantee, technical guarantee, safety guarantee and evaluation guarantee, so as to ensure the smooth progress of digital management and optimization of municipal infrastructure. By implementing these strategies and measures, we can effectively improve the operational efficiency, service quality and sustainable development capacity of cities and promote the modernization of urban governance.

## 1. Introduction

The traditional municipal infrastructure management mode relies on manual inspection and empirical decision-making, which has some disadvantages, such as information lag, resource mismatch and insufficient emergency response. The fixed period of road maintenance leads to excessive maintenance or delayed treatment, and frequent waterlogging events in heavy rain expose the lack of dynamic monitoring of drainage system. The global wave of smart city construction provides a new path to solve the above problems. Through the deep integration of technologies such as IoT (Internet of Things), big data and AI, the closed-loop management of infrastructure has become the key direction of urban governance modernization [1-2].

In recent years, many countries have introduced policies to promote the integrated development of smart cities and new infrastructure. China's "14th Five-Year Plan" clearly put forward "building a smart city governance system", and Shanghai, Shenzhen and other cities have taken the lead in building a "one network unified management" platform for urban operation covering transportation, energy, water affairs and other fields [3]; Singapore realizes the whole life cycle simulation of infrastructure through the "virtual Singapore" digital twin platform; The EU's "Smart City Lighthouse Plan" focuses on cross-sectoral data sharing and citizen participation mechanisms [4]. However, the existing practice still faces two core contradictions: at the technical level, the ability of integrating massive heterogeneous data and value mining is insufficient; At the management level, the division of power and responsibility between departments leads to the phenomenon of "data islands" widely, and the dynamic optimization model lacks adaptive adjustment to urban complex systems.

## 2. Digital management of municipal infrastructure under the background of smart city

In the context of smart cities, the digital management framework of municipal infrastructure is

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designed to achieve efficient management and service optimization of urban infrastructure by integrating advanced information technology [5-6]. Technical architecture is the core of digital management of municipal infrastructure under the background of smart city, which includes several key components as shown in Figure 1.

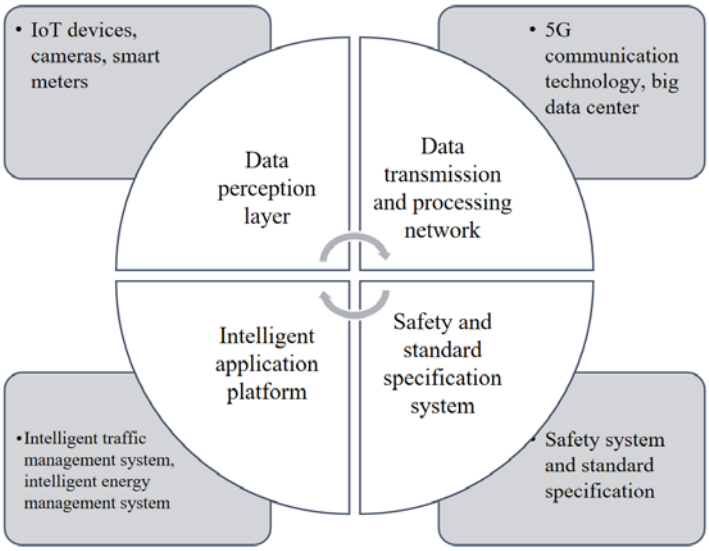


Figure 1 Digital management framework of municipal infrastructure

Among them, the data sensing layer collects real-time data in traffic, energy, environment and other fields by deploying various sensors and monitoring devices, such as IoT devices, cameras, smart meters, etc., to ensure accurate capture and efficient transmission of information [7].

Data transmission is a key link in the process of digital transformation. Use advanced communication network technologies, such as 5G communication technology and big data center, to realize real-time data transmission and efficient interoperability. At the same time, build a large-scale data processing center and use cloud computing technology to process massive data to ensure the safe storage and rapid analysis of data.

Application platform is the ultimate goal of digital transformation. At this level, it is necessary to build various smart city applications, such as intelligent traffic management system and intelligent energy management system. These systems are built based on digital infrastructure, and the collected data are deeply mined and applied by using big data analysis, AI and other technologies to realize the intelligence and refinement of urban management.

In the process of digital transformation, security and standardization are important factors to ensure the stable operation of the whole system. Establish a sound security system to ensure the safe and controllable process of data collection, transmission, processing and application. At the same time, formulate unified standards and specifications to ensure the interconnection and cooperation between different systems.

The construction of smart cities involves many departments and fields, so it is necessary to break the information island and strengthen the cooperation between departments [8]. By establishing a unified data platform, information sharing can be realized, and management efficiency and service level can be improved. The construction of smart cities should fully embody the people-oriented concept. In the process of infrastructure informatization and digital upgrading, we should strengthen public participation, listen to people's opinions and meet their needs. Popularize the relevant knowledge of smart city through various forms, improve the digital literacy of citizens, and form a smart city construction pattern with the participation of government, enterprises and the public. Digital upgrade is a continuous process, which requires continuous follow-up of new technologies, continuous innovation and iterative optimization of existing systems. In this way, we can not only maintain the modernization level of the city, but also meet the growing needs of the citizens.

## 3. Digital optimization method of municipal infrastructure

Under the background of smart city construction, the digital management and optimization of municipal infrastructure has become the core path to improve the city's operational efficiency, service quality and sustainable development ability. By integrating IoT, big data, cloud computing, AI and other advanced technologies, we can realize the goal of transforming from traditional extensive management to refined and intelligent management. This paper puts forward the following main digital optimization methods:

### 3.1 Data-driven resource integration and sharing

Using tools such as sensor networks, video monitoring terminals and mobile terminals, multi-dimensional data such as traffic flow, energy consumption and water quality are collected in real time [9]; Establish a unified data platform to break the "data island" between departments, realize the standardized processing and shared circulation of cross-domain data, and provide support for global decision-making; Use big data analysis technology to identify the peak usage of facilities, predict the maintenance cycle, optimize the resource allocation scheme through machine learning algorithm, and dynamically adjust the brightness of street lamps or water supply pressure to reduce energy consumption.

### 3.2 Intelligent perception and dynamic monitoring system

Deploy low-cost and low-power IoT nodes to key nodes such as bridges, tunnels, pipe networks and pipelines to monitor structural safety, leakage risks and load changes in real time; Based on GIS map integration three-dimensional modeling technology, the distribution of underground pipelines and the state of above-ground facilities are presented in the form of digital twins, which helps managers to quickly locate fault points and simulate emergency treatment plans. Set the threshold to trigger the automatic alarm system, start the emergency plan for sudden accidents, and cooperate with the emergency response department to shorten the disposal time.

### 3. 3 Intelligent operation and maintenance of facilities in the whole life cycle

In the planning and design stage, the building information model is used to simulate the construction process and the later operation effect, and the geographical information system is combined to optimize the location layout; Relying on the historical operation data of equipment to train AI model, predict the aging trend of parts and replace them in advance, and reduce the economic losses caused by unplanned downtime; The public lighting and air conditioning systems are controlled by time-sharing strategy, and the carbon footprint tracking and emission reduction targets are achieved by combining renewable energy access [10].

### 3.4 Collaborative service model innovation

This model improves the efficiency of urban governance through collaborative service innovation. In terms of government services, the online approval channel will be opened to realize the online declaration and cross-departmental countersignment of the construction permit for enterprises occupying roads, greatly simplifying the process; In terms of public participation, the mobile terminal repair service function is developed, and citizens can upload photos of problems and automatically locate them. The system uses AI to intelligently classify and distribute them to responsible units to realize closed-loop processing; At the same time, the collaborative linkage mechanism of municipal, traffic police and fire departments is established, and through unified data interface protocol, signal light timing optimization and automatic reservation of emergency lanes are realized during major events to improve emergency response capability.

### 3.5 Simulation deduction and planning decision support

At the level of planning and decision-making, it relies on simulation deduction technology to provide scientific support. By constructing high-precision digital sand table, the influence of new viaduct and other infrastructure on the surrounding traffic and business environment is simulated to assist the pre-project evaluation; The capacity evaluation model is used to simulate and calculate the urban drainage system, identify the bottleneck link, and provide priority suggestions for the

reconstruction of waterlogging prevention and control projects; In addition, economic variables are introduced to preview the effect of urban management measures such as traffic restriction policy, comprehensively evaluate its potential impact on traffic mitigation and related industries, and improve the foresight and accuracy of policy formulation.

### 3.6 Pay equal attention to security and privacy protection

In the process of technology application, we attach great importance to security and privacy protection. The information related to sensitive geography and citizens' travel trajectory is encrypted and desensitized by using state secret algorithm to prevent data abuse; Implement a strict hierarchical authority management mechanism to ensure that third-party units can only access necessary equipment parameters and restrict their access to complete monitoring content; At the same time, the key business database adopts redundant backup architecture in different places, which has the ability to cope with emergencies such as natural disasters and ensures the sustained and stable operation of the city's core system.

## 4. Implementation path and guarantee mechanism

### 4.1 Phased propulsion strategy

Under the background of smart city, the digital management and optimization of municipal infrastructure need to adopt a systematic and gradual promotion strategy, from infrastructure construction to deep application.

#### 4.1.1Infrastructure construction stage

The key point of this stage is to build the infrastructure and platform of digital management. Including the establishment of a unified data collection network, the deployment of IoT sensing equipment, the construction of urban data centers and cloud platforms, and the realization of comprehensive sensing and data aggregation of municipal infrastructure. At the same time, it is necessary to formulate unified data standards and interface specifications to lay the foundation for subsequent system integration and interconnection. Practical experience shows that relying closely on the research results of management, information technology and other related disciplines can effectively promote the infrastructure construction of digital management of municipal public facilities.

#### 4.1.2 System integration stage

After the completion of infrastructure construction, the focus shifts to the integration and collaboration of various systems. By constructing a City Information Model (CIM) platform, data fusion and business collaboration among various subsystems of municipal infrastructure can be achieved. At this stage, it is necessary to break the traditional model of independent operations among departments, achieve a shift from independent operations to overall coordination, and promote cross departmental data sharing and business linkage.

#### 4.1.3 Intelligent application stage

This stage focuses on deepening data analysis and intelligent application, and realizing the predictive maintenance and intelligent management of municipal infrastructure. Through big data analysis, AI and other technologies, real-time monitoring, fault early warning and intelligent scheduling of municipal facilities are realized. For example, dynamically adjust the layout of public charging piles, predict the flow of people in business districts and deploy intelligent applications such as bike-sharing in advance. With the rapid progress of technology, the concept of "smart city" has gradually become the development direction of modern cities, and municipal infrastructure is changing from traditional management to intelligent management.

#### 4.1.4 Continuous optimization stage

After the system runs stably, it enters the continuous optimization stage. By establishing a

long-term evaluation mechanism, the operation effect of the digital management system is evaluated regularly, and the system functions and business processes are continuously optimized according to the evaluation results and technical development. At the same time, explore the establishment of a sustainable urban renewal mechanism, promote the shortcomings of urban infrastructure, and strengthen the construction of consumer infrastructure.

### 4.2 Safeguard measure

In order to ensure the smooth progress of digital management and optimization of municipal infrastructure, it is necessary to establish a perfect guarantee mechanism (as shown in Figure 2).

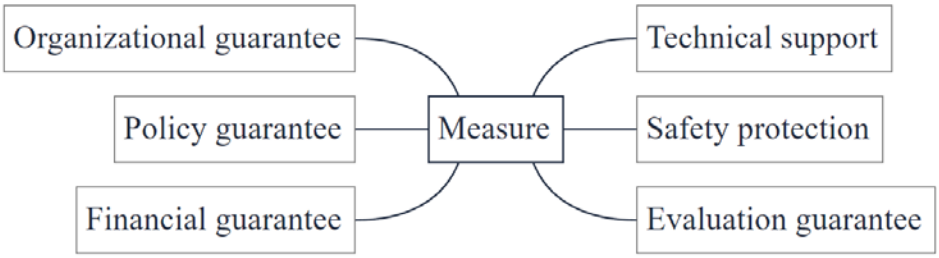


Figure 2 Safeguard mechanism

#### 4.2.1 Organizational guarantee

Establish a strong organizational leadership system, clarify the division of responsibilities of various departments, and form a coordinated working mechanism. The construction of smart cities should give full play to the subjective initiative of all departments, break the traditional mode of overall planning, and realize the transformation from independent operations to overall planning. It is suggested to set up a leading group for smart city construction led by the main leaders of the municipal government to coordinate the digital management of municipal infrastructure and solve the problem of cross-departmental collaboration.

#### 4.2.2 Policy guarantee

Formulate a sound system of policies and regulations to provide institutional guarantee for the digital management of municipal infrastructure. The Opinions on Continuously Promoting Urban Renewal jointly issued by the General Offices of the General Office of the Central Committee of the CPC and the State Council marked the basic formation of the top-level design framework for urban renewal and provided policy guidance for the digital management of municipal infrastructure. All localities should formulate specific implementation plans and supporting policies in light of actual conditions, and define work objectives, key tasks and safeguard measures.

#### 4.2.3 Financial guarantee

Establish a diversified capital investment mechanism to ensure the capital demand for digital management of municipal infrastructure. The central government continues to support the implementation of urban renewal and explore the establishment of a sustainable urban renewal mechanism. Local governments should increase financial input, and at the same time attract social capital to participate through PPP mode and franchising, so as to form a fund guarantee mechanism for government guidance and market operation.

#### 4.2.4 Technical support

Strengthen technological innovation and personnel training to provide technical support for digital management of municipal infrastructure. The rapid development of technology makes it difficult for city managers to keep up with the pace of technological progress, so it is necessary to strengthen cooperation with universities, scientific research institutions and scientific and technological enterprises and introduce advanced technology and management experience. At the same time, strengthen the training of professional talents and build a compound talent team that understands both municipal management and information technology.

### 4.2.5 Safety protection

Establish and improve the network security and data security guarantee system to ensure the safety and reliability of digital management of municipal infrastructure. With the improvement of the digitalization of municipal infrastructure, the network security risks also increase. It is necessary to strengthen network security protection and establish a data security management system to ensure the safety of key information infrastructure. Promote the integration of network, cloud, computing and security, and improve the security protection capability of digital management of municipal infrastructure.

### 4.2.6 Evaluation guarantee

Establish a scientific evaluation mechanism and regularly evaluate the effect of digital management of municipal infrastructure. Through the establishment of key performance indicators (KPI) system, the efficiency, benefit and satisfaction of digital management are comprehensively evaluated, and problems are found in time and improved continuously. Third-party evaluation agencies are introduced to ensure the objectivity and fairness of evaluation results and provide scientific basis for decision-making.

## 5. Conclusion

Digital management and optimization of municipal infrastructure under the background of smart city is the core path to improve urban operation efficiency, service quality and sustainable development ability. By integrating IoT, big data, cloud computing, AI and other advanced technologies, this paper puts forward some main optimization methods, such as data-driven resource integration and sharing, intelligent perception and dynamic monitoring system, intelligent operation and maintenance of facilities throughout their life cycle, collaborative service model innovation, simulation deduction and planning decision support, and equal emphasis on security and privacy protection. On the technical architecture, a digital management framework including data perception layer, data transmission layer and application platform layer is designed, emphasizing the importance of security and standardization. In the aspect of implementation path, it puts forward a phased promotion strategy, including four stages: infrastructure construction, system integration, intelligent application and continuous optimization, and establishes corresponding guarantee mechanisms, such as organizational guarantee, policy guarantee, financial guarantee, technical guarantee, safety guarantee and evaluation guarantee. These research results provide theoretical basis and practical guidance for the digital transformation of municipal infrastructure under the background of smart cities.

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