Future Cities Advisory Outlook 2024

Digital Urban Governance

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Annual Report 2024

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Future Cities Advisory Outlook 2024: Digital Urban Governance

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Preface

Wang Shi
Chair of UN-Habitat China Future Cities Council
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In the third decade of the 21st century, the world faces tremendous uncertainty, and cities globally are confronting unprecedented complex challenges. The intensification of climate change, the far-reaching impacts of the post-pandemic era, and evolving geopolitical landscapes are testing the resilience and adaptability of cities worldwide. These challenges not only affect the daily lives and well-being of urban residents but also pose severe tests to cities' infrastructure, economic development, and social stability. Against this backdrop, finding effective responses to multiple crises has become a common pursuit for urban managers and practitioners globally.

Digital urban governance has opened new possibilities for addressing these challenges. With the rapid development of information technology, digital tools are reshaping urban governance methods, providing powerful support for optimizing resource allocation, improving service efficiency, and enhancing citizen participation. Through data-driven decision-making and intelligent management approaches, cities can more flexibly respond to environmental and social changes, reduce carbon footprints, improve resource utilization efficiency, and promote green, low-carbon development. Meanwhile, digital technology has the potential to help narrow social inequalities, bridge the digital divide, and enable more people to benefit from technological progress, moving towards more inclusive urban development.

Globally, many cities have actively explored and implemented digital urban governance, achieving remarkable results. Chinese cities have demonstrated vibrant innovation in this regard, such as building digital infrastructure, providing inclusive digital public services, developing smart transportation, creating green and smart livable environments, and implementing precise and refined urban governance. These practices have not only effectively improved government service efficiency and reduced management costs but also greatly enhanced residents' sense of participation and fulfillment, injecting new momentum into urban prosperity and sustainable development.

These digital urban governance practices provide valuable references for global cities in addressing climate change and enhancing governance capabilities. They demonstrate that digital technology can not only promote more efficient management of cities in complex environments but also facilitate global exchange and learning, helping other cities move toward a more sustainable and resilient future.

The "Future Cities Advisory Outlook 2024:

Digital Urban Governance" report aims to comprehensively analyze these trends and challenges, focusing on the profound impact of digital transformation on urban governance. Through this report, we hope to summarize China's practices and experiences in this field and provide new perspectives and solutions for global cities' sustainable development. The report not only depicts a panoramic technological landscape of digital urban governance but also provides a roadmap for achieving digital urban governance. Furthermore, the report puts forward a Global Digital Urban Governance Action Initiative. We hope this report can provide valuable insights and action guidelines for urban decision-makers, technology innovators, and civil society.

The digital transformation of cities is not merely a technological process but also a transformation of mindset and society. It requires us to rethink the role of cities, modes of citizen participation, and paths to sustainable development. We firmly believe that through technological innovation, policy guidance, and international cooperation, global cities have the capacity to address the complex challenges of the 21st century. As global cities continue to explore and cooperate in digitalization, we have reason to believe our world can collectively move toward a more prosperous, inclusive, and sustainable future urban landscape. By building smart, inclusive, and resilient digital urban ecosystems, we can create a better and more sustainable urban living environment for current and future generations. Let us work together to create a new future of urban governance and contribute wisdom and strength to the sustainable development of urban civilization.

Acknowledgement

Future Cities Advisory Outlook 2024: Digital Urban Governance is the fourth flagship report of UN-Habitat China Future Cities Council (CFCC). The compilation of this report was made possible through the generous support of Vanke Foundation, Xinchao Media Group, and iSoftStone Smart Technology Co., Ltd.

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Key Findings and Messages

UN-Habitat China Office launched UN-Habitat China Future Cities Council (CFCC) in 2019, which aims to promote sustainable urban development through the application of digital technologies. CFCC's membership consists of tech companies dedicated to promoting people-centered smart city development, leaving no one behind in the digital age, and realizing a more sustainable urban future. "Future Cities Advisory Outlook 2024: Digital Urban Governance" is the fourth annual flagship report of UN-Habitat China Future Cities Council. Firstly, the chapter 1 analyzes the trends and challenges of global urbanization, key strategies to address the urbanization challenges, and proposes the digital technologies, as the new motivation that empower urban governance; the chapter 2 provides the technical panorama of digital urban governance, which includes digital urban management, urban transport and transportation, environmental resilience maintenance, pollution monitoring and management, waste classification and circulation, historic building protection, urban energy management, digital government services, health care services as well as quality education and study 10 scenarios; Chapter 3 focuses on the development of the roadmap of digital urban governance; Chpater 4 collects 5 urban cases and 5 enterprise cases, offering strategic and practical approaches for global digital urban governance; Chapter 5 summarizes China's development experience on digital urban governance and launches a global initiative for digital urban governance.

Chapter 1 Introduction

1. Major challenges of sustainable urban development

Cities have become an important spatial base of human civilization with continuous economic and social development. Cities account for only 3% of the planet's land area, but 56% of the world's population is concentrated in cities and more than 80% of global GDP is generated by cities. Since the publication of the Agenda, sustainable urban development continues to face serious challenges. According to the 2024 report of the Sustainable Development Solutions Network (SDSN), SDG 11 still faces significant or major challenges in most regions of the world, and even a downward trend in some countries in Eastern Europe and Oceania.

The UN Sustainable Development Goals Report 2024 identifies four of the most serious challenges to SDG 11:

- The global slum crisis is worsening: 24.8% of the world's urban population still lives in informal settlements (slums) without access to safe housing and basic public services.
- Air quality has improved, but not enough to protect health; on average, 4.2 million people have died from urban air pollution.
- Access to public transportation still needs to be improved; only 60% of the world's urban population has access to convenient

public transportation.

• Urban resilience is urgent; the total number of disasters has increased fivefold over the past 50 years, and the average number of people affected by disasters has risen to more than 130 million per year over the past decade.

2. Digital urban governance for sustainable development

Digital technologies have dramatically changed human society. With the wave of new technological revolution, a series of digital technologies for data production, storage, and processing, such as mobile communications, Internet of Things (IoT), cloud computing, automation, artificial intelligence (AI), blockchain, and big data, have emerged and been adopted in different areas. These digital technologies have not only profoundly changed the way people work and live and the way organizations operate but have also triggered a shift in global urban governance from "urban governance" to "digital urban governance."

Digital urban governance, as its name suggests, is a mode of urban governance formed by the use of digital technologies. Based on the practical problems encountered and application scenarios in different areas of a city, this model establishes a multi-stakeholder governance network through the innovative application of digital technologies, positively responding to the practical needs of urban governance.

3. Global practical experience of digital urban governance

In recent decades, many cities in developed countries have taken the lead in exploring approaches to adopt digital technologies for urban governance, providing extensive experience for many developing countries, including China, to promote digital urban governance.

(1) Singapore: The "Singpass" digital service platform

• Multi-channel electronic authentication to enhance security.

• Access to a wide range of public and private services to improve inclusiveness.

• A multi-participatory digital ecosystem to improve service sustainability.

(2) New York: The "NYC311" citizen hotline platform

• Multi-channel contact link to improve inclusiveness.

• Strict service quality control to ensure efficient response.

• Creating a service request map for transparency and accountability.

(3) Barcelona: The "Sentilo" public open data platform

• Data-driven management to improve the efficiency of urban operations.

• Open access to data for sustainable urban development.

• Open source platform to create an innovative ecology for digital governance.

4. Chinese actions promoting digital urban governance

Under the Strategic Plan of the Chinese central government, city governments have attached great importance to and continuously promoted digital transformation, striving to develop digital urban public services and digital urban operation management.

(1) Digital urban public services

In recent years, local governments have explored the digital transformation of public services based on the idea of providing a "one-stop service," leading to the emergence of a number of digital platforms and "super applications" for public services. According to the 2023 China Provincial Mobile Government Service Report, all provincial governments have launched public service apps and applets on WeChat or Alipay. Citizens can access the public service platform both online and offline to apply for government services, obtain daily services, and query policy documents. They can also submit service requests, complaints about urban issues, and policy suggestions through the online citizen hotline.

(2) Digital urban operations management

To achieve the SDGs of "inclusive, resilient, safe, and sustainable" cities, city managers must be able to identify problems in the functioning of the city and take appropriate measures to resolve them. In recent years, local governments have explored the development of digital platforms for urban operations management, albeit under different names. Shanghai's "One Network Unified Management" and Beijing's "Haidian City Brain." are the two typical cases of digital urban operations management.

Chapter 2 Technical Panorama of Digital Urban Governance

Applying digital technologies in urban governance effectively modernises the governance system and governance capabilities, which is necessary to meet the public's demand for government services. It is also able to directly or indirectly contribute to achieving Sustainable Development Goals (SDGs) proposed by the United Nations (UN).

Chapter 2 focuses on the application of digital technologies in 10 different urban governance scenarios, including digital urban management, urban transport and transportation, environmental resilience maintenance, pollution monitoring and management, waste classification and circulation, historic building protection, urban energy management, digital government services, health care services as well as quality education and study. It aims to illustrate how the application of technologies in governance scenarios contributes to achieving SDGs and produces a technical panorama of digital urban governance.

At the beginning of each scenario section, it will be explained how the digital technology or system enhances the achievement of SDGs under this scenario. Then there will be a description of the overall framework and working mechanism of the technology or system. A practical case or example will be included at the end of each section to demonstrate how it has an effect on urban governance efficiency and SDG achievement.

Chapter 3 Roadmap of Digital Urban Governance

Urban governance is related to the security and stability, comprehensive strength and operational efficiency of the city, while it is also the pivot of the national governance system, depending on the development efficiency and pace of reform of the whole country.

The first stage is the informatization stage, whose main goal is to build its informatization system for each business department involved in urban governance, moving from traditional paper-based office to paperless and informatization.

The second stage is the digitalization stage.

Its main goal is to build a city-level big data platform based on big data technology and general artificial intelligence technology, to realize the unified convergence and management of government data, the interconnection of data between different businesses, and to build an intelligent brain for each vertical field on this basis.

The third stage is the intelligentization stage. Its main goal is to realize a "cross-system, all-connected, all-intelligent" five-network fusion system for digital urban governance, namely, one-network perception of urban status, one-network sharing of urban data, one-network unified management of urban governance, one-network collaboration of government offices, and one-network handling of government services.

There are three phased key aspects of digital urabn governance:

• The nascent stage of digital urban governance. This stage applies to cities that are trying to get off the ground, usually with some key business departments taking the lead in unidirectional promotion, focusing on analytical guidance and supplemented by business coordination. Its core is located in auxiliary decision-making, the goal is to realize the data integration and system opening of various lines and begin to try to study and judge the urban situation and difficult problems through data analysis.

• Digital urban governance development phase. This stage applies to cities with a certain construction base, usually with partial system integration, but with business standards still not harmonized. Its core is set on coordination and linkage, and a cross-departmental and cross-line working mechanism within the government has begun to take shape, and data integration and mechanism fusion have begun.

• Digital urban governance maturity. This stage applies to cities that are developing more rapidly, and its core is in command and scheduling, realizing "one-door acceptance, one-order dispatching, integration of peace and war, and closed-loop questioning". The goal is to integrate business, technology and data to achieve efficient collaboration across levels, geographies, systems, departments and businesses, i.e., "three integration and five transitions".

Chapter 4 Cases Studies

This chapter, taking the ten digital urban governance scenarios mentioned in Chapter 2 as the main focus, covers multiple aspects including primary-level governance, data operation, traffic management, ecological protection, medical health, e-government, and public services. It provides five city cases and six enterprise cases, offering Chinese strategies and solutions for global cities to leverage digital innovation for urban governance.

The city cases include Pinghu City, Zhejiang Province, which focuses on building a digital urban governance system: the application of "GanZhiHui + Event Hub" in urban governance; Guilin City, Guangxi Zhuang Autonomous Region, which focuses on ecological protection: digital empowerment of Li River ecological governance; Yantian District, Shenzhen City, which focuses on the digital management and operation of urban infrastructure: the application of the smart urban management information system in digital urban governance; Anji County, Huzhou City, which focuses on smart city transportation to improve residents' quality of life: the application of a one-stop smart travel platform in urban traffic management; and Fuyang District, Hangzhou City, which focuses on smart healthcare: the application of "cross-hospital recognition of examination and test

results" in urban governance.

The enterprise cases include Ant Group: Alipay digital platform empowering urban public services with a focus on e-government services; JD Technology, focusing on building a data operation platform: the application of the Beijing Economic Development Zone governance chain platform in urban governance; Ordos Digital City Technology Co., Ltd.: the application of "DuoduoPing · MaShangShenghuo" (a combination of administration and technology) in urban governance, empowering primary-level governance; Onewo Inc.: "full-domain intelligent operation" innovates in urban governance by empowering full-domain intelligent operation; Shenzhen Smart City Technology Development Group Co., Ltd., which empowers the urban housing construction system with digital technology to promote the renovation of old urban residential communities, promoting sustainable urban regeneration.

Chapter 5 Recommendations

1. Implementation pathways for digital urban governance in China

China adheres to a people-centered development philosophy and has strategically planned and prioritized digital urban governance at the national level. This has resulted in the establishment of clear strategic plans and national frameworks for digital urban governance, the regular organization of meetings and on-site visits to drive progress, for the better implementation and operation of digital urban governance.

The realization of digital urban governance involves complex coordination processes among different levels and departments within the government, as well as between the government and enterprises. To optimize resource allocation and effectively implement digital urban governance, China has established a series of mechanisms such as goal setting, task forces, and an "enterprise bidding" system. These mechanisms have facilitated effective coordination and cooperation among various stakeholders involved in digital urban governance.

In the process of promoting the digital transformation of urban governance, there may sometimes be implementation deviations, where the application of digital technologies fails to fundamentally solve real-world problems and may even lead to negative outcomes such as excessive costs or resource waste. To address this, China has established mechanisms such as chief data officers, "evaluation-driven construction," and collaborative production to correct deviations in the implementation of digital urban governance.

2. Emerging risks in digital urban governance

While digital urban governance can indeed empower the achievement of Sustainable Development Goals (SDGs), a series of emerging risks associated with the application of digital technologies persist. To further enhance the performance of digital urban governance and improve urban sustainability, various stakeholders in cities need to take effective measures to address these risks collectively.

Tangible risks refer to the potential vulnerabilities inherent in the digital systems of various urban domains, related to the security, stability of their hardware, software, networks, and data processing systems. These risks include technical vulnerabilities, algorithmic biases, and data security issues.

As digital systems are applied to various urban domains and interact with people, they

may have negative impacts on individuals, organizations, and society as a whole. These impacts include privacy violations, the digital divide, and the abuse of digital power.

When citizens use digital systems in various urban domains, their understanding of how these systems operate may vary due to differences in life experiences, educational backgrounds, and other factors. This can lead to a perception of risk that differs from the actual risk, resulting in perceived risks such as perceived fairness risks, perceived security risks, and perceived trust risks.

3. Global initiative for digital urban governance

Initiative 1: create a global expert panel and policy dialogue forum for digital urban governance.

Initiative 2: build a security governance system to address emerging risks.

Initiative 3: design a consensus-based data framework and digital infrastructure standards.

Initiative 4: support continuous research and development and application of digital urban technologies.

Initiative 5: build a capacity development network for digital urban governance.

Initiative 6: promote best practice selection for digital urban governance.

4. Future trends in digital urban governance

Emerging technologies such as blockchain, quantum computing, and artificial intelligence are increasingly being applied to urban governance, driving the efficient resolution of "one-stop services" and "one-time approvals," and promoting the transformation of digital urban governance.

As a significant trend in digital urban governance, distributed urban governance involves engaging "edge institutions," non-governmental organizations, the public, and other entities in urban governance. This new governance model is based on open communication, coordination, and linkage between the government and external entities. The decentralized nature of distributed urban governance relies on blockchain and other distributed technologies, which can distribute governance power and data processing to different nodes and participants, thereby achieving more efficient and transparent management.

Cross-regional data collaboration is a novel approach that involves utilizing diverse data sources and expertise across different regions within and between countries to generate societal impact. Data from different regions not only empowers urban governance within their respective regions but also plays a significant role in promoting urban governance in other regions. As a result, cross-regional data collaboration has become a future trend in digital urban governance.

01

Introduction

Chapter 1 Inrtoduction

There are still major challenges in achieving sustainable urban development goals. Urban governance is essential for sustainable urban development, and digital technologies could offer new opportunities.

Digital urban governance has the potential to strengthen multiple areas of sustainable urban development, such as urban housing, transportation, public services, heritage preservation, emergency response, environmental protection, and public space. The digital urban governance experiences of cities such as Singapore, New York, and Barcelona offer insights for cities in developing countries. Over the past decade, the Chinese central government has continuously strengthened the top-level designing of digital urban governance policies, and local municipalities have actively explored digital urban governance approaches, making a number of notable achievements.

This report illustrates the trends and challenges of global urbanization, as well as the key strategies to address urban issues, and digital technology as a new driving force for empowering urban governance.

1.1 Major challenges of sustainable urban development

Cities have become an important spatial base of human civilization with continuous economic and social development. Cities account for only 3% of the planet's land area, but 56% of the world's population is concentrated in cities and more than 80% of global GDP is generated by cities. In recent years, the global urbanization process has accelerated, especially in developing countries. According to United Nations (UN)-Habitat statistics in 2023, the population is rapidly concentrating in many developing countries. Some cities in African and Asian countries are experiencing average annual growth rates above 5% and are expected to maintain these high growth rates in the near future.

"Better City, Better Life" is a beautiful aspiration of human society. People continue to concentrate in cities for a better life, but this rapid concentration has led to a series of economic, social, and environmental "urban diseases," such as poverty, traffic congestion, and environmental pollution. How to deal with these urban diseases and achieve sustainable urban development have become growing concerns in human society.

To bring greater global attention to sustainable urban development, the UN has taken a series of steps. In December 2013, the 68th Session of the UN General Assembly decided to designate October 31 of each year as World Cities Day starting in 2014. Moreover, at the UN Summit on Sustainable Development in 2015 (Figure 1-1), UN member countries adopted The 2030 Agenda for Sustainable Development (hereafter referred to as "the Agenda") and the 17 Sustainable Development Goals (SDGs), specifically setting SDG 11 for cities. SDG 11 aims to create "inclusive, safe, resilient and sustainable cities and human settlements" and consists of 10 targets: Safe and affordable housing (11.1); Affordable and

sustainable transport systems (11.2); Inclusive and sustainable urbanization (11.3); Protect the world's cultural and natural heritage (11.4); Reduce the adverse effects of natural disasters (11.5); Reduce the environmental impact of cities (11.6); Provide access to safe and inclusive green and public spaces (11.7); Strong national and regional development planning (11.a); Implement policies for inclusion, resource efficiency, and disaster risk reduction (11.b); and Support least developed countries in sustainable and resilient building (11.c)

Since the publication of the Agenda, sustainable urban development continues to face serious challenges. According to the 2024 report of the Sustainable Development Solutions Network (SDSN), SDG 11 still faces significant or major challenges in most regions of the world, and even a regressive trend in some countries in Eastern Europe and Oceania (Figure 1-2).

The UN Sustainable Development Goals Report 2024 identifies four of the most

Figure 1-1: 2015 UN Summit on Sustainable Development
Source: UN News Centre

serious challenges to SDG 11 :

- The global slum crisis is worsening: 24.8% of the world's urban population still lives in informal settlements (slums) without access to safe housing and basic public services.
- Air quality has improved, but not enough to protect health; on average, 4.2 million people have died from urban air pollution.
- Access to public transportation still needs to be improved; only 60% of the world's urban population has access to convenient

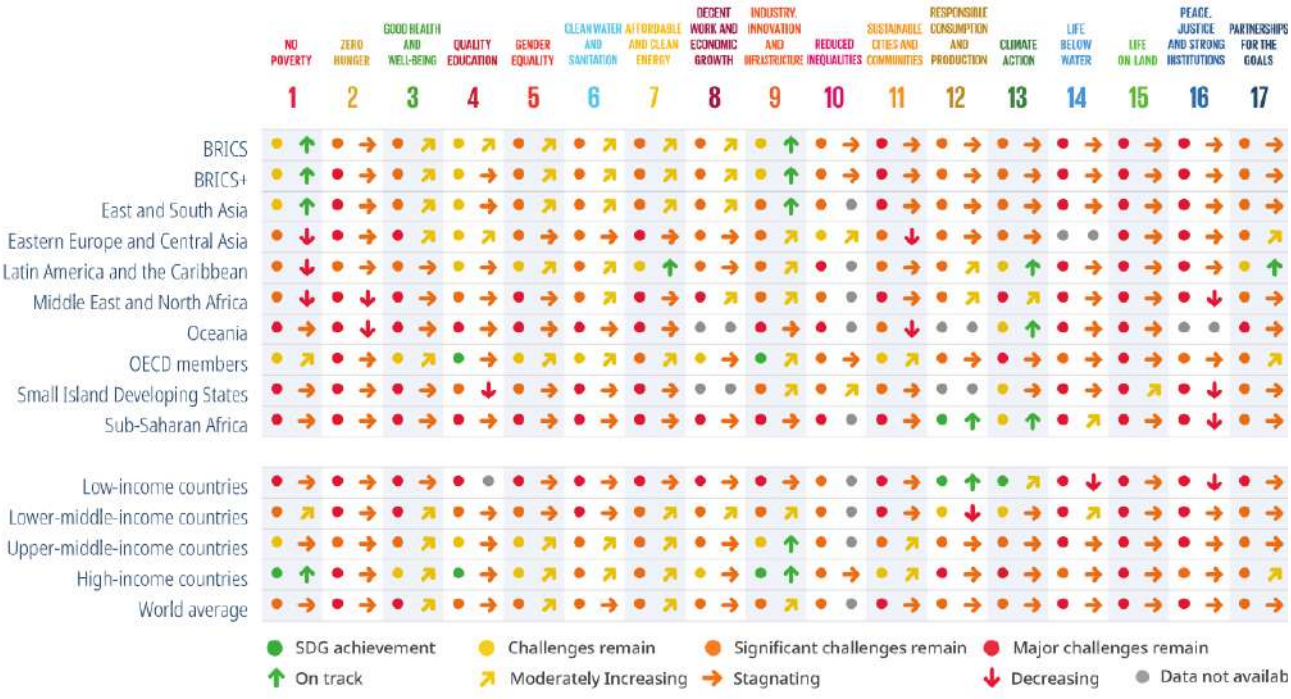


Figure 1-2: 1-2 2024 SDG dashboards by region and income group
Source: SDSN

public transportation.

• Urban resilience is urgent; the total number of disasters has increased fivefold over the past 50 years, and the average number of people affected by disasters has risen to more than 130 million per year over the past decade.

Urban governance is crucial for sustainable urban development. As suggested by UN-Habitat's World Cities Report 2022, "Whether and how economic opportunities; supportive social networks; and access to land, infrastructure and services are accessible to the urban poor is largely dependent on the efficacy of urban governance and institutional arrangements. Urban governance remains central to effective crisis response and sustainable urban development". In the context of the serious challenges posed by sustainable urban development, there is an urgent need for human society to seek innovative modes of urban governance to improve the living, productive, and ecological environments of cities. To this end, the rapid development of digital technologies offers possible new approaches.

1.2 Digital urban governance for sustainable development

1.2.1 Digital urban governance

Digital technologies have dramatically changed human society. By 2023, the global population's mobile phone, Internet, and social media usage rates exceeded 50% , and the share of the digital economy in GDP of 51 major economies around the world averaged 46%. With the wave of new technological revolution, a series of digital technologies for data production, storage, and processing, such as mobile communications, Internet of Things (IoT), cloud computing, automation, artificial intelligence (AI), blockchain, and big data, have emerged and been adopted in different areas. These digital technologies have not only profoundly changed the way people work and live and the way organizations operate but have also triggered a shift in global urban governance from "urban governance" to "digital urban governance."

Urban governance is "the sum of the many ways individuals and institutions, public and private, plan and manage the common affairs of the city", emphasizing the participation of different stakeholders, such as city governments, businesses, social organizations, citizens, and others, throughout the urban affairs process. Digital urban governance, as its name suggests, is a mode of urban governance formed by the use of digital technologies. Based on the practical problems encountered and application scenarios in different areas of a city, this model establishes a multi-stakeholder governance network through the innovative application of digital technologies, positively responding to the practical needs of urban governance. Compared with traditional urban governance, digital urban governance differs in terms of data collection, data storage, incident decision-making, and incident disposal.

(1) Data collection

Stakeholders use sensor networks to automatically collect information on public affairs, reducing the need for manual data collection.

(2) Data storage

Stakeholders collaboratively establish information systems and databases related to public affairs, reducing reliance on paper records.

(3) Incident decision-making

Decision-makers adopt new urban decision-making models based on data analysis, reducing their reliance on human judgment.

(4) Incident disposal

Drones, robots, and other actuators are used to automatically eliminate urban problems, reducing the need for manual disposal.

1.2.2 Technical implementation of digital urban governance

To achieve sustainable urban development through the application of digital technologies, it is necessary to establish a digital system that monitors in real time the "vital signs of a city" in its daily operations, as well as to make accurate analyses and effective decisions based on the data.

According to the white paper on smart cities (2022) jointly issued by China industrial control systems cyber emergency response team and others, real-time monitoring and accurate analysis of "vital signs" require a five-layer technical structure consisting of smart terminal, edge computing, data networks, cloud computing, and smart solutions, with appropriate security protection measures for each layer. The smart terminal layer is used to collect and record short-range urban "vital signs" data; the edge computing layer is used to respond quickly to urban problems through real-time computing; the data network layer is used to realize lossless transmission of data and decision-making information; the cloud computing layer is used to aggregate huge amounts of urban "vital signs" data to carry out integrated calculations for decision support; and the smart solution layer is used to formulate comprehensive solutions that can be applied to human–computer interaction to improve the quality of urban operations in different areas (figure 1-3).

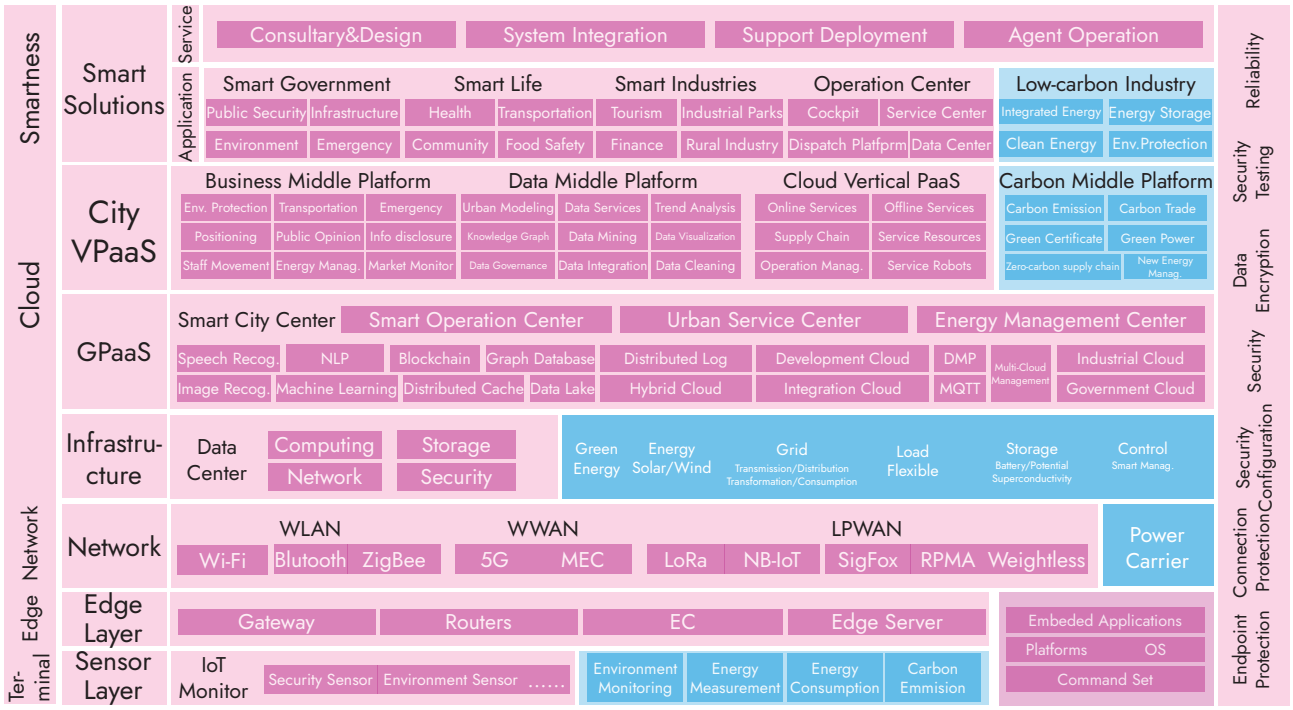


Figure 1-3: Technical framework for digital urban governance
Source: Translated from the White Paper on Smart Cities (2022)

Many of the SDG 11 goals can be realized to varying degrees through the application of digital technologies. Based on the analysis of the SDG 11 targets of the Agenda, it is possible to identify scenarios for the application of digital urban governance in which digital technologies can enable the achievement of these targets.

(1) Safe and affordable housing (SDG 11.1)

The Agenda requires ensuring access to safe and affordable housing with basic public services for low-income groups. Digital technologies allow city managers to continuously improve housing safety and security and reduce the cost of providing access to basic public safety services. For example:

Smart security scenario: Real-time monitoring of the housing periphery is realized through the collection of housing environment data by sensors. When abnormal behavior or invasion occurs, the system will immediately issue an alarm and notify security personnel or automatically take defensive measures to ensure that the lives and properties of residents are protected and housing security is effectively enhanced.

Smart elevator scenario: By installing sensors on the housing elevator system, the system can detect potential safety hazards of the housing elevator in advance, automatically alert the housing manager, and assist engineers in repairing the equipment; it can also automatically identify electric bikes in the elevator, stop operation, and report to the housing manager when this happens to reduce potential safety hazards from battery charging in the building, which may cause a fire.

(2) Affordable and sustainable transport systems (SDG 11.2)

The Agenda requires the provision of safe, affordable, accessible, and sustainable transport systems for all, the improvement of road safety and, in particular, the expansion of public transport, paying special attention to the needs of people in vulnerable situations, women, children, people with disabilities, and older people. The target is twofold: one is to improve the safety of urban transport, the other is to improve the capacity of public transport services for all residents, including vulnerable groups, so that they have access to affordable and sustainable public transport services. Digital technologies can enable city managers to improve the operational efficiency of urban transport systems and optimize the allocation of urban public transport resources to enhance service capacity. For example:

Smart traffic light scenario: Sensing equipment installed at traffic intersections allows real-time monitoring of traffic flow and road conditions. Based on traffic condition data, the system automatically adjusts traffic lights to achieve a "segmented green wave" for congested roads during peak hours. By improving the probability of vehicles passing through the congested area after one stop, rapid diversion of traffic flow can be achieved, which reduces fuel consumption and exhaust emissions caused by road congestion and improves the sustainability of the urban transportation system.

Smart bus scenario: By collecting real-time information on bus cabin load and station traffic through sensors, comprehensive analysis is carried out with the help of big data, AI, and other technologies. This analysis helps calculate and predict peak hours and popular demand locations for public transportation, which can help public transportation managers adjust bus operating routes to better meet citizens' public transport needs.

(3) Inclusive and sustainable urbanization (SDG 11.3)

The Agenda requires the development of inclusive and sustainable cities and capacities for participatory, integrated, and sustainable planning and management of human settlements. The target is twofold: one is to promote the inclusion of diverse groups and environmental sustainability in the city-building process, the other is to promote public participation and environmental sustainability in settlement planning and management. Digital technologies can help city managers improve the inclusiveness of urban public services, and different stakeholders (such as citizens) can participate more easily in urban planning, construction, operation, and management. For example:

Public service portal scenario: By integrating different government departments to establish a one-stop online platform for comprehensive urban government services, all public services related to "birth, growing, sickness, death, food, clothing, housing, transportation, living and working" in citizens' daily lives can be gradually integrated. The portal enables citizens to benefit from public services through "one visit at most" offline and "no visit at all" online, enhancing service accessibility and citizen satisfaction and creating more inclusive and sustainable urban public services.

Citizen hotline scenario: Based on the Citizen Hotline, city managers can integrate information from various departments to establish a comprehensive digital platform for citizens to participate in urban governance. Citizens can make service requests, provide feedback, and report urban problems through online means such as web portals and offline means such as hotlines. Next, the hotline platform assigns relevant government departments to handle requests and provide timely feedback, thereby enhancing citizens' willingness to participate in urban planning and management and realizing more inclusive and sustainable urban operations.

(4) Protect the world's cultural and natural heritage (SDG 11.4)

The Agenda requires increasing efforts to protect the world's cultural and natural heritage. The target requires city managers to increase investment and efficiency in the conservation of natural and cultural heritage. Digital technologies allow city managers to further enhance the visibility of natural and cultural heritage and improve the efficiency of conservation practices and conservation research. For example:

Digital tourism scenario: Using various types of sensing devices, city managers can reproduce scenic spots and cultural resorts with high ornamental value in a virtual space, thus realizing the sustainable preservation of fragile natural and cultural heritage online. Virtual reality can guide citizens and tourists to experience the charm of natural and cultural heritage in an immersive way, thereby enhancing their willingness to participate in the protection and active dissemination of natural and cultural heritage.

Smart protection of ancient buildings scenario: By installing sensing devices and creating digital twins for ancient buildings, city managers can engage in real-time monitoring of the condition of ancient buildings, issue timely warnings of damage risks, and provide strong data support for practitioners and researchers to carry out efficient restoration and protection work and scientific research on ancient buildings.

(5) Reduce the adverse effects of natural disasters (SDG 11.5)

The Agenda requires ensuring a significant reduction in the number of deaths and people affected by disasters, such as floods, as well as a significant reduction in direct economic losses related to global GDP resulting from such disasters, with a focus on protecting the poor and vulnerable. This target includes reducing the impact of both natural disasters and production accidents on human life and property. Digital technologies can help city managers predict the impact of hazards and optimize resource allocation for emergency responses. For example:

Natural disaster emergency scenario: Using data from satellites, sensors, and other devices, the system can calculate and predict the time and intensity of typhoons, earthquakes, floods, and other natural disasters, and provide decision support to city managers to carry out preparation work such as reinforcing facilities and evacuating personnel. After a disaster, by using satellites, drones, and other equipment to quickly scan the disaster area and create a digital twin of the area, city managers can improve the efficiency of rescue command and reduce the impact of disasters on the city.

Smart supervision of dangerous chemicals scenario: By installing sensors and conducting dynamic monitoring of dangerous chemical processing facilities, storage facilities, and transportation vehicles in the city, city managers can monitor the flow and storage status of various types of chemicals in real time. The system can automatically issue early warning of abnormal conditions and take preset control measures (e.g., automatic shutdown of transmission pipelines) before accidents occur, thereby reducing the possibility of production accidents and mitigating their impact on the city.

(6) Reduce the environmental impact of cities (SDG 11.6)

The Agenda requires the reduction of negative environmental impacts of cities per capita, including by paying close attention to air quality and urban waste management. This target focuses on reducing air, water, and solid waste pollution in urban development. Digital technologies can help city managers reduce pollution when building and managing communities. For example:

Smart environment monitoring scenario: By deploying air pollution, water pollution, and solid waste pollution sensors throughout the urban area to capture air, water, and solid waste pollution levels in real time, city managers can achieve 24-hour automatic environmental inspection and law enforcement, and accurately locate pollution sources. Through early detection and timely elimination of urban pollution, the negative impact of urban production and living activities on the natural environment can be reduced.

Smart building scenario: By installing sensors in buildings and creating an IoT-based building-level management platform, real-time monitoring of indoor environmental parameters, such as temperature, humidity, and air quality, can be realized. Based on the monitoring results, the system can automatically control various facilities in buildings, such as lighting, curtains, and air conditioning, to improve energy efficiency and reduce waste, optimize building management efficiency, and reduce the negative impact of buildings on the urban environment.

(7) Provide access to safe and inclusive green and public spaces (SDG 11.7)

The Agenda requires ensuring the provision of universally accessible, safe, inclusive, barrier-free, and green public spaces for all, especially women, children, older

people, and people with disabilities. Digital technologies can help city managers reduce costs and increase inclusion in the planning and management of public spaces.

Green space smart planning scenario: By integrating community information based on Geographic Information System (GIS), the scenario can assist planners in designing urban green spaces and public facilities within these green spaces, to meet citizens' public green space needs and enhance the inclusiveness of urban public space planning.

Smart park scenario: By installing various types of sensors in urban parks and using GIS, AI, and other technologies, automatic lighting and automatic irrigation can be implemented in parks, thereby improving citizen satisfaction and optimizing resource consumption in parks, further enhancing the sustainable development of public spaces.

1.3 Global practical experience of digital urban governance

In recent decades, many cities in developed countries have taken the lead in exploring approaches to adopt digital technologies for urban governance, providing extensive experience for many developing countries, including China, to promote digital urban governance.

1.3.1 Singapore: the "Singpass" digital service platform

Singpass is a digital service platform launched by the Singapore government in 2003 to provide secure and convenient online access to public and private services to Singapore citizens, permanent residents, and foreigners (Figure 1-4). Singpass has become a key component of Singapore's digital urban governance, with a user base of over 97% of Singapore citizens and permanent residents. Singpass has successfully enhanced the safety, inclusiveness, and sustainability of Singapore's public services through its cross-sectoral and collaborative online service platform.

Multi-channel electronic authentication to enhance security: The Singpass platform is designed with multiple authentication methods to ensure the security of Singapore residents when enjoying online services. Specifically, users can confirm their identity through biometrics such as facial recognition, or through SMS verification codes and digital payment passwords. With its multi-channel security verification, the platform ensures that citizens are not exposed to loss of privacy and property due to identity theft when using public services. By ensuring the security of online public services, citizens' willingness and satisfaction to use online services are enhanced.

Access to a wide range of public and private services to improve inclusiveness: The Singpass platform aims to provide a one-stop online service portal, which ensures one-stop government service delivery by integrating relevant government departments. In addition, it attracts a large number of private organizations, such as banks and educational institutions, which provide services on the platform, and has become a model for the rest of the world in developing online government service portals. After verifying their personal identity and logging in, citizens can apply for more than 2,700 services provided by 800 public and private agencies on the platform and complete service transactions through online payment, generating 41 million transactions per month, which has greatly improved the efficiency of public service delivery in Singapore.

A multi-participatory digital ecosystem to improve service sustainability: Based on seamless, secure, and transparent data

exchange between government departments, external users access Singpass by opening the Application Programming Interface (API) gateway. This enables the private sector in various fields, such as finance, healthcare, and education, to provide services to citizens via Singpass and rely on the government's guarantee of the authenticity of Singpass's personal data to conduct online transactions. The broad participation of diverse organizations creates economic and social value for Singpass, increases private sector participation in service provision and citizens' willingness to use these services, and improves the sustainability of urban public services.

Figure 1-4: Citizens can use their Singpass e-ID card to access public services
Source: asiaone.com

1.3.2 New York: the "NYC311" citizen hotline platform

In 2003, New York City opened the 311 Hotline (NYC311) specifically for non-emergency urban incidents. In 2009, the official 311 Online website, NYC311 mobile app, and other online channels were opened, which, together with the 311 Hotline, serve as a unified platform for New York City to provide government information and respond to non-emergency requests from citizens (Figure 1-5). NYC311 has improved citizen participation in urban governance and promoted the sustainable development of the city through the establishment of a comprehensive citizen demand response system. According to the official evaluation report, in the first quarter of 2024, NYC311 received 12.9 million service requests, with an average response time of 63 seconds during peak hours and 30 seconds during off-peak hours.

Multi-channel contact link to improve inclusiveness: The NYC311 platform focuses on strengthening the response capacity of different channels, by opening various online and offline channels to receive service requests from the public, such as telephone, SMS, website, mobile app, and social media, and accepting requests in different forms, such as text, voice, picture, and video, thus enabling digitally disadvantaged groups to make service requests. NYC311 assigns a unique service order number to requests made by the public, and based on this, can engage in cross-channel follow-up communication, thereby continuously improving the inclusiveness of public services.

Strict service quality control to ensure efficient response: When NYC311 was created, quality management was carried out based on the regulatory model of corporate customer service, and an independent evaluation department was established to assess operators' service quality by monitoring conversation records. By developing a standardized cross-departmental knowledge base for popular requests, operators' ability to respond to citizens' requests and levels of standardization have been improved to ensure that NYC311 and relevant government departments can quickly address citizen requests. According to statistics, 85% of citizen service requests are resolved after their first contact with NYC311.

Creating a service request map for

transparency and accountability: Since 2010, the NYC311 platform has used data analytics and visualization tools to update 311 service request information in real time, forming the NYC311 Service Request Map and opening it for public use. Citizens can view the content of requests, the responsible government agencies, the status of problem solving, and other basic information on the Map. This visualization illustrates changing trends and regional distribution, which not only enhances the government's transparency and accountability in urban governance but also increases citizens' willingness to participate in urban governance, thereby improving the sustainability of public services.

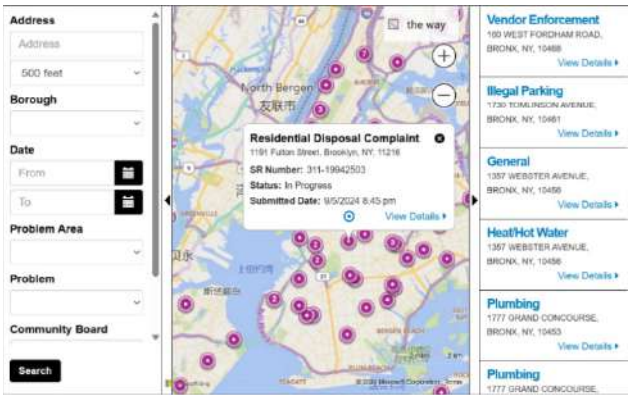


Figure 1-5: NYC311 Service Request Map
Source: portal.311.nyc.gov

1.3.3 Barcelona: the "Sentilo" public open data platform

Sentilo is an open source IoT platform promoted by the Barcelona City Council in 2012 to collect, store, and visualize data from urban sensors and actuators. Equipped with the ability to share data between digital systems in different digital structures, Sentilo is currently being used to monitor a number of areas, such as the energy efficiency of municipal buildings and urban noise pollution levels, to improve the city's level of sustainable development (Figure 1-6). According to its monitoring data, more than 28,000 sensors and actuators are connected to Sentilo, with more than 4.8 billion service requests processed.

Data-driven management to improve the efficiency of urban operations: Sentilo's 28,000 smart sensors spread across the city collect more than 10 types of data, such as weather, traffic, noise, and energy consumption, providing data support for city managers to detect and respond to urban incidents such as meteorological disasters, traffic congestion, and noise pollution. Sentilo helps Barcelona optimize decision-making in public services and infrastructure through the analysis of historical data, reduce operating costs, and achieve refined management. For example, by installing smart meters and connecting them to the Sentilo platform to monitor and optimize the irrigation status of the city's parks, Barcelona has increased its irrigation water savings rate by 25%, saving approximately US$555,000 in municipal maintenance costs each year.

Open access to data for sustainable urban development: The data collected by the 28,000 sensors on the Sentilo platform are entirely public, allowing users to access information on air quality, noise pollution, or traffic flow, to take appropriate measures to improve their quality of life and promote sustainable development. For example, by connecting data from parking space sensors across the city, the Sentilo platform helps drivers know what parking spaces are available nearby. For drivers, this reduces the time spent looking for a parking space and improves their travel experience; for the city as a whole, this improves the efficiency of parking use, reduces traffic congestion and tailpipe emissions, and mitigates the city's negative environmental impact.

Open source platform to create an innovative ecology for digital governance: Barcelona promotes the construction of an innovative

ecosystem of digital urban governance by providing access to public data to incentivize citizens and businesses to participate in the development of smart city solutions. As an open source platform, Sentilo's program code is completely public. Any enterprise, research institution, or individual developer can develop applications based on Sentilo's data and APIs, creating innovate digital city governance scenarios. Barcelona has created an innovation ecosystem that involves multiple interactions between the government, enterprises, research institutions, and citizens, significantly reducing the cost of building digital infrastructure. Sentilo is currently deployed in several Spanish cities.

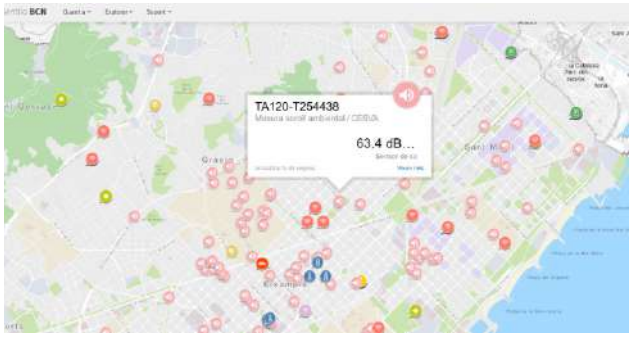


Figure 1-6: Sentilo sensor map
Source: sentilo.bcn.cat

1.4 Chinese actions promoting digital urban governance

1.4.1 Strategic plan of the Chinese central government

With the rapid development of the Internet and other digital technologies in China, the Chinese government attaches great importance to digital urban governance.

In 2015, the fourth Central Urban Work Conference was held in Beijing, which clearly stated that it was necessary to "adhere to people-oriented, scientific development, reform and innovation, and rule by law, change the mode of urban development, improve the urban governance system, improve urban governance capacity, focus on solving outstanding problems such as urban diseases, continuously improve the quality of the urban environment, the quality of the people's lives, and the competitiveness of cities, and build harmonious, livable, vibrant and distinctive modern cities." It also stressed the need to "strengthen the construction of digital platforms for urban management and integration of their functions, build comprehensive urban management databases, and develop intelligent applications for people's livelihood services". This meeting further emphasized the comprehensive implementation of the policy of governing the country by law, planning, constructing, and governing cities in accordance with the law, and promoting the modernization of the urban governance system and governance capacity, and put forward work requirements for the construction and improvement of the functions of digital platforms in the process of urban operation and management.

In 2016, China's National Development and Reform Commission (NDRC) issued the Outline of the Thirteenth Five-Year Plan for National Economic and Social Development, which explicitly suggested "strengthening the construction of modern information infrastructure, promoting the development of big data and IoT, and constructing smart cities". This requirement highlights the need for local municipalities to build digital infrastructure, including placing greater emphasis on the application of big data and IoT technologies in the city-building process.

In 2021, the NDRC issued the Outline of the Fourteenth Five-Year Plan and Vision 2035 for National Economic and Social Development, which further proposed to "promote the construction of new-type smart cities in a graded and classified manner..... improve the city's operation and management service platforms, build city

data resource systems, and promote the city data brain construction". For the first time, the construction requirements for grading and classification were put forward, emphasizing that local governments should promote digital transformation according to their own conditions; this document focused not only on improving "hardware," such as digital infrastructure, but also "software," such as urban data resource systems and application scenarios.

In 2022, General Secretary Xi Jinping's report to the 20th National Congress of the Communist Party of China (CPC) further suggested "accelerating the transformation of the development mode of mega and super-mega cities, implementing urban renewal actions, strengthening urban infrastructure construction, and creating livable, resilient, and smart cities". This report puts forward higher requirements for digital urban governance, in which "livable" and "resilient" are the goals of urban development, while "smart" is the means, further strengthening the application of digital technologies to make cities smarter, thereby making them more livable for residents and more resilient to external shocks.

In 2023, the central government issued the Overall Layout Plan for the Construction of Digital China, which called for using digital technologies to enable comprehensive economic and social development, including strengthening the digital economy, developing an efficient and collaborative digital government, creating a confident and prosperous digital culture, building an inclusive and convenient digital society, and developing a green and smart digital ecological civilization. This plan puts forward general requirements for the development of digital economy, digital culture, digital society, and digital ecological civilization in Chinese cities, aiming to enable coordinated political, economic, social, cultural, and ecological development with digital technologies, and sets higher requirements for digital urban governance.

In 2024, the NDRC and four other departments jointly issued the Guidance on Deepening the Development of Smart Cities and Promoting the Digital Transformation of the Whole Area of Cities, which put forward more comprehensive requirements for digital urban governance, including promoting digital transformation in all fields, enhancing support for digital transformation in all aspects, and optimizing the digital transformation ecology in the whole process. This document covers various fields of urban infrastructure, economy, society, culture, ecology, public services, urban resilience, and security. The construction of hardware infrastructure and software data resource systems is given equal importance, and systematic requirements are formulated for institutional arrangements, the participation of multiple stakeholders, and regional cross-city digital collaboration, with the aim of promoting high-quality urban development, high-efficiency urban governance, and high-quality urban life through digital technologies.

In conclusion, since 2015, the central government's high-level vision for digital urban governance has become increasingly clear. From the initial construction of urban management platforms and information infrastructure to "digital transformation in all fields, all aspects, and the whole process," the central government has a clearer and more systematic understanding of and requirements for digital urban governance, and also puts forward more comprehensive requirements for local municipalities.

1.4.2 Typical practices in Chinese cities

With the strategic plan requirements of the

central government, local municipalities have paid more attention to the continuous promotion of digital transformation, which had led to a number of typical practices in different cities. Typical practices in two areas, namely urban public services and urban operations management, are discussed as examples.

(1) Digital urban public services

Since the beginning of the 21st century, the application of digital technologies to provide a "one-stop service" has been a theoretical conception of the academic community. In recent years, local governments have explored the digital transformation of public services based on the idea of providing a "one-stop service," leading to the emergence of a number of digital platforms and "super applications" for public services. According to the 2023 China Provincial Mobile Government Service Report, all provincial governments have launched public service apps and applets on WeChat or Alipay.

Citizens can access the public service platform through online (e.g., government service websites, mobile apps, WeChat or Alipay applets) and offline (e.g., service counters and self-service terminals) methods. After accessing the platform, citizens can apply for government services, obtain life services, search for policy documents, and submit service requests, complaints, and suggestions through the platform's citizen hotline area.

Shanghai: "doing one thing efficiently" leads to improved administrative service effectiveness

In 2018, the Shanghai Municipal Government issued the Work Plan for Comprehensively Promoting "Government Online–Offline" and Accelerating the Construction of Smart Government. The plan required the creation of a general portal to provide one-stop public services to the public, to enable citizens and enterprises to manage public affairs with one general portal and login once for online circumstances, one door and visit once at most for offline circumstances . In September 2019, the Shanghai Municipal Government issued the Work Plan for the Construction of the Super Application "Sui Shen Ban," to provide one-stop public services to the public and create the best, most comprehensive and optimal "Government Online–Offline" experience through a multi-channel and wide-coverage mobile government service. In January 2020, the "Sui Shen Ban" app was officially launched (Figure 1-7). By the end of 2023, there were 81.46 million real-name individual users and 3.39 million enterprise users registered.

Since 2020, Shanghai has continued to improve the effectiveness of its "Government Online–Offline" with the goal of "doing one thing efficiently." "Doing one thing efficiently" is based on the actual experience of users; it integrates closely related hot services from different departments into "one thing" services closely related to citizens' daily lives, to significantly improve the user experience of citizens and enterprises. For example, the relevant departments have grouped nine services related to the birth of a child from five departments into "one thing for birth," so that parents of a newborn baby can apply for all nine services at the same time via their mobile phone. As of 2023, 49 online services for individuals and businesses, such as birth and medical insurance payments, were made available through the Government Online–Offline platform, significantly improving the efficiency and service quality of the government's public services. According to the UN E-Government Report 2024, Shanghai ranked 12th in the online service level index of 193 cities worldwide, with its online service

level rated as "very high".

Zhejiang: automated approval "smart processing in seconds" improves service experience

In 2014, Zhejiang province established the first national online government service platform integrating province-level, city-level, and county-level governments, called the "Zhejiang Government Service Network," and developed a mobile app for the platform called "Zhe Li Ban" (Figure 1-8). By promoting the transformation of government functions based on citizens' daily lives, the Zhejiang Provincial Government has endeavored to implement the principle that for government services, "one visit is the bottom line, no visit is the norm, and visiting many times is the exception." As a comprehensive platform that provides one-stop public services in Zhejiang province, "Zhe Li Ban" also actively explores other areas of life services, such as blind dating services, to increase citizens' willingness to use the platform. Currently, the platform has over 120 million real-name registered users, with an average of 3 million connections every day.

Since 2021, to further improve the efficiency of government services and the service experience of the public, the "smart processing in seconds" service has been launched, in which high-frequency services are automatically approved by machines instead of manual approval. By integrating relevant departmental databases, users do not need to provide additional information or only need to provide a small amount of information, because relevant documents automatically flow through the system and are approved without manual intervention by government staff. As a result, approval can be obtained immediately through the system. Currently, "smart processing in seconds" is used in hundreds of government services in seven categories closely related to production and public life, such as provident fund, social security, medical insurance, education, real estate, preferential pension, and agriculture, forestry, fishery, and animal husbandry, which has greatly improved the service experience and efficiency of government services, thereby increasing citizens' satisfaction with these services.

Guangdong: dialect recognition helps bridge the digital divide

In May 2018, to further promote the digital transformation of public services in cities in Guangdong province, the Guangdong Provincial Government created the "Yue Sheng Shi" one-stop public service platform (Figure 1-9) for about 100 high-frequency public services. This platform leverages Guangdong's Internet technology and service advantages to promote a shift from "department-centric" to "user-centric" governance and continuously optimize the public's experience with government services. According to official statistics, as of January 2024, the platform had over 180 million real-name registered users, making it one of the largest local government service platforms in China.

Guangdong Province has the highest population mobility in China and its residents use various dialects, including Cantonese. For the migrant and elderly populations in Guangdong, who are part of the digital disadvantaged groups, finding the necessary services has become increasingly difficult, highlighting the issue of the "digital divide". As a result, "Yue Sheng Shi" provides a "Care-for-the Elderly Service Zone" for older people and a "Dialect Search" function, which can recognize 24 major dialects in China. Users only need to set the dialect to be recognized in advance, and the system can recognize and extract keywords from

users' speech and display the text in a timely manner. It also provides relative possible search content, effectively improving the ability of digitally disadvantaged groups to access government information and public services, thereby enhancing the inclusiveness of these public services.

(2) Digital urban operations management

To achieve the SDGs of "inclusive, resilient, safe, and sustainable" cities, city managers must be able to identify problems in the functioning of the city and take appropriate measures to resolve them. In recent years, local governments have explored the development of digital platforms for urban operations management, albeit under different names. Shanghai's "unified management through one network" and Beijing's "Haidian City Brain" will be demonstrated as the example of the practices.

Shanghai's "unified governance through one network": closed-loop management of urban incidents

At the end of 2017, the Shanghai Municipal Government issued the Guidelines for Strengthening the City's Urban Management Refinement Work, which emphasized for the first time the implementation of urban refinement management using digital technologies in Shanghai. In 2020, the Shanghai Municipal Government issued the Three-Year Action Plan for the Construction of Shanghai's Urban Operation "unified management through one network" (2020–2022), officially launching the construction of the "unified management through one network" system. The system applies big data, cloud computing, blockchain, AI, and other digital technologies to create a digital twin of the city, aiming to realize comprehensive situational awareness, smart trend prediction, integrated resource planning, and

Figure 1-7: Homepage of "Sui Shen Ban" & Figure 1-8: Homepage of "Zhe Li Ban" &Figure 1-9: Homepage of "Yue Sheng Shi"
Source: "Sui Shen Ban" WeChat applet & "Zhe Li Ban" WeChat applet & "Yue Sheng Shi" WeChat applet

collaborative actions between humans and machines. With this system, city managers can drive the transformation of urban governance from intensive human interaction to human–machine interaction, from empirical judgment to data analysis, and from reactive interaction to human–computer interaction.

To improve urban operations, Shanghai focuses on promoting closed-loop management of urban incidents. Shanghai's city, district, street, and township governments have set up their respective Urban Operation Management Centers (UOMC) as the command center of the "One Network Unified Management" system, to enhance the awareness of urban operations incidents and the ability to deal with them. In the event of an incident in urban operations, the UOMC can detect the problem through the three channels of the system: automatic detection by sensors, inspection and reporting by civil servants, and reporting by citizens through the "12345" Mayor Hotline. The UOMC where the incident occurs initiates the corresponding process. Based on the type of incident, the UOMC manually or automatically assigns the corresponding responsible department and transmits the incident handling requirements to the department's available personnel. After the disposal personnel have completed the on-site disposal, they must transmit the disposal results to the UOMC through their smart terminals. The UOMC then assesses the urban management performance of different government departments, based on information on urban incident results summarized by the system and verification information from inspectors. Through this process, the system ultimately forms a closed loop of urban incidents from discovery to resolution, and the entire closed loop is sent for visualization and monitoring by UOMC command personnel. If an incident is reported by a citizen through the "12345" Hotline, a call back to the reporting citizen is necessary to inform them of the disposal result and ask them to make an evaluation of the result (Figure 1-10). By optimizing the government's organizational structure, business process reengineering, and interdepartmental data sharing, "Unified Management through One Network" has enabled the transformation of urban operations and management from fragmented to holistic, effectively improving the safety, inclusiveness, sustainability,

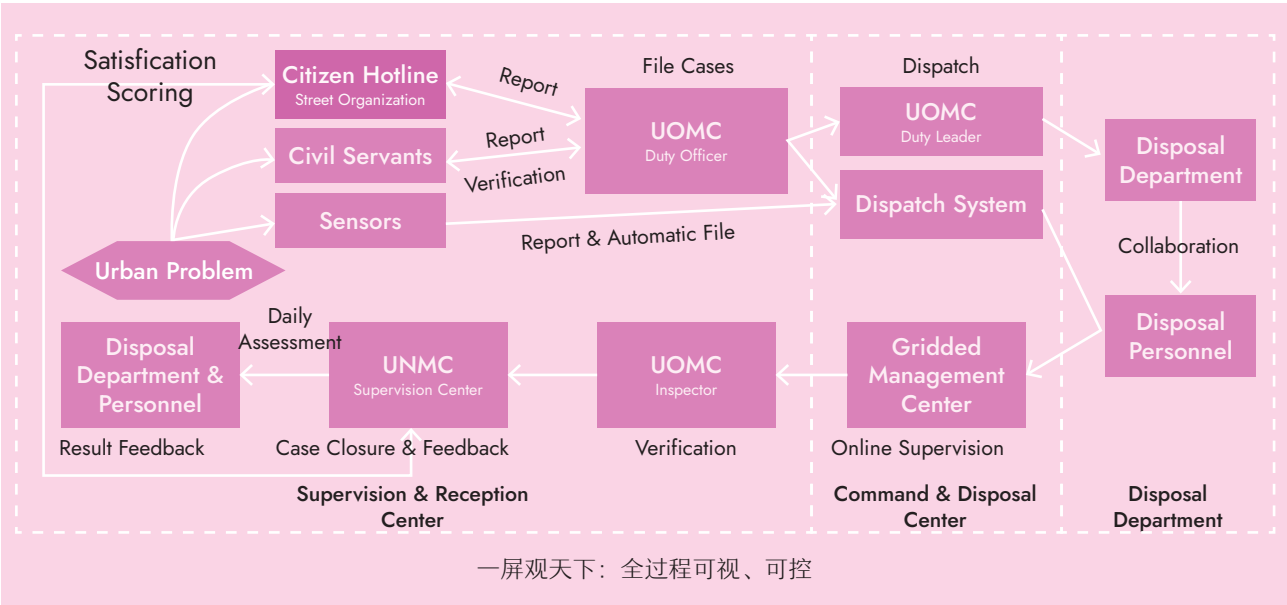


Figure 1-10: Working process of "One Network Unified Management"
Source: Translated from Wang et al., 2023

and responsiveness of Shanghai's daily urban operations management and disaster resilience.

Beijing's "Haidian City Brain": a multi-participation urban digital ecosystem

In January 2018, the Haidian District Government of Beijing first proposed the idea of building the "Haidian City Brain" and started construction of the project the same year. In 2020, "Haidian City Brain 1.0" was basically completed and started operation. Supported by a cloud platform, the "Haidian City Brain" aggregates and processes different types of data collected by the network of sensors, and with the help of the big data center and the arithmetic support of the AI arithmetic center, it transforms public data into governance effectiveness of characteristic application scenarios. By aggregating different types of sensor data such as urban traffic, environment, and infrastructure, the "Haidian City Brain" constructs a three-dimensional map containing spatial and temporal information of "people, vehicles, places, things, and objects" in Haidian District using digital twin technology, enabling the dynamic correlation of the actual situation of Haidian District's urban operations in the virtual world. Furthermore, by superimposing other layers of application scene data, it can provide visual information support for decision-makers to identify urban operation problems, optimize the allocation of governance resources, monitor the level of urban environmental pollution in real time, and improve the agility of community governance, which effectively promotes the sustainable urban governance of Haidian District.

The "Haidian City Brain" focuses on building a digital ecosystem. In 2019, the Haidian District Government initiated the establishment of the "City Brain Industry Alliance." Relying on state-owned science and technology enterprise Zhongguancun Smart City Co., Ltd as a platform enterprise, the Alliance has encouraged domestic IT enterprises from different fields to join in the construction and operation of the "Haidian City Brain," forming an "innovation partner" construction and operation mode with collaborations between the government, platform enterprises, Alliance enterprises, and think tanks (Figure

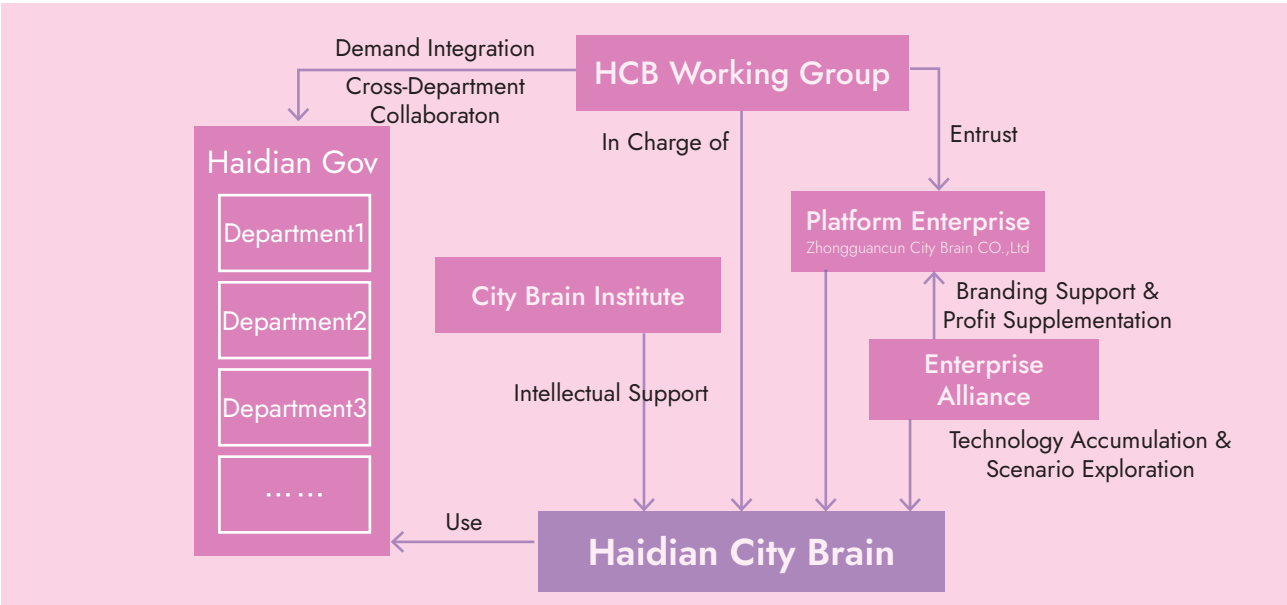


Figure 1-11: Working process of "One Network Unified Management"
Source: Translated from Wang et al., 2023

1-11). Through the clear division of labor between the government's scenario provision, enterprises' technical support, and think tanks' summary and refinement, a set of replicable "City Brain" products and a theorical model of construction have been developed. This model has not only improved the sustainable urban governance of Haidian District but also the ability of Alliance enterprises to compete in the national smart city market, resulting in a "win–win" situation in terms of social value and economic value. In this process, the Haidian District Government has gradually established interdependence with Alliance enterprises and social organizations, ensuring the coupling of interests and the effective flow of knowledge among different stakeholders, as well as the high efficiency of project construction and operation. Currently, the Alliance consists of 98 technology enterprises interested in exploring innovative business scenarios.

1.5 Summary

This chapter outlines technological realization approaches and examples of the application of digital urban governance to enable sustainable urban development.

With the application of digital technologies on many urban areas, digital urban governance has become an important means to promote sustainable urban development. Although it is not easy to achieve good performance in digital urban governance, if the advanced digital technologies can be fully utilized and the concept of "people-centered" is adhered to, and the innovation of digital urban governance models can be continuously promoted, digital urban governance will promote the sustainable development of global cities and provide more lasting impetus for these cities to achieve inclusive, safe, resilient, and sustainable development.

Technical Panorama of Digital Urban Governance

02

Chapter 2 Technical Panorama of Digital Urban Governance

Applying digital technologies in urban governance effectively modernises the governance system and governance capabilities, which is necessary to meet the public's demand for government services. It is also able to directly or indirectly contribute to achieving Sustainable Development Goals (SDGs) proposed by the United Nations (UN).

For example, under the scenario of managing urban transport, Intelligent Transportation Systems (ITS) can help increase transport efficiency, decrease carbon emissions and reduce environmental impacts by streamlining transport management and advising on decision-making, which makes transport systems more sustainable (SDG 11.2 affordable and sustainable transport systems). Under the scenario of providing government services, one-stop government services through one network based on unified ID databases enables people to complete all the necessary procedures through one online portal by encouraging multiple departments to coordinate together and thus increases effectiveness and transparency of local government departments (SDG 16.6 developing effective, accountable and transparent institutions).

This chapter presents a variety of urban governance scenarios and digital technologies or systems that are applied. It aims to illustrate how the application of technologies in governance scenarios contributes to achieving SDGs and produces a technical panorama of digital urban governance.

At the beginning of each scenario section, it will be explained how the digital technology or system enhances the achievement of SDGs under this scenario. Then there will be a description of the overall framework and working mechanism of the technology or system. A practical case or example will be included at the end of each section to demonstrate how it has an effect on urban governance efficiency and SDG achievement.

2.1 Scenarios and digital technologies of urban governance

2.1.1 Digital urban management

Urban data operation refers to the process of integrating and managing public administrative data that was originally scattered across different departments and systems through a unified system. This enables the digital management of various urban governance scenarios, which is known as "unified governance through one network" in the Chinese context. There have been many cities in China making use of "unified governance through one network" to integrate, process and analyse data from multiple scenarios such as transport management, urban resilience and pollution management and provide support for event handling and decision-making. Unified governance through one network for digital urban management contributes to achieving SDGs. On the one hand, it promotes the sustainable development of cities in various scenarios including transportation, urban resilience, and pollution

management (Sustainable Development Goal 11: Sustainable Cities and Communities). On the other hand, it also enhances the collaboration among government departments and promotes urban governance efficiency (Sustainable Development Goal 16: Peace, Justice, and Strong Institutions).

(1) Technical concept - unified governance through one network

There are several layers of "unified governance through one network". The foundation layer is data collection by physical devices gathering information from various sources .

The collected data are integrated and processed for further analysis in the next layer. Stream processing for real-time data handling and batch processing for large-scale data are both applied. It also involves algorithms and models to interpret the data, identify patterns, and generate insights. It may also include predictive analytics to forecast future trends.

The application and visualization layers are those end-users of local authorities directly use. The application layer can help manage resources and dispatch services under different scenarios, such as transport management, environmental emergency response and pollution monitoring. The visualization layer offers an interfaces to interact with the system to view data, receive alerts and locate incidents (Figure 2-1).

(2) How it works – data integration through one network making cities more efficient and sustainable (SDG 11: Sustainable Cities and Communities; SDG16: Peace, Justice, and Strong Institutions)

Currently, many cities have adopted the digital urban operation of "unified governance through one network" to support their urban governance. For example, since Shanghai established unified governance through one network, there have been over 50 departments in charge of 200 systems and 1000 application services integrated into the network. It enables the departments that are

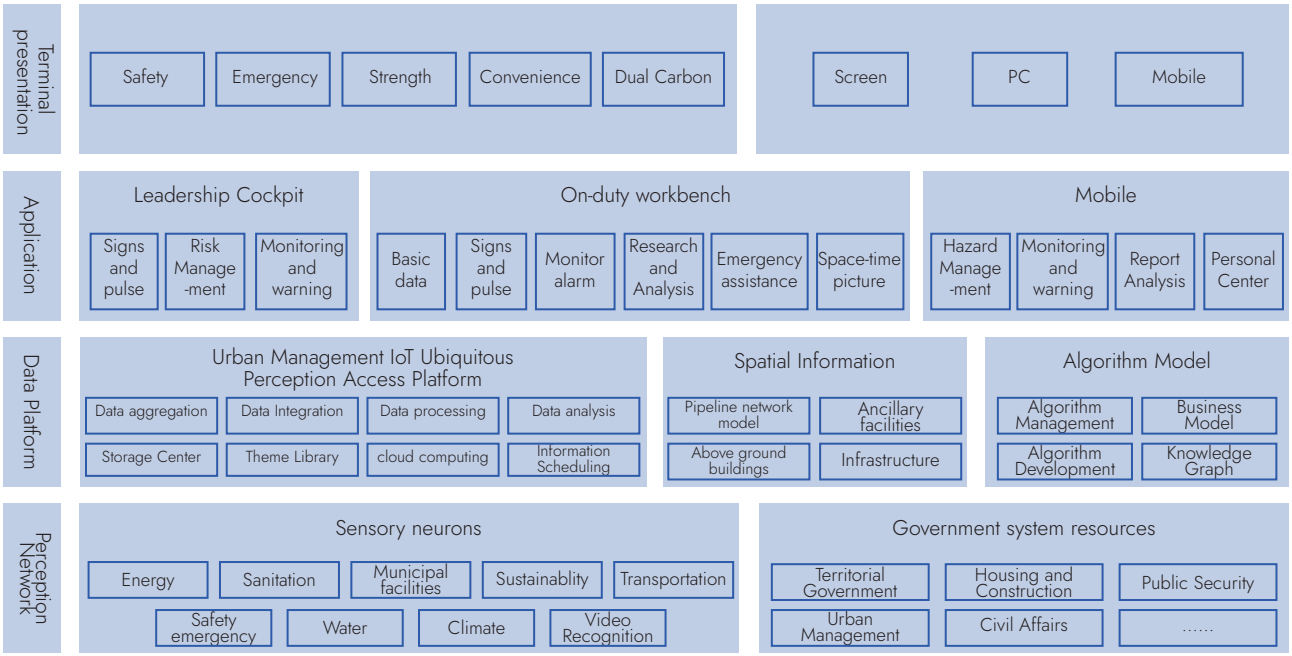


Figure 2-1: General architecture of unified governance through one network
Source: Jia, 2022

responsible for various businesses, including transport, environmental management, pollution monitoring, emergency response, public security and energy supply, to be timely updated with the latest situations and cooperate to address the issues and make urban governance more efficient and sustainable. Furthermore, Shanghai has built up a supervision mechanism with a set of indicators to assess the governance efficiency of departments. The indicators are service-oriented and therefore encourage the departments to cooperate well and take measures efficiently.

In Ningxia Hui Autonomous Region, a unified network has been established for public security. It conducts a four-level police governance, covering region, city, town and local areas. There are 22 town-level public security departments located in the 5 cities in the region, which are all integrated into the police governance network. It has achieved to handle and finish the dangerous driving cases within 48 hours and shortened criminal investigations by 13 days, demonstrating significant improvement in urban governance efficiency by unified digital technologies.

2.1.2 Urban transport and transportation

Intelligent Transportation Systems (ITSs) integrating a variety of digital and communication technologies can optimize traffic flows and increase transportation efficiency, which reduces fuel consumption and carbon emissions by the transport sectors and thus contributes to sustainable development (SDG11.2 affordable transport systems).

(1) Technical concept – Intelligent Transportation System (ITS)

Generally, an ITS works through data collection, data processing and analysis, and applications on various scenarios. It can be both integrated into unified governance through one network and developed and applied as an individual system.

The system collects real-time data from various sources such as traffic cameras, GPS devices and sensors embedded in roads. The collected data include but are not limited to traffic flows, vehicle speeds, and incidents.

Afterward, the system typically employs machine learning and big data analysis algorithms to process and analyze the data, in order to identify traffic flow patterns, predict traffic conditions, and detect potential issues.

At the application stage, analysed data are referred to make decisions about traffic management, for example adjusting traffic light timings, rerouting traffic, and providing real-time traffic updates (Figure 2-2). The system can also monitor the condition of roads and infrastructure, alerting maintenance crews to necessary repairs before the situation becomes critical. In this way, an ITS can make urban transport more sustainable and safe.

(2) How it works – ITS increasing transport efficiency, saving energy and reducing emissions (SDG11.2 affordable transport systems)

A good ITS case is G15 Jialiu Highway in Shanghai. The highway is approximately 13km long and equipped with ITS technologies. Based on the data collected by infrastructures such as millimetre waves, laser radar, and edge equipment, the ITS can automatically identify and locate accidents, analyse the overall traffic situation, predict the traffic status in a short time, and help with decision-making on alleviating congestion. Meanwhile, problems such as water accumulation, ice formation and potholes can also be identified and reported in a timely process. Since the

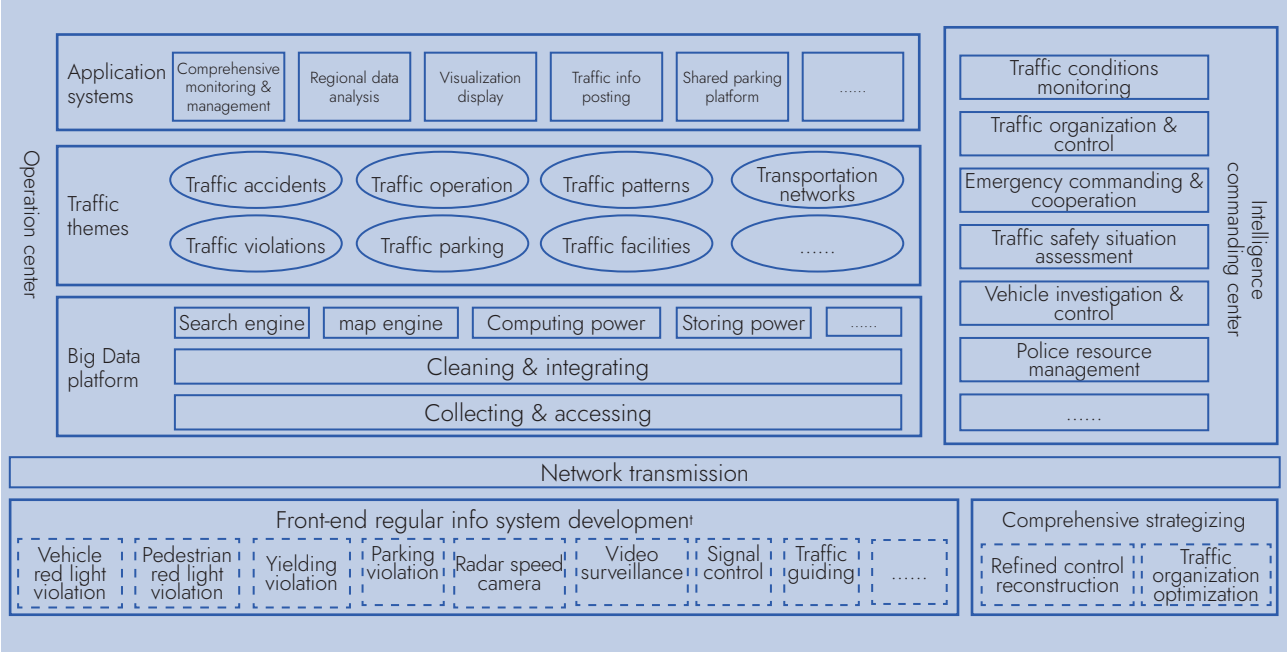


Figure 2-2: An overall architecture of the Intelligent Transport System
Source: Fan and Yao, 2022

opening, there has been a 35% increase in the speed of emergency response and a 49.6% increase in the average daily traffic volume compared to the same period last year on this highway. About 72% of the emergencies have been automatically recognized and alarmed. The increases in transport efficiency can effectively save energy and reduce carbon emissions.

In addition to ITS mainly for road transport, smart technologies based on data governance benefit public transportation as well. For example, One Code Pass enables people to take 20 underground lines, over 1560 bus routes and 17 ferries in Shanghai. It enables people to enter a station 30% faster than swiping a magnetic card, which significantly improves the efficiency of public transport and results in reductions in environmental impact. The code pass is developed by a series of big data technologies, such as data collection, data integration, and itinerary planning based on AI, the mechanism of which is similar to ITS.

Besides, autonomous driving enhancing traffic efficiency, reducing congestion, and minimizing emissions through optimized routing and reduced idle times can be applied in various transportation scenarios including automobile, public transport, and shipping. It also has the potential to decrease accidents by eliminating human error, further contributing to safer urban environments. Currently, cities such as Shenzhen in Guangdong, Beijing, and others have started testing autonomous driving on roads. Wuhan in Hubei has put more than 400 autonomous driving taxis (robotaxis) into operation. Ports like Shanghai Port, Tianjin Port, and Shenzhen's Mawan Port have applied unmanned container transfer vehicles.

Practical case –Intelligent Transportation Systems (ITS) in Japan

Japan's Intelligent Transportation Systems (ITS) emphasize on managing key social issues and addressing road safety and congestion through the integration of advanced vehicle-road collaborative technologies, improving

transportation. The benefits include improved safety through initiatives like the Driving Safety Support System (DSSS) leading to a reduction in accidents in challenging road environments and the widespread adoption of the Electronic Toll Collection (ETC) system achieving a 92% utilization rate, which significantly enhances traffic flow and efficiency.

Japan's ITS employs a range of technologies, including advanced navigation, non-stop toll collection (ETC), vehicle-road collaborative technologies, and automated driving support. For instance, the ETC 2.0 system utilizes Dedicated Short-Range Communications (DSRC) for high-capacity, two-way communication, enabling real-time traffic information exchange and optimal route planning. Furthermore, ITS applications include traffic induction systems that dynamically disseminate real-time traffic information to drivers, and advanced safety driving support systems that provide guidance to minimize travel time, costs, and environmental impact. The integration of these technologies not only improves the driving experience but also supports policymakers in making informed decisions regarding traffic management and road safety.

Japan's ITS also emphasizes the development of cooperative ITS, aiming to create a highly connected and efficient transportation network that addresses the needs of an ageing society and increasingly complex transportation demands.

2.1.3 Environmental resilience maintenance

Cities are facing increasingly deteriorating challenges of environmental resilience. Early warning and early action is one of the best-proven and cost-effective methods to reduce the impacts of natural hazards. United Nations Educational, Scientific and Cultural Organization (2024) supports countries in establishing, maintaining and improving early warning systems, which can improve urban resilience and achieve the SDG (SDG11.5 reduce the adverse effects of natural disasters).

(1) Technical concept - Early Warning Systems

United Nations Office for Disaster Risk Reduction (UNDRR) (n.d.) defines an Early Warning System (EWS) as "an integrated system of hazard monitoring, forecasting and prediction, disaster risk assessment, communication and preparedness activities systems and processes that enable individuals, communities, governments, businesses, and others to take timely action to reduce disaster risks in advance of hazardous events". In general, an Early Warning System (EWS) works in a way that aligns with the concept of an information system and can be connected to unified governance through one network.

An EWS collects data from various sources, which may include sensors, satellite imagery, weather data, and other environmental monitoring systems. To be specific, an EWS for flooding is usually equipped with various types of automatic rain level stations and video monitoring stations while a one for geologic hazards is with Global Navigation Satellite System (GNSS), seismometers, tilt meters and video monitoring systems.

The collected data are processed and analyzed to establish a set of warning indicators and warning thresholds by intelligent methods. The data analysis can also be used to assess and plan evacuation routes, identify temporary shelter places, and offer advice on emergency response. It may also have a feedback mechanism to assess the effectiveness of the warnings and to improve the system over time.

Once a potential risk is identified, the EWS communicates this information to the relevant authorities, organizations, or the

public through various channels such as text messages, mobile apps and broadcastings.

In addition, EWS can be integrated with other systems, such as emergency response systems, to ensure a coordinated response among several local government departments. A general architecture of an EWS for geologic hazard refers to Figure 2-3.

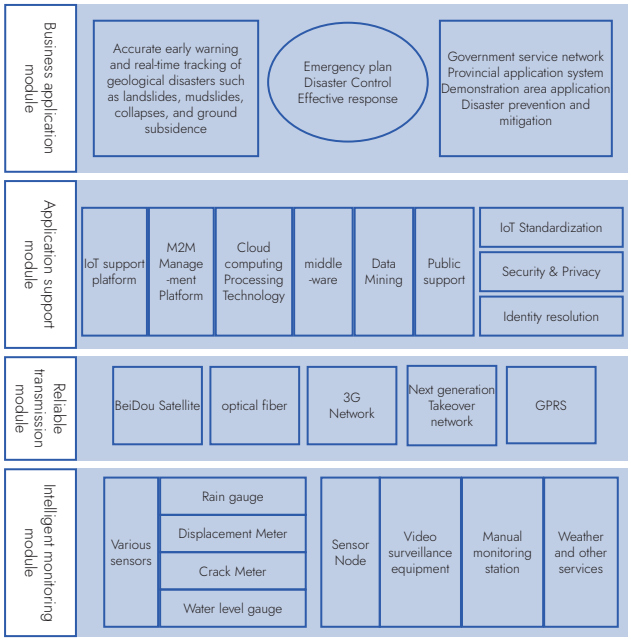


Figure 2-3: geologic hazard warning system architecture
Source: Chen et al., 2015

(2) How it works – EWS reducing the impacts of natural hazards (SDG11.5 reduce the adverse effects of natural disasters)

One good case is EWS for mountain torrents disasters in Boshan District. The area developed a comprehensive monitoring network that covers 18 reservoirs and 17 rivers. Based on the monitoring network and intelligent methods, a public service platform for monitoring and early warning was established. A mobile application "Torrents Defense" was also developed for warning notifications.

Since the establishment of the EWS for torrents in 2012, more than 100,000 transfer warnings have been delivered for more than 100,000 times by text messages, and 2000 times by broadcasting. This has successfully reminded 3,000 to evacuate and relocate, preventing 500 casualties. For example, on 11 August 2019, the average rainfall in the Boshan District was 351.1 millimetres due to the effect of Typhoon Lekima. This triggered the EWS to issue a warning notification of "immediate evacuation". Two hours later there was a flood that resulted in the collapse of 5 houses and water intrusion into about 100 houses. However, thanks to the efficient notification and decision advice from the EWS, people living in the dangerous area were all informed and evacuated to shelter places in advance, successfully avoiding causalities.

2.1.4 Pollution monitoring and management

There are environmental impacts on water, air and soil by cities. A pollution monitoring and management system plays an important role in reducing the environmental impacts of cities by timely reporting pollution incidents and improving coordination among government departments. It increases the efficiency in pollution management so as to mitigate the environmental impacts of cities (SDG 11.6 reduce the environmental impact of cities).

(1) Technical concept – pollution monitoring and management system

A pollution monitoring and management system can be applied both for multiple pollutions such as water, air, and noise, and for a specific one. It can also be integrated into an Integrated digital urban management system. In general, a pollution monitoring and management system consists of a sensing layer, a data transport layer, and an application layer.

The Internet of Things system serves as the foundation of the sensing layer. It is composed

of various environmental monitoring devices and can collect multi-dimensional data of different types. Frequently used devices can be air quality monitors for air pollutants, eg. particulate matter (PM2.5 and PM10), nitrogen dioxide (NO2) and volatile organic compounds (VOCs), water quality monitors for parameters such as pH, dissolved oxygen, chemical oxygen demand (COD), and noise level meters. The transport layer connects the sensing layer and the application layer, where different types of data are transmitted through the network infrastructure and the data interface. The application layer is user-oriented and consists of subsystems with different functions. It can be embedded with intelligent algorithms to conduct water environment monitoring, environmental quality assessment, pollution prediction, pollution source tracing and governance decision-making (Figure 2-4). For example, machine learning algorithms such as artificial neural network (ANN), support vector machine (SVM), and genetic algorithm (GA) carry out continuous self-learning, adaptation, and optimization based on the training data from datasets. They then obtain the main pollutant categories through the classifier and ultimately achieve water pollution source tracing through classification matching.

(2) How it works – pollution monitoring and management system mitigating or avoiding pollution impacts (SDG 11.6 reduce the environmental impact of cities)

For example, an integrated air-land-sky intelligent monitoring system has been developed in Ningxia Hui Autonomous Region. At present, there are 1,698 various environmental quality monitoring points, including 54 automatic air quality monitoring stations, 114 water quality monitoring points, 294 soil monitoring points, 1,032 noise monitoring points, and 204 radiation monitoring points in the region. It has achieved full coverage of air-land-sky pollution monitoring across the region, which has significantly solved the problem of shirking responsibilities among local authorities and improved the efficiency in managing pollution incidents, reducing negative environmental

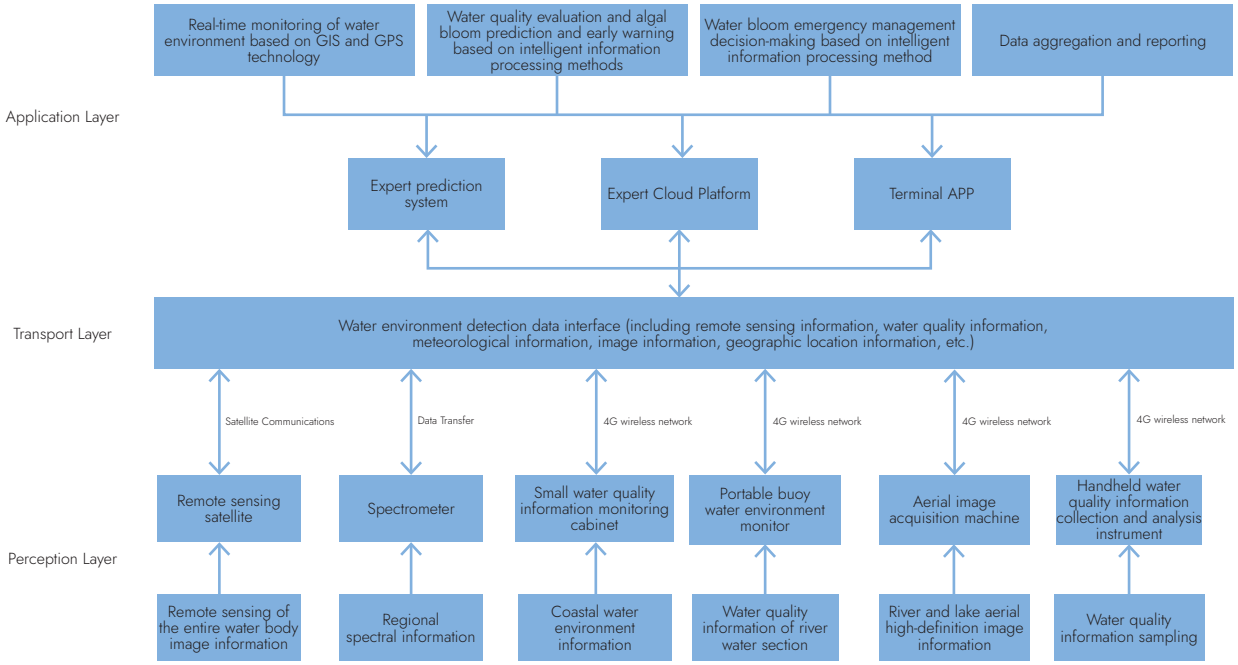


Figure 2-4: Architecture of a water pollution monitoring system
Source: Yu et al., 2019

impacts and improving the regional environmental sustainability.

2.1.5 Waste classification and circulation

Waste is the fourth largest source sector of emissions, accounting for 3% of total greenhouse gas emissions in 2017. It is important to put "3R" principles into practice, which aim to enhance resource reuse, reduce the waste amount and improve recycling efficiency. An intelligent waste management system can increase the efficiency in classification, decrease total waste amounts, and improve reuse and circulation, which is significant to mitigate the environmental impact of cities (SDG 11.6 reduce the environmental impact of cities).

(1) Technical concept – waste management system

An intelligent waste management system usually consists of three layers. Sensors and cameras are used to identify and categorize waste items in the sensing layer by detecting the physical properties of waste (eg. size, shape, colour, and material composition). For example, infrared sensors can detect certain materials, such as plastics or metals, based on their thermal or spectral signatures.

The data collected by the devices are transmitted to various applications through mobile networks, the Internet, satellite communication networks, etc.

In the application layer, deep learning such as Support Vector Machine (SVM) and Convolutional Neural Networks (CNN) are trained to analyze the data and recognize different types of waste. Further steps can also be taken, such as advising on sorting wastes into different bins, warning on incorrect classifications, tracking compliance with waste management regulations and generating reports for regulatory government departments (Figure 2-5).

(2) How it works – waste management system reducing waste amounts and improving recycling efficiency (SDG 11.6 reduce the environmental impact of cities)

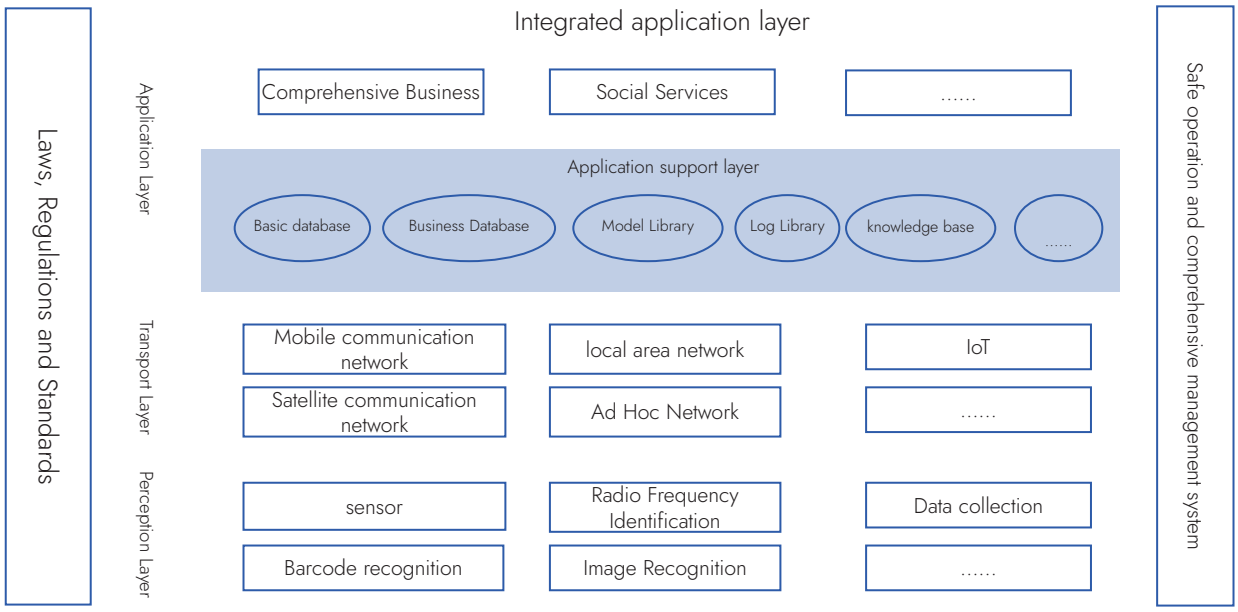


Figure 2-5: Architecture of waste classification system
Source: Li, Lin and Cai, 2019

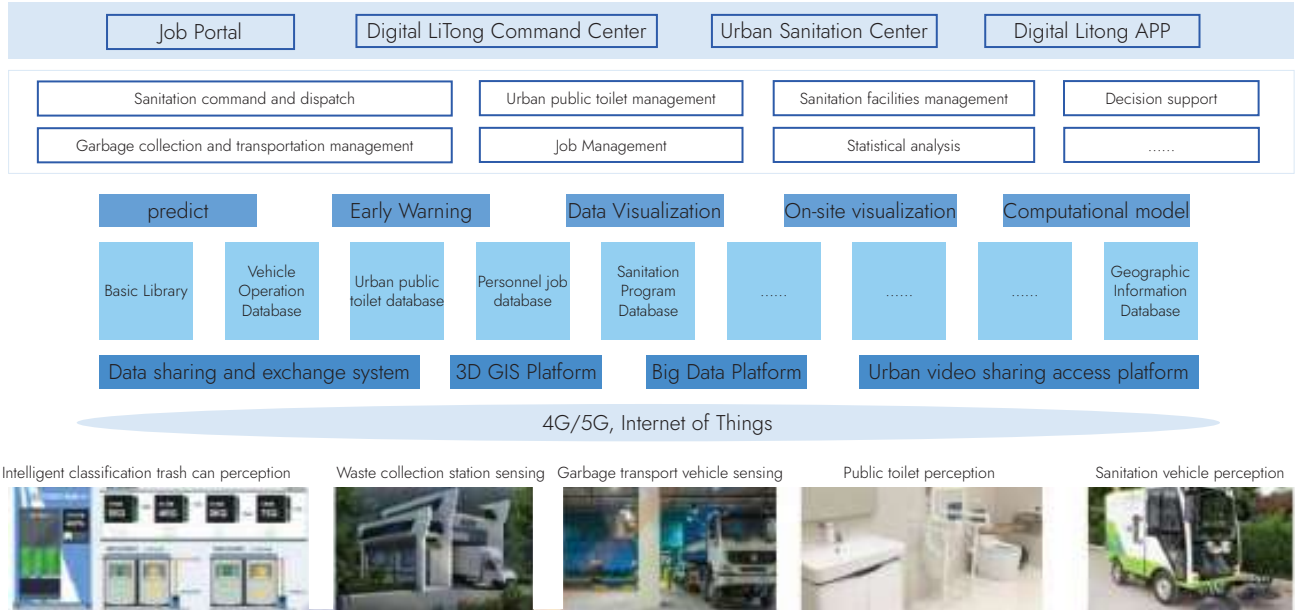


Figure 2-6: Architecture of Digital Waste Management in Litong, Wuzhong, Ningxia Hui Autonomous Region
Source: China Academy of Information and Communications Technology, 2023a

For example, Litong District, in Wuzhong, Ningxia Hui Autonomous Region, developed an integrated urban data governance system, which has a subsystem of Digital Waste Management. The subsystem is equipped with GPS positioning cards, smart wearable devices, and in-vehicle intelligent terminals. It enables the regulatory department to be updated with the working status of waste management in real-time, which promotes the transparency and efficiency of waste management (Figure 2-6).

2.1.6 Historic building protection

Digital technologies play a significant role in engaging the public participation in preservation of historical heritage, which is significant to sustain urban civilization (SDG11.4 protect the world's cultural and natural heritage). Smart technologies such as the Internet of Things (IoT), Building Information Models (BIM) and digital twins can protect historical sites by constructing 3D models, detecting damages and taking effective measures.

(1) Technical concept – information system of historic building protection

The digital technologies are often applied together as an information system, which can also be integrated into unified governance through one network. A digital management system of historic buildings generally consists of four parts. The bottom part is a variety of sensors, such as inclinator, precision level, laser range finder and crack meter, to detect vibrations, displacements, cracks, deformations and other conditions of the structures. Unmanned Aerial Vehicle (UAV) tilt photogrammetry and 3D laser scanning may also be applied. Then the information collected by sensors is transmitted through IoT transmission protocols to a local server installed in the old building. The server performs preliminary data cleaning and compression. The processed data are then transmitted to cloud or local computing devices.

After transmission, the data are analysed by algorithms trained by machine learning, which results in fewer errors in analysis. At

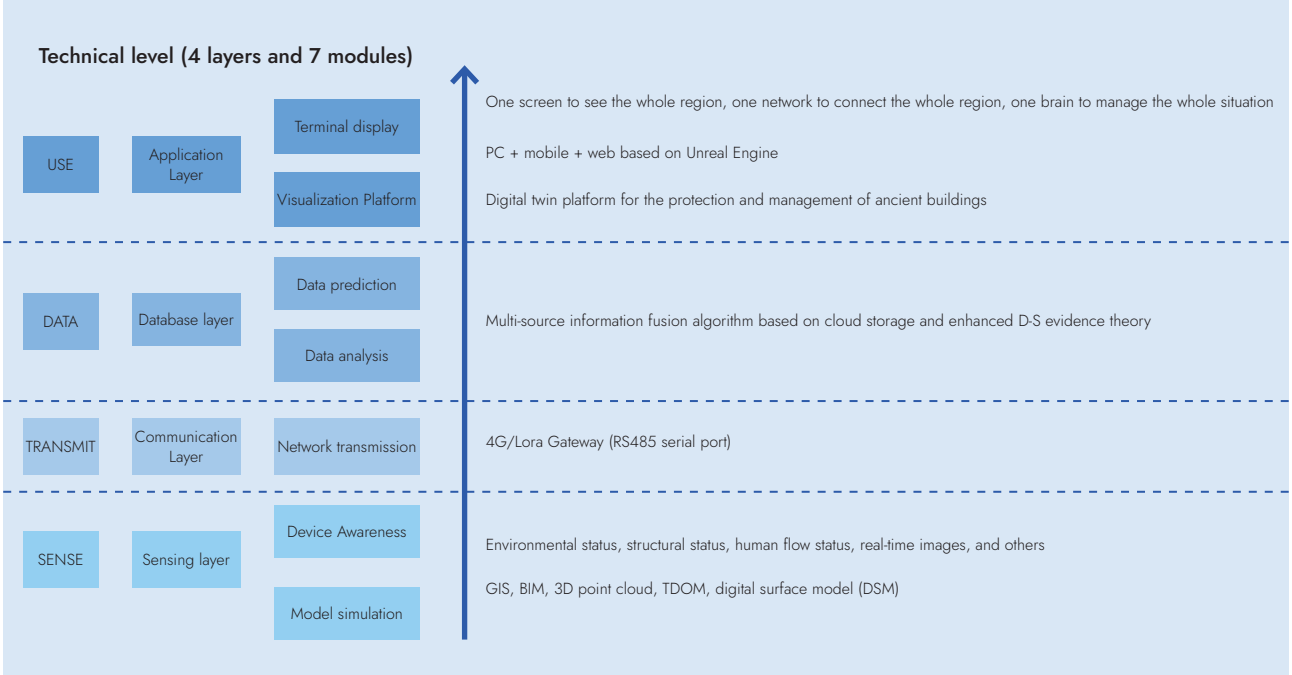


Figure 2-7: monitoring system architecture
Source: Shi, 2023

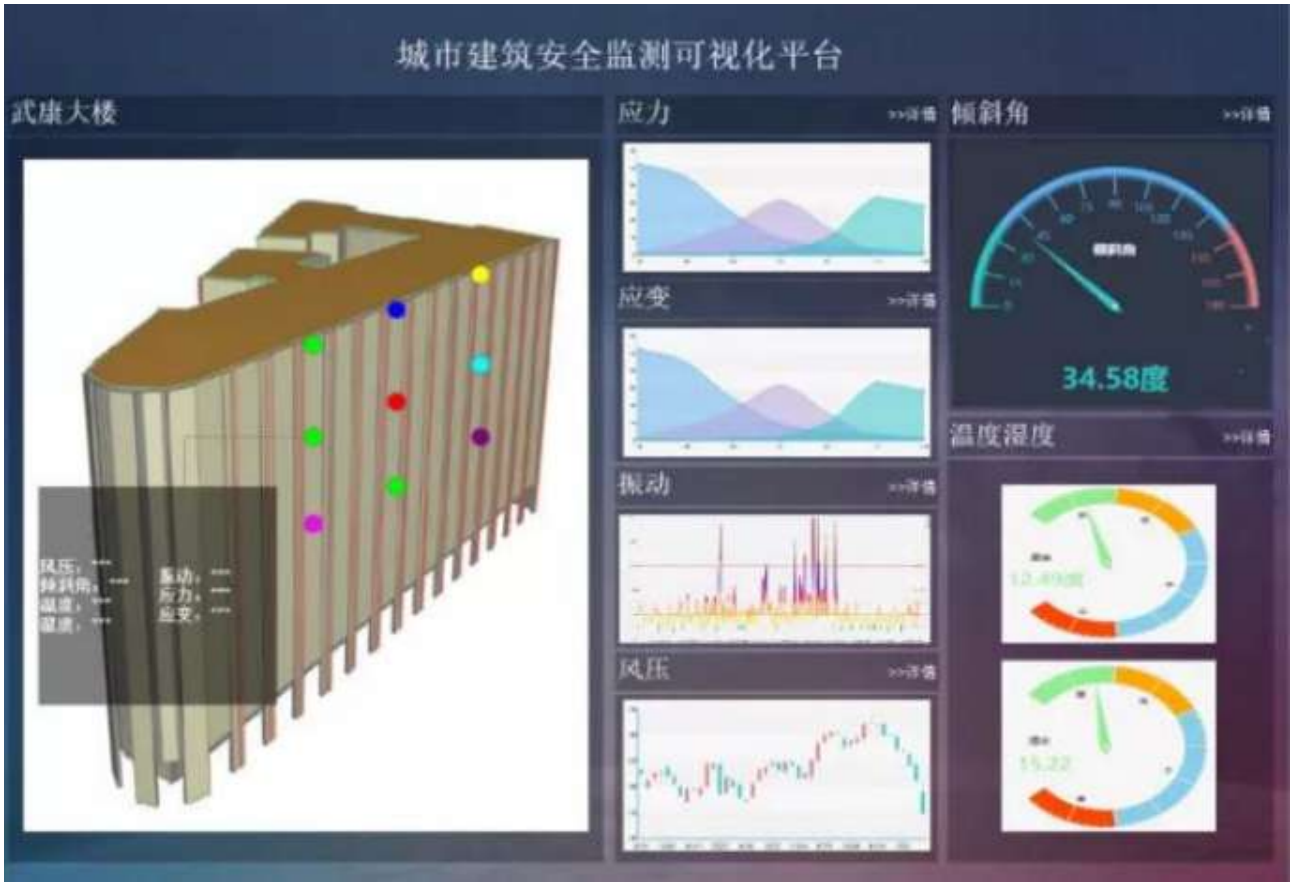


Figure 2-8: visualization system of urban building monitoring for Wukang Building
Source: Shanghai Xuhui, 2021

the visualization level, the data such as stress, strain, vibration, wind pressure, tilt angle, temperature, and humidity of the buildings are displayed on a screen. This digital management system can be connected to the Integrated digital urban management system and enables relevant local authorities to timely respond to any deteriorating conditions of historical buildings (Figure 2-7).

(2) How it works – historic protection system maintaining historic buildings and sustaining urban civilization (SDG11.4 protect the world's cultural and natural heritage)

In Shanghai, there have been 3126 historic buildings in the city that have been digitally compiled. This is the foundation of the digitalized preservation. At present, some of the buildings have been protected by further measures. Over 2000 smart sensors have been installed on 87 historic buildings in Hongkou District. The devices are finally connected to the city-level digital historic building protection system so that problems such as abnormal vibrations can be detected and sent to local authorities for processing or reaction. A digital twin of the landmark Wukang Building (Normandie Apartments) is constructed and a smart management system is applied for 7-24 monitoring and preservation (Figure 2-8).

2.1.7 Urban energy management

A smart grid is an automated electricity supply network that connects electricity suppliers, transmission networks and end users and monitors the real-time mutual flow of electricity and information from the power plants to user terminals. It is self-resilient to maintain security, self-optimizing to achieve maximum efficiency of assets and equipment, and self-adaptive to coordinate electricity generation and storage. Thus the smart grid is significant in increasing the efficiency of energy (from generation to end-use stages), expanding the usage of renewable energy, and making cities more sustainable (SDG7 Affordable and clean energy; SDG11 Sustainable cities and communities).

(1) Technical concept – smart grid

A smart grid consists of several sets of technology, such as highly integrated communication systems based on open architecture, sensing and metering technologies, and advanced decision-making support systems. The digital technologies applied in the technologies of smart gird are summarized in Figure 2-9 .

In addition to common technologies such as sensors and IoT, communication networks, data analysis, data processing, data integration and management, smart gird also employs Advanced Metering Infrastructure (AMI), Grid Automation and Control Systems, Virtual Power Plants (VPPs) and cybersecurity. AMI systems involve smart meters that can record electricity consumption in real-time and communicate that information back to the utility company. This allows for more accurate billing and helps consumers monitor and control their energy usage. VPPs are networks of Distributed Energy Resources (DERs) that are managed as a single entity. They use digital technologies to coordinate the output of various energy sources and respond to changes in demand or supply. With the increased use of digital technologies, smart grids are also more susceptible to cyber threats. Therefore, robust cybersecurity measures are essential to protect the grid from attacks and ensure the integrity of the data being transmitted.

(2) How it works – a smart grid increasing energy efficiency and expanding renewable energy usage (SDG7 Affordable and clean energy; SDG11 Sustainable cities and

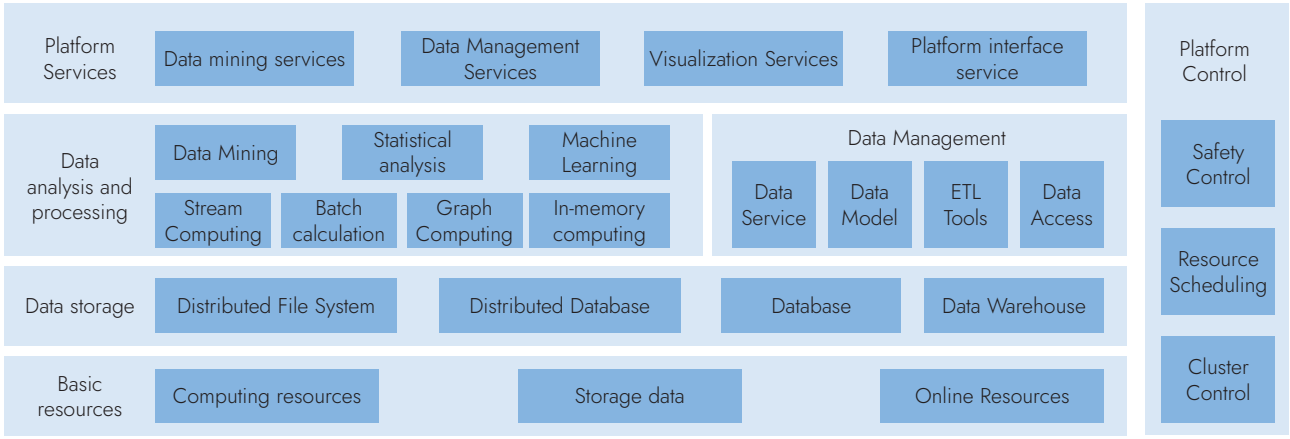


Figure 2-9: Architecture digital technologies employed by smart grid
Source: Zhu, Ma and Liu, 2024

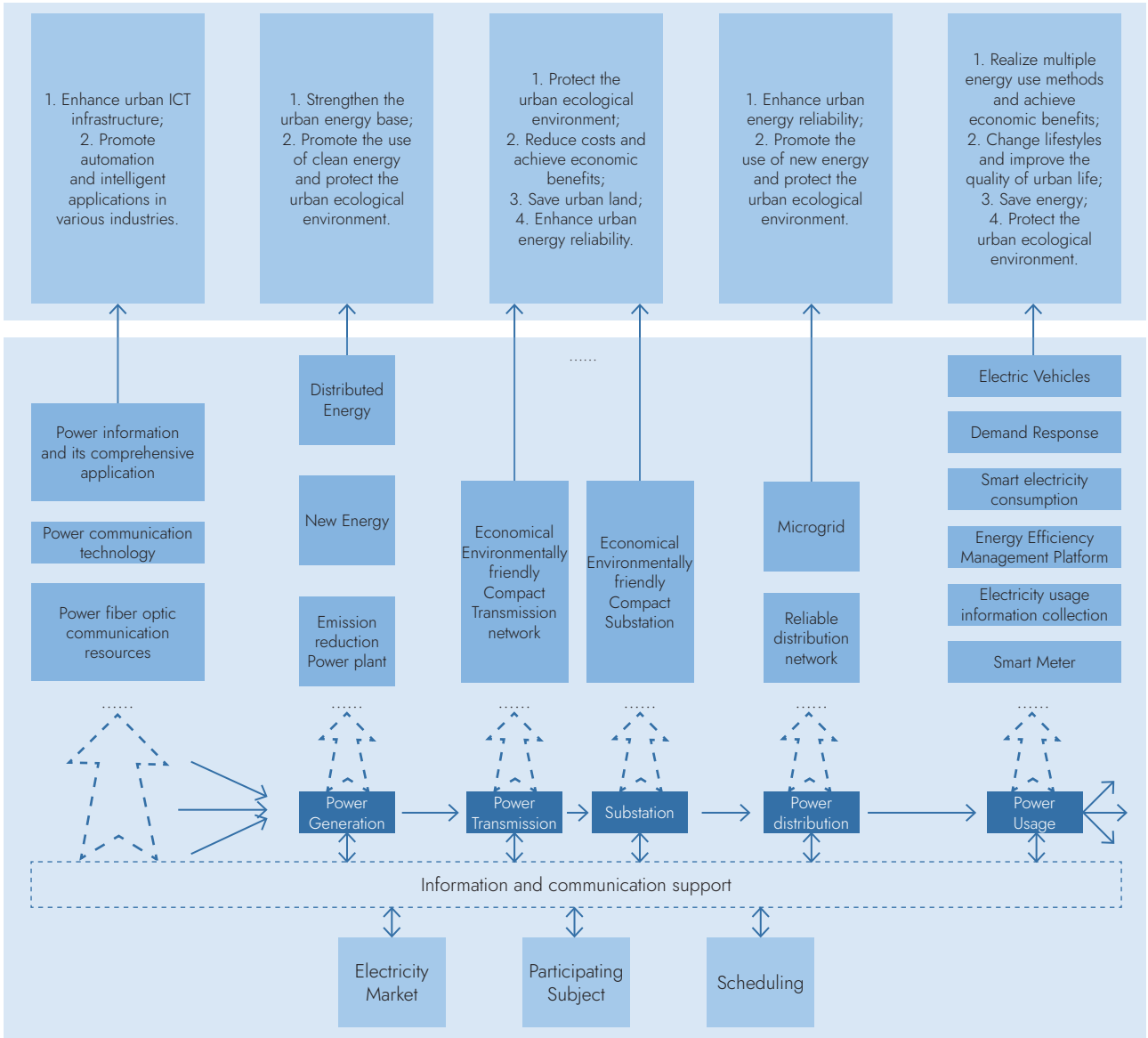


Figure 2-10: How smart grids contribute to urban sustainability
Source: Gao et al., 2015

communities)

A smart grid has an effect on achieving SDGs in a variety of ways. At the electricity generation stage, it integrates renewable energy sources into the grid and reduces the reliance on fossil fuels and thus improves the percentage of renewable energy use. During transmission, it contributes to saving urban land by optimizing the use of space for energy infrastructure, such as compact substations and integrated power and communication facilities. At the distribution stage, a smart grid can save energy by reducing urban energy consumption through optimized energy distribution and demand response systems. It also makes efficient use of communication resources for power information and demand response, enhancing the overall efficiency of the grid. Finally, smart grids enable the use of technologies like electric vehicles, distributed generation, microgrids, and energy management platforms, which also contribute to efficient energy use and environmental protection. Moreover, smart grids offer economic advantages by reducing costs and promoting the use of clean energy sources, which can lower the overall energy expenses and therefore the energy can be more affordable, especially for vulnerable groups (Figure 2-10).

2.1.8 Digital government services

Digital government services, similar with the concept "e-government", is to offer online government services through digital technologies, which is close to "one-stop government services through one network.

Different from the unified governance through one network focusing on integrated management and efficient coordination by multiple government departments, one-stop government services through one network emphasizes and increases ease and convenience in accessing government services for citizens and businesses. It simplifies the service processes by reducing the need to visit multiple government departments in person or switch between different online systems and thus considerably increases the efficiency of government service delivery and reduces bureaucracy, which is environmental friendly (SDG 11 Sustainable cities and communities) and beneficial in making local authorities more effective, accountable and transparent (SDG16 Peace, justice and strong institutions).

(1) Technical concept - one-stop government services through one network

The key technologies employed by one-stop government services through one network can be concluded from the service delivery process. In addition to data integration, data sharing and exchange, interface design and development, the one-stop services also involve remote identity verification, intelligent guidance or instruction (voice recognition and natural language processing), quotation of electronic certificates and electronic signatures (image recognition), can be seen in Figure 2-11.

(2) How it works – E-government services through One Network making services more convenient and making institutions stronger (SDG 11: Sustainable Cities and Communities; SDG16: Peace, Justice, and Strong Institutions)

At present there have been a number of cities in China developing and applying one-stop government services through one network. For megacities, for example, in Shanghai, the Network has been established for years and turned to be comprehensive. There have been 3,688 services offered online through the Network, serving more than 81.46 million registered individual users and more than 3.39 million enterprises by October 2023. The

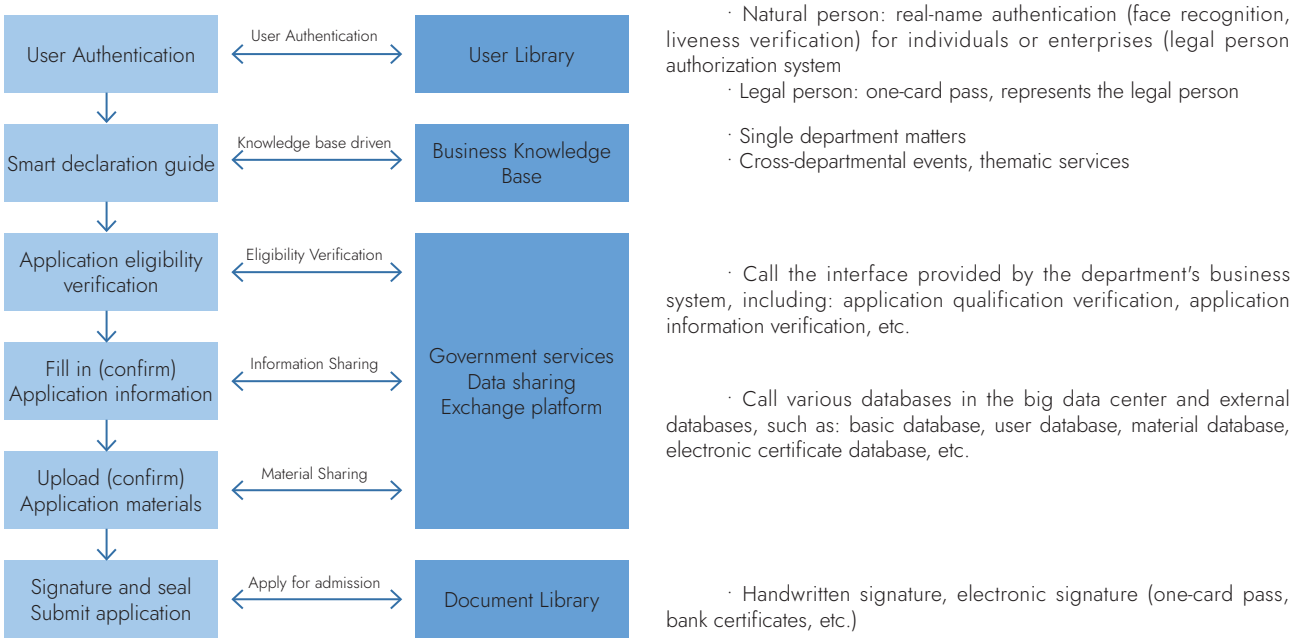


Figure 2-11: online service delivery process of one-stop government services through one network
Source: Zhu and Wang, 2020

total number of service access has reached 400 million. Taking the example of corporate tax payment for enterprises, the processes of declaration and payment of personal income tax, social insurance fees, and housing provident fund have been streamlined. In the past enterprises were required to submit 11 paper materials, go to 3 departments and operate on 3 systems, yet currently the entire process can be done online with one single portal with 74 data items have been pre-filled.

In addition, other technologies also promote the efficiency of digital urban governance in the context of electronic government services. For example, considering the characteristics of block-chain are decentralized and tamper-proof, the databases of various government departments can be shared as block-chain nodes while guaranteeing the shared data still keep their ownership. It ensures that the rights and responsibilities for data quality and security are clearly defined at each node, thereby promoting the accuracy and efficiency of data used by various departments for government services and enhancing the transparency of government services. Digital government service humans, which are developed by foundation models and vertical large models for government services, can provide the public with service consultation, certificate making, and chart pre-filling. Currently, the digital government service humans in Pudong New Area Government Service Center in Shanghai have launched five services with over 1300 cases handled by June 2024, which improves the satisfaction of government services for the public and the efficiency of government services.

Practical case – E-government in Estonia

The Estonian e-government system has transformed the country into a global leader in digital administration, offering a multitude of benefits to its users. Citizens and residents enjoy a wide array of online public services, including digital identification, digital signatures, electronic tax filing, online medical prescriptions, and internet voting. These services not only provide convenience but also result in significant savings of time

and money. The digital identification system is foundational, being compulsory for all citizens and used extensively for authentication and digital transactions. For instance, filing an online tax declaration takes an average of just five minutes, while the process of selling a car can be completed remotely in less than 15 minutes. High levels of trust in these online services reflect their reliability and the strategic role they play in daily operations.

The backbone of Estonia's e-government is its innovative use of technology. At the core is the digital identification system, which allows citizens to securely access various services online. The X-Road, a secure internet-based data exchange layer, enables different information systems to communicate and exchange data. This technology supports the development of new e-services by leveraging data already stored in state databases. The system's security is underpinned by a legal framework focused on data protection, privacy, and security. Additional technologies such as block-chain have been adopted for secure identity management and transaction infrastructure. These technological advancements have made Estonia's e-government not only a powerhouse but also a model for other nations aspiring to enhance their digital public services.

2.1.9 Health care services

Digital technologies such as smart wearables, Internet of things, remote monitoring, artificial intelligence, big data analytics, platforms, tools enabling data exchange and storage and tools enabling remote data capture and the exchange of data and sharing of relevant information across the health ecosystem creating a continuum of care have proven potential to enhance the quality of medical services and health outcomes by improving medical diagnosis, data-based treatment decisions, digital therapeutics, clinical trials, self-management of care and person-centred care, especially in remote areas (SDG3 Good health and wellbeing). To be specific, the technologies can be applied to electronic health records, electronic medical records, remote medical consultation systems, two-way referral mechanisms, family health monitoring and medical service by visual telephone. The fifth-generation mobile network (5G) as a foundation of a variety of ICT technologies makes a great contribution to digital health, for example by supporting remote surgeries.

(1) Technical concept – 5G

5G offers significant improvements over its predecessors (4G, 3G, 2G) in several key areas, including higher speeds, lower latency, increased connectivity and improved reliability. 5G provides much faster data transmission rates and significantly lower latency (the time it takes for a signal to travel from sender to receiver) than 4G, which is crucial for remote surgery that requires real-time responses. It also supports higher density and higher reliability of connected devices, enabling more devices to be connected to the network simultaneously without loss of speed or reliability (Figure 2-12).

Thus the 5G provides high-speed, low-latency network connections that allow doctors to accurately control surgical robots from a distance to perform surgeries. The high data transmission rate and large bandwidth of 5G networks ensure the real-time, non-lagging transmission of medical images, which is crucial for real-time high-definition audio and video transmission in remote surgery. The low latency of 5G networks ensures that the doctor's instructions can be transmitted to the remote surgical robot in real-time so that precise control actions can be made.

(2) How it works – 5G enabling remote surgery (SDG3 Good health and wellbeing)

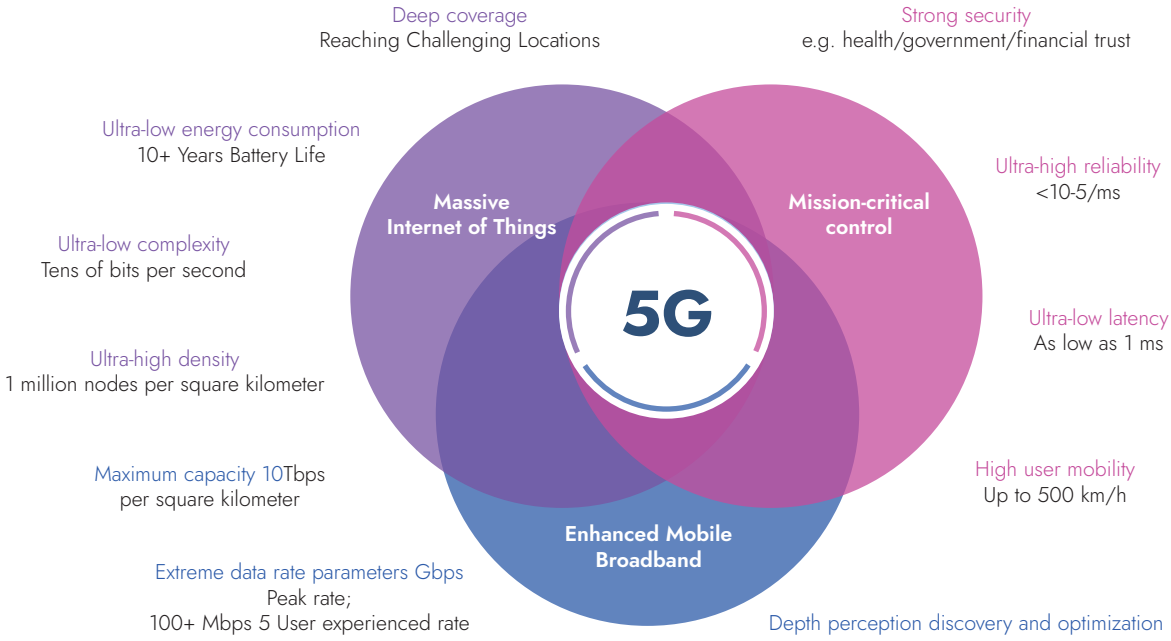


Figure 2-12: Features of 5G
Source: Schafer, 2019, edited by author.

A number of remote surgeries have been successfully performed with 5G network. For example, a remote surgery of a lung tumour was conducted on a patient in Kashgar in Xinjiang Uygur Autonomous Region by medical experts in Shanghai in July 2024, between which there are about 5000 kilo-meters. Another example is a surgery of prostatectomy conducted on a patient in Haikou in Hainan province by doctors in Beijing in July 2023. The surgery completed 3000 kilo-meters away demonstrated the reliability of 5G in cross-sea communication.

2.1.10 Quality education and study

The accessibility of educational resources and personalised learning materials can be increased by digital technologies with lower costs so that inclusive and equitable quality education becomes easier to achieve (SDG4 Quality education). Cloud computing serving as a foundation technology plays a significant role in building up an online intelligent education platform and thus promoting education equity by providing on-demand cloud services. It can also cater to the personalized study needs of users.

(1) Technical concept – cloud computing

Cloud computing is the delivery of computing service resources, including servers, databases, networking, and intelligence over the Internet. It enables a connected, data-driven, and intelligent learning environment that can be accessed across various settings and by different users.

There are usually several layers in the architecture of an intelligent learning environment based on cloud computing. The basic layer consists of various technological tools and equipment such as cameras, digital teaching materials, smart electronic whiteboards, intelligent projection devices, laptops, tablets and smartphones. The data layer includes databases that store various types of data collected from the learning environment. The service layer provides

services such as feedback and management and includes personalized recommendations, resources and service clouds. The top layer for application includes different venues for learning such as classrooms and other spaces equipped with AI and VR technologies.

(2) How it works – cloud computing promoting education equity and meeting personalised learning needs (SDG4 Quality education)

The National Smart Education Platform for Primary and Secondary Schools in China serves as a critical tool for enhancing educational equity and quality through digital means. Based on a variety of digital technologies, it provides a vast array of high-quality resources to students regardless of their geographical locations, thereby reducing the urban-rural divide and promoting equity in education. The platform's personalized learning services cater to diverse student needs, fostering autonomous learning and improving engagement and efficiency.

It also supports the development of digital literacy and encourages educational innovation, making a good contribution to creating a modern digital landscape. The platform's data-driven approach allows for continuous improvement of its services, making it a dynamic and responsive educational tool that aligns with the strategic goals of high-quality educational development in China.

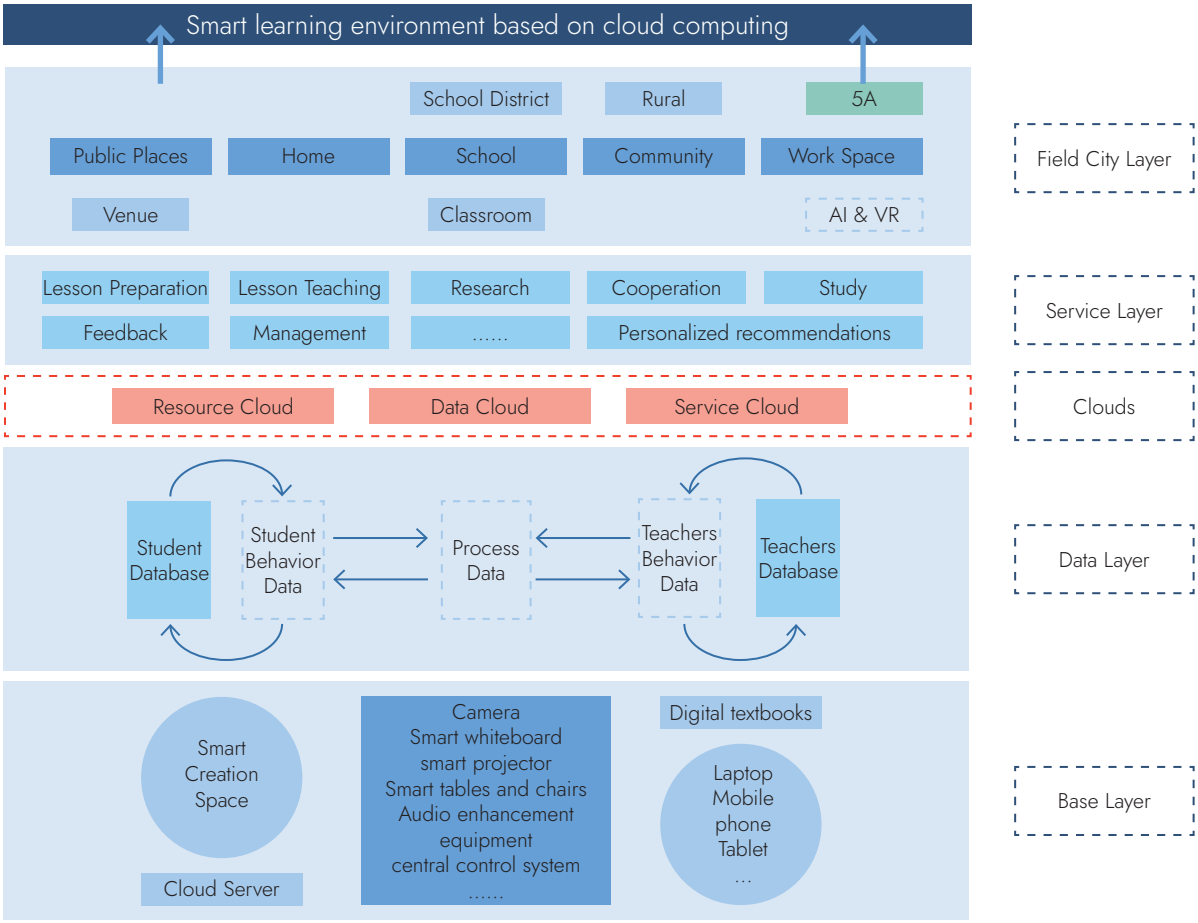


Figure 2-13: Architecture of an intelligent learning environment based on cloud computing
Source: Yang, Zeng and Gao, 2018.

2.2 Summary

2.2.1 Technical panorama

There are a number of digital technologies applied for urban governance scenarios making cities and communities more sustainable. This chapter collects the main digital technologies and systems (unified governance through one network, ITS, EWS, pollution monitoring and management system, waste management system, historic building protection system, Smart Grid, one-stop government services through one network, 5G, Cloud computing) that are often employed by ten urban governance scenarios (Digital urban management, Urban transport and transportation, Environmental resilience maintenance, Pollution monitoring and management, Waste classification and circulation, Historic building protection, Urban energy management, Digital government services, Health care services, Quality education and study) and demonstrate how they improve the governance efficiency and contribute to achieving SDGs.

Table 1: Urban governance scenarios, techs applied and how they contribute to SDGs

Urban governance scenario	Digital technology or system	How it contributes to SDGs	Specific targeted SDG
Digital urban management	Unified governance through one network	Enhancing the collaboration among government departments and promoting urban governance efficiency	SDG11 Sustainable Cities and Communities; SDG16 Peace, Justice, and Strong Institutions
Urban transport and transportation	Intelligent Transport System (ITS)	Optimizing traffic flows, increasing transportation efficiency, reducing fuel consumption and carbon emissions	SDG11.2 Affordable and sustainable transport systems
Environmental resilience maintenance	Early Warning System (EWS)	Monitoring environmental situations in real-time, planning evacuation routes, identifying shelter space, advising on emergency responses	SDG11.5 reduce the adverse effects of natural disasters
Pollution monitoring and management	Pollution monitoring and management system	Increasing pollution management efficiency, mitigating or avoiding pollution impacts	SDG11.6 reduce the environmental impact of cities
Waste classification and circulation	Waste management system	Reducing the waste amount and improving recycling efficiency	SDG11.6 reduce the environmental impact of cities
Historic building protection	Historic building protection system	Constructing digital models, detecting damages and taking effective measures	SDG11.4 protect the world's cultural and natural heritage

Urban governance scenario	Digital technology or system	How it contributes to SDGs	Specific targeted SDG
Urban energy management	Smart grid	Increasing energy efficiency (from generation to end-use stages), expanding the usage of renewable energy	SDG7 Affordable and clean energy; SDG11 Sustainable Cities and Communities
Unified digital government services	One-stop government services through one network	Simplifying government service procedures, increasing service delivery efficiency, reducing bureaucracy	SDG11 Sustainable Cities and Communities; SDG16 Peace, Justice, and Strong Institutions
Health care services	5G	Supporting real-time network communication, enabling remote health care	SDG11.2 Affordable and sustainable transport systems
Quality education and study	Cloud computing	Providing cloud services, building up intelligent education platforms, promoting education equity, meeting personalised study needs	SDG11.5 reduce the adverse effects of natural disasters

Since most scenarios involve data collection, integration and processing, analysis, and application, this chapter summarizes the main technologies applied in each scenario according to the different stages of data processing (Table 2).

Due to the abundance of technical concepts and the inconsistency in granularity, the digital technologies involved in this chapter are categorized by the main technological classifications in the ICT (Information and Communications Technology) field.

The technologies mentioned in each scenario of urban governance in this chapter are divided into five categories: big data, artificial intelligence, digital security, foundational technology and professional technology. Specifically, big data technologies can be classified according to the main process of data processing (inner loop), or can be classified according to the main technologies employed (outer loop). Artificial intelligence technology can be classified according to the purpose of the algorithms (inner loop), or can be classified according to the categories of large models (outer loop). Digital security can be classified according to the main processes of digitalization (inner loop), or can be classified according to commonly used digital security technologies (outer loop). Foundational technologies are classified according to the technical concepts involved in this chapter (inner loop), or can be classified according to the main equipment and links of communication transmission (outer loop). The technologies involved in specific scenarios in this section are categorized as professional technologies (inner loop only).

2.2.2 Innovations and prospects

In addition to the digital technologies above, there are emerging cutting-edge innovations such as 6G and quantum computing paving

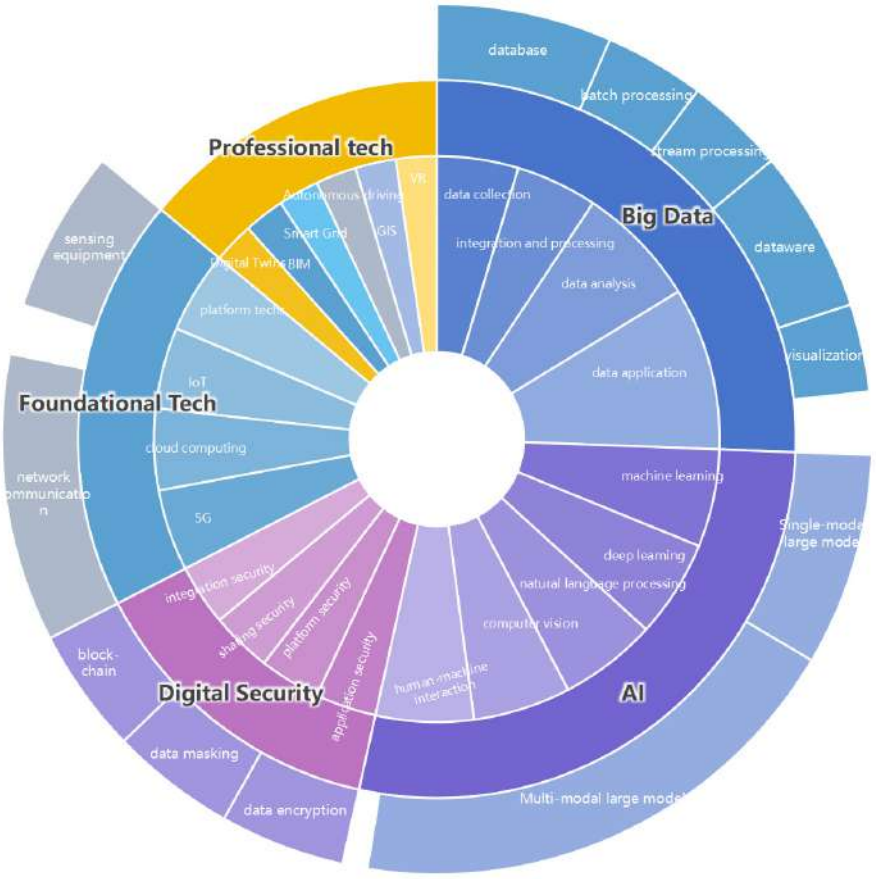


Figure 2-14: General categories of the digital technologies involved in this chapter
Source: created by author.

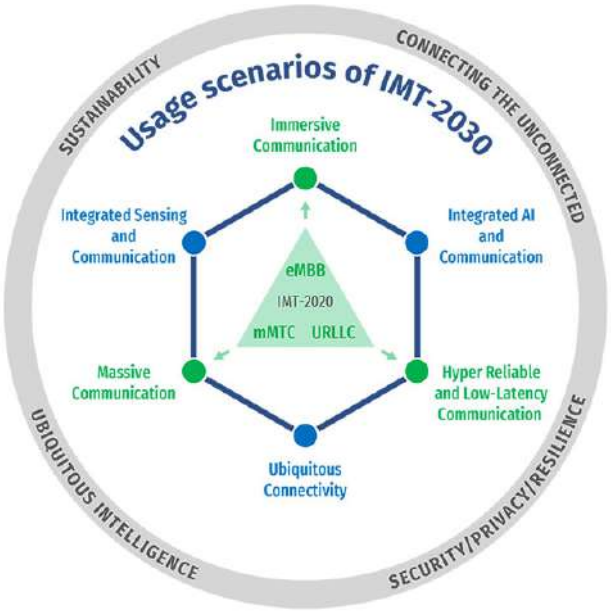


Figure 2-15: 6G diagram approved by ITU
Source: ITU-APT Foundation of India, 2023

the way for making urban governance more efficient and sustainable.

(1) 6G

At the 44th meeting of the International Telecommunication Union Radio-communication Sector 5D Working Group (ITU-R WP5D), ITU finalised the 6G Vision Framework which is contained in the new draft Recommendation ITU-R M.IMT. FRAMEWORK FOR 2030 AND BEYOND. The standard includes six key usage scenarios of 6G, including Immersive Communication, Integrated AI and Communication, Hyper Reliable and Low-latency Communication, Ubiquitous Connectivity, Massive Communication, Integrated Sensing and Communication. Under the new standard, 6G

is expected to continue to build an inclusive information society and support SDGs by bridging digital divides and enhancing ubiquitous connectivity.

(2) Quantum computing

Quantum computing represents a new approach to processing information, harnessing the principles of quantum mechanics to manipulate quantum bits (qubits), for computational tasks. Different from traditional computing, quantum computing has the potential to break through the limitations of classical computational power. The feature of qubits is their ability to simultaneously hold and manipulate multiple states, a unique capability that arises from the quantum mechanical effect of superposition, which enables quantum computers to perform complex calculations at speeds unattainable by classical machines.

Quantum computing has the potential to bring benefits to a number of scenarios in different industries, especially in pharmaceuticals, chemicals, automotive and finance, which have a good effect on SDGs such as Good Health and Well-being.

2.2.3 Further thinking

(1) Digital urban governance with full domain and process coverage

Unified governance through one network achieves digital management of a variety of urban governance scenarios for urban governors by integrating and analysing public data from different local government departments. One-stop government services through one network offers a wide range of e-government services for urban residents by simplifying service procedures. In general, digital urban governance has been relatively comprehensive and going to be refined, meeting the demands of subtle scenarios.

In May 2024, the National Development and Reform Commission, the National Data Administration, the Ministry of Finance, and the Ministry of Natural Resources jointly issued "Guidance on Deepening the Development of Smart Cities and Promoting the Digital Transformation of Cities". It aims to promote urban digital transformation in all fields, enhance urban digital transformation support in all-round, and optimize the urban digital transformation ecosystem in the whole process. In the future, the completeness, systematicity and synergy of digital city governance will be further improved to meet the people's growing needs for a better life and promote the realization of sustainable development goals.

(2) Local background based technology utilization

Based on the cases of Shanghai and Ningxia implementing digital urban governance in this chapter, it can be concluded that the adoption of digital technology should be based on local context. The focus of the application of digital governance technologies should depend on the extent of urban digital transformation, economic development level, and urban population.

For mega-cities that already have a certain foundation for digitalization, such as Shanghai, the focus of technology application should be the improvement in the comprehensiveness of digital governance as well as e-government services and optimization in usage or service experiences through supervision and assessment mechanisms. For areas with small economic volumes, especially monocentric regions such as Ningxia, the financial resources available for digital governance are usually relatively limited, therefore it is prior to apply

digital techs for simple and high-demanded scenarios so as to be cost-effective and becoming a model to motivate or lead the other places.

(3) Inclusive and digital urban governance for bridging the digital divide

This chapter presents a number of digital technologies and their positive effects, however, the adoption of digital technologies should not pursue the advance of technologies blindly. The key of the technology adoption is to be inclusive and avoid the digital divide. For example, despite the widely used and good cases, early warning systems (EWS) may be too advanced and not be the best solution for the groups who do not know how to use smartphones or those who are less accessible to the Internet.

It is good to see that EWS are often implemented with manual labour and equipment. At the same time warning information is sent by EWS through networks and broadcasting, and primary level monitors working at the country level carry out manual notification through a traditional method - playing a gong to inform everyone. Therefore, the application of digital technologies should avoid or mitigate the information gap and thus make sure to leave no one behind.

Table 2: Specific technologies and equipment employed in different data processing stages in each scenario

Urban governance scenario	Digital technology or system	Data processing stages
		Data collection
Digital urban management	Unified governance through one network	Sensing devices of transport, environment, pollutants, and waste management; information systems of local government departments
Urban transport and transportation	Intelligent Transport System (ITS)	Traffic cameras, sensors embedded in roads, gps devices
Environmental resilience maintenance	Early Warning System (EWS)	Satellite imagery, weather monitoring devices or facilities (eg. Automatic rain level stations, Global Navigation Satellite System (GNSS), seismometers, tilt meters)
Pollution monitoring and management	Pollution monitoring and management system	Monitoring equipment for water, air and noise
Waste classification and circulation	Waste management system	Gps positioning cards, smart wearable devices, in-vehicle intelligent terminals

Data processing stages			Others
Integration and processing	Analysis	Applications	
Stream processing (for real-time demands, eg. Monitoring systems, social media feeds), batch processing (for large-scale data)	Algorithms and models to interpret the data, identify patterns, and generate insights	Integrated and efficient management based on coordination among multiple government departments	
Iot transmission	Machine learning algorithms and big data analytics	Adjusting traffic light timings, rerouting traffic, providing real-time traffic updates, reducing fuel consumption and carbon emissions, monitoring the condition of roads and infrastructure, alerting maintenance crews to necessary repairs	5G
Satellite communication, optical fibre communication	Data mining	Establishing a set of warning indicators and warning thresholds, assessing and planning evacuation routes, identifying temporary shelter places, offering advice on emergency response	Cloud computing
Iot transmission	Prediction model	Environment monitoring, environmental quality assessment, pollution prediction and governance decision-making	
Mobile networks, internet, satellite communication networks	Support Vector Machine (SVM) and Convolutional Neural Networks (CNN)	Advising on sorting wastes into different bins, warning on incorrect classifications, tracking compliance with waste management regulations, generating reports for a regulatory government department	

Urban governance scenario	Digital technology or system	Data processing stages
		Data collection
Historic building protection	Historic building protection system	Inclinator, precision level, laser range finder and crack-meter, uav tilt photogrammetry
Urban energy management	Smart grid	Sensing and metering technologies, eg. Advanced Metering Infrastructure (AMI)
Unified digital government services	One-stop government services through one network	Information systems of local government departments
Health care services	5G	Smart wearables
Quality education and study	Cloud computing	Cameras, digital teaching materials, smart electronic whiteboards, intelligent projection devices, laptops, tablets, audio enhancement devices and smartphones

Data processing stages			Others
Integration and processing	Analysis	Applications	
Iot transmission (lora gateway, lora protocols); data cleaning, compression	Machine learning algorithms	Visualization, detecting damages, taking effective measures such as making an alert	Digital twins, bim
Highly integrated communication system based on open architecture	Advanced decision-making support system	Maintaining the security, achieving maximum efficiency of equipment, coordinating electricity generation and storage	Data security; grid automation and control systems; Virtual Power Plants (VPPs)
Data sharing and exchange, interface design and development	Remote identity verification, intelligent guidance or instruction (voice recognition and natural language processing), quotation of electronic certificates and electronic signatures (image recognition)	Reducing the need to visit multiple government departments in person or use different online systems, increasing ease and convenience in accessing government services for citizens and businesses	Block-chain
Iot transmission, tools enabling data exchange and storage	Artificial intelligence, big data analytics	Improving medical diagnosis, data-based treatment decisions, digital therapeutics, clinical trials, self-management of care and person-centered care	5G
Databases	Image recognition, natural language processing	Providing feedback and management, including personalized recommendations, resources in the cloud, equipping classrooms with ai and vr technologies	Cloud computing

03

Roadmap of Digital Urban Governance

Chapter 3 Roadmap of Digital Urban Governance

Urban governance is related to the security and stability, comprehensive strength and operational efficiency of the city, while it is also the pivot of the national governance system, depending on the development efficiency and pace of reform of the whole country. At the same time, the development of a city's digital urban governance is inextricably linked to the city's digital infrastructure support conditions. In general, according to the development of different regions, the construction of digital urban governance is mainly divided into three stages:

The first stage is the informatization stage, while the main goal is to build its informatization system for each business department involved in urban governance, moving from traditional paper-based office to paperless and informatization. At the same time, in order to support the overall goal of government informatization, the government network and government cloud need to be built in a complementary manner for the municipalities, so that they can be realized for the individual business departments and solve the needs and difficulties in the departmental business applications. Based on the cloud and network infrastructure, the sharing and connection of multiple people within the department can be realized.

The second stage is the digitalization stage. Its main goal is to build a city-level big data platform based on big data technology and general artificial intelligence technology, to realize the unified convergence and management of government data, the interconnection of data between different businesses, and to build an intelligent brain for each vertical field on this basis. At this stage, the cross-departmental data is shared to realize "fewer people running and more data operating" and use these data to make business-oriented assisted decision-making and intelligent analysis to serve the business of individual departments, such as the traffic brain and the environmental brain.

The third stage is the intelligentization stage. Its main goal is to realize a "cross-system, all-connected, all-intelligent" five-network fusion system for digital urban governance. At this stage, based on the existing cloud and network digital technology infrastructure and big data platform, the application fields of core technologies are more extensive. Cities have begun to build a new generation of infrastructure for urban management - one-network unified management, structured on top of the existing vertical business systems of various departments, to fully open up the urban management, emergency response, comprehensive governance and other municipal governance networks (and systems), which upwardly can provide leaders of the municipal government with auxiliary decision-making, and downwardly can be connected to the community and the streets to support primary level governance. Simultaneously build a one-network system for government

services, centralize government services for residents and enterprises into one office hall, or integrate them into one APP, realizing one-stop or no-meeting processing. Eventually, to achieve the goal of "multi-network integration and interconnection", the "government office network" will drive the "urban governance network" and "government services network". The goal of "multi-network integration and interconnection" is to drive the "one-network management of urban governance" and "one-network handling of government services" through the "one-network collaboration of government offices", thus realizing the co-construction, co-governance and sharing of urban governance between the government and the residents, as well as the seamless integration of governance and services.

In addition, after completing the above three key phases of urban digital governance construction, how to better operate and continue to provide intelligent services is a goal that is being explored globally. At present, China's urban digital governance has been moving towards the third stage, with the deep development of digital government, the construction of city-level platforms has been gradually improved, and the policy guidance and business needs are gradually focusing on scenario innovation and application practice. The State Council issued the "Guiding Opinions of the State Council on Strengthening the Building of a Digital Government", which points out that "the construction of digital government, with 'scenario' as the starting point, innovate the 'three integration and five cross' digital governance model". Circular of the Ministry of Science and Technology and six other departments on the issuance of the "Guiding Opinions on Accelerating Scenario Innovation to Promote High-Quality Economic Development with High-Level Application of Artificial Intelligence". The National Development and Reform Commission, the National Data Bureau and other ministries and commissions jointly issued the "Guiding Opinions on Deepening the Development of Smart Cities and Promoting the Digital Transformation of the Entire Urban Area", which also points out that "the next goal of digital urban governance will be to embark on the path of digital operation and service by promoting the innovation of the digitalization system, the innovation of the operation and maintenance model and the synergistic development of digitalization.

3.1 General objectives of digital urban governance

The ultimate goal of digital urban governance is for the government to better manage and serve residents and enterprises in the city. As a city manager and service provider, the government builds innovative scenarios and applications for urban management, primary level governance, social services, and other areas to support business operations, improve the ability of the digital government to supervise, and enhance the level of handling in urban governance.

Specifically, its key objectives are divided into the following five parts (Figure3-1):

(1) Security: from after-the-fact handel to prevention.

Safety is the bottom line of a city's development, and the governments of cities around the world have invested a high percentage of their financial resources in safety and stability. In the era of digitalization, the traditional after-the-fact handling has

been transformed into pre-prevention, which realizes early warning of all kinds of risks through technologies such as Internet of Things (IoT), big data, and artificial intelligence, so as to prevent issues from occurring in the first place.

(2) Decision-making: from experience-based to data-driven

Traditionally, government agencies have relied heavily on accumulated past experiences and case studies from other cities to inform their decision-making processes. However, past experiences are often subject to sampling bias and may not adequately reflect the rapid changes and advancements occurring in contemporary cities. In the digital age, data-driven decision-making supported by digital and intelligent tools has emerged as a more accurate and efficient approach to drive business development.

(3) Coordination: from siloed management to integrated collaboration

Government agencies are traditionally structured along departmental lines, with clear divisions based on specific functional areas such as emergency response, environmental protection, and transportation. As cities develop, there is a growing prevalence of cross-departmental and cross-functional events and operations. For instance, during major events, multiple agencies must coordinate their efforts. In the digital age, enabling governments to combine centralized and decentralized management approaches and facilitate cross-departmental coordination is a critical goal.

(4) Supervision: from manual reporting to systematic oversight

Traditionally, governments have relied on government officials from various departments to conduct inspections and patrols to perceive events occurring within cities. With the advancement of technology, cities have begun to establish channels for residents to proactively report incidents, such as the 12345 citizen hotline. However, these labor-intensive supervisory methods inevitably lead to oversight blind spots. In the digital era, systematic and intelligent supervision through IoT devices, data comparison, and algorithm analysis to automatically detect various events has become the prevailing trend.

(5) System: from government governance to collaborative governance

The development of digital urban governance ultimately hinges on the transformation of government systems. The traditional approach of single regulatory departments taking the lead is shifting towards a broader framework of co-construction, co-governance, and shared benefits among various departments.

Ultimately, through the achievement of the above five goals, the overall promotion of digital urban governance strategy, improve digital government regulatory capacity, improve urban governance "one thing" disposal level, and solve the sustainable development of various SDGs indicators.

3.2 Key stages of digital urban governance

To achieving the above five overall objectives of digital urban governance, the following three phased key aspects of digital urban governance have been summarized through research and summarizing the different construction approaches and development cycles of various cities (Figure 3-2):

The nascent stage of digital urban governance: this stage is applicable to cities that are just starting to explore digital

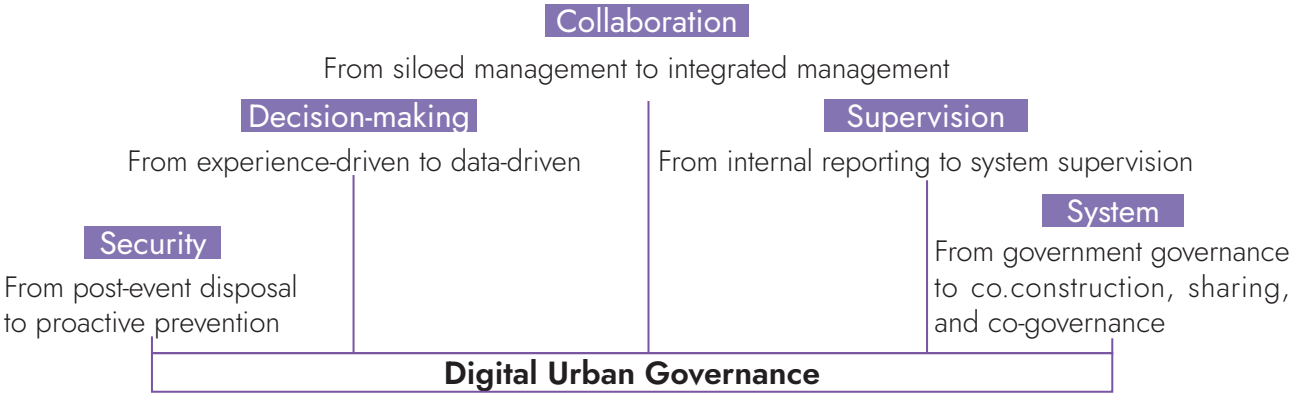


Figure3-1: Overall goal of digital urban governance
Source: Created by author

governance. It is usually led by key business departments and involves a one-way push with a primary focus on analysis and guidance, supplemented by business coordination. The core objective is to support decision-making by integrating data from various departments and systems, and to initiate the use of data analysis to assess urban conditions and address complex issues.

Development stage of digital urban governance: this stage applies to cities with a certain level of construction foundation. These cities have typically integrated some systems but have not yet standardized their business processes. The main objective is to coordinate and collaborate, with cross-departmental and cross-functional working mechanisms within the government taking shape. Efforts are made to integrate data and align mechanisms.

The mature stage of digital urban governance: this stage is suitable for rapidly developing cities. The main objective is command and control, aiming to achieve "one-stop acceptance, unified task assignment, integration of peacetime and wartime operations, and closed-loop feedback." The ultimate goal is to integrate business, technology, and data to enable efficient coordination across levels, regions, systems, departments, and businesses, achieving what is known as i.e., "three integration and five transitions".

3.3 Framework for the construction of digital urban governance - integrated system of five networks

After clarifying the overall goal and construction stage of digital urban governance, the next step is to build a five-network convergence business system for digital urban governance. In the process of digital urban governance, the main goal of the government is to manage and serve the enterprises and residents in the city, and "good governance, prosperity, and benefit for the people" is the top priority. Then the five-network system of "one-network perception, one-network sharing, one-network unified management, one-network collaboration, one-network office" for digital urban governance comes into being. One network sensing" refers to the real-time perception of the overall situation of the city, all kinds of Internet of Things devices to realize the interconnection and interoperability. "One network sharing" refers to the integration and sharing of data from multiple sources based on the urban digital base. "One network unified management" refers to one network unified management of urban governance, which is a new generation of infrastructure for urban management, structured on top of the existing vertical business systems of

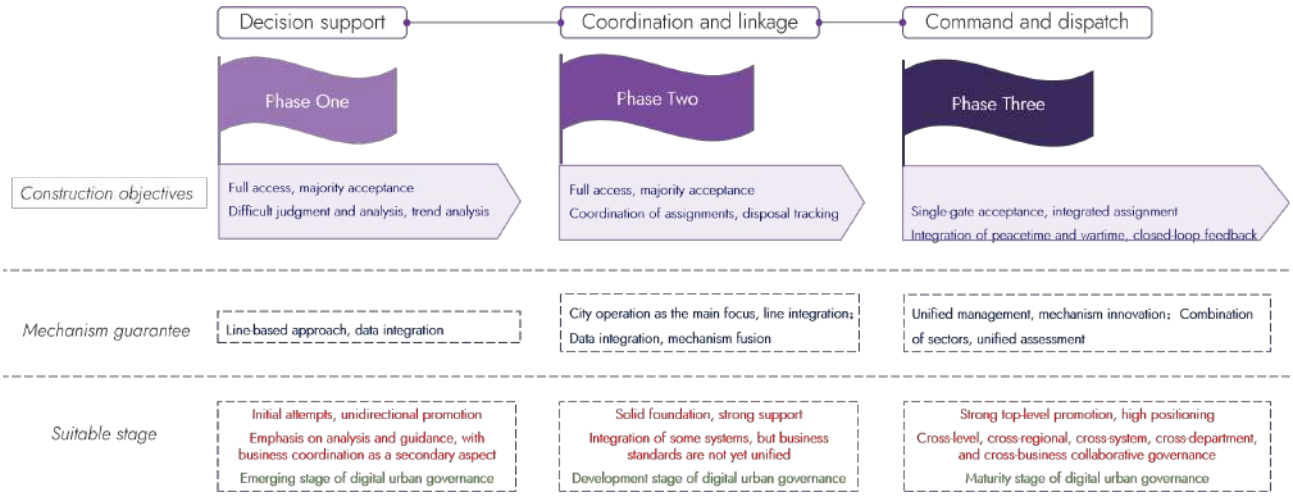


Figure3-2: Key phases of digital urban governance
Source: Created by author

various departments, and comprehensively connects urban management, emergency response, comprehensive governance and other governance networks (and systems) in the city. Upwardly, it can provide auxiliary decision-making for the leaders of the municipal government. Downwardly, it can connect communities and streets to support primary level governance. "One Network Collaboration" refers to the government's operation of one network collaboration, the unified integration of government office systems and applications, task-centered, to enhance the efficiency of collaboration. "One Network" refers to one network for government services, which integrates the entry points for government services, builds channels for residents to participate in urban governance, and improves people's livelihoods. Ultimately, the integration of the "Government Office Collaboration Network" will drive the convergence of the "City Governance Network" and the "Government Service Network" to achieve collaborative construction, governance, and sharing of urban governance between the government and residents, as well as seamless integration of governance and services (Figure3-3).

3.3.1 Unified perception of city status

Urban state one-network perception is like the "five senses" that perceive the state of the city, which is one of the sources of urban information generation. Urban state of a network perception is divided into active perception and passive perception, can be obtained in the process of urban operations in the flow of people, traffic flow, the environment, public safety, energy consumption and economic information in various fields, through the classification of various types of information collection, organization and definition of criteria, standardization of the use of resources to avoid waste. Currently, city perception faces four major challenges: incomplete perception content, single perception tool, shortage of overall coordination, and insufficient operation and management. In view of the above challenges, the city needs to build a city perception system to realize the four major objectives of "omni-perception, accurate control, well-layout and stable and effective".

Urban State One-Net Perception acts as the central nervous system for cities, perceiving

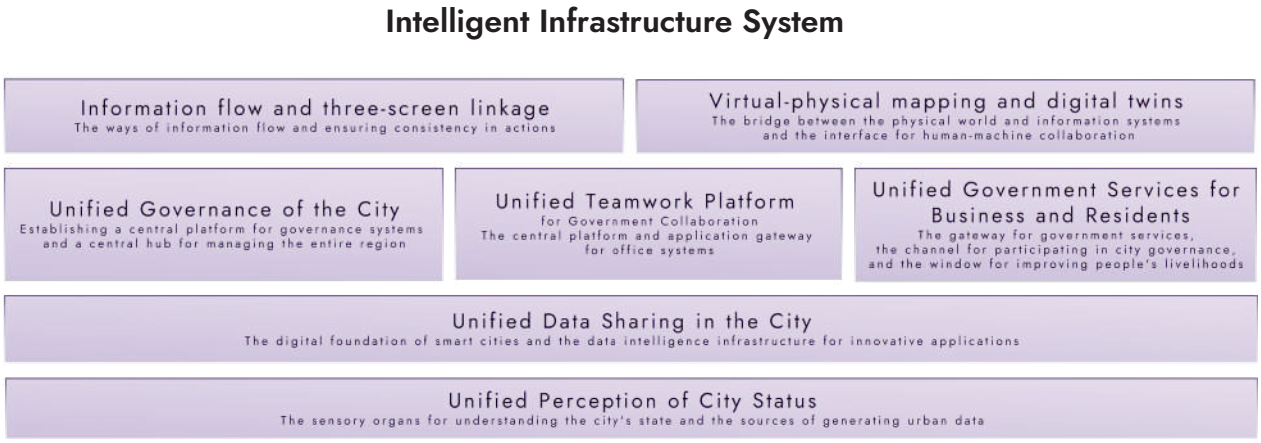


Figure3-3: Overall design of five-network integration
Source: Created by author

urban conditions through a vast network of sensors, controlling these sensors, and providing data services to various applications.

The perception system, akin to a city's five senses, connects downward to various perception entities, including sensing devices and groups participating in perception. Through vision (images, videos, etc.), hearing (audio, decibels, etc.), smell (gas types and concentrations, etc.), taste (solid chemical substance concentrations, etc.), and touch (deformation, pressure, etc.), it perceives aspects such as pedestrian flow, traffic flow, environment, public safety, energy consumption, and economy.

Serving as the central nervous system, the perception system, continuously monitors the status of all connected sensors and participants. It can remotely control devices and issue commands to citizen participants, while providing a unified platform for managing the entire system.

The perception system acts as a data hub, collecting and processing sensory information. It then provides data services and device management interfaces to various applications. This allows government agencies and other stakeholders to access real-time data and control connected devices without managing the underlying infrastructure.

First, cities are complicated places with a lot to sense, however, due to limited resources, it is impossible to perceive everything. Based on the extensive application demands of smart cities, six categories of perceived content have been identified as the most important and commonly used: pedestrian flow, traffic flow, environment, public safety, energy consumption, and economy. The first step in building an urban perception system is to categorize these six categories, subdivide them into primary and secondary subcategories, and identify key perception indicators. This provides a planning reference map for urban perception builders, a perception resource directory for smart city application developers, and a perception demand list for departmental management. Perception indicators are associated with required sensing methods, layout standards, sensing frequency, granularity, format, and transmission methods of sensing data, thereby guiding the construction of the perception system (Figure 3-4).

Secondly, it is necessary to standardize the construction of four types of perception

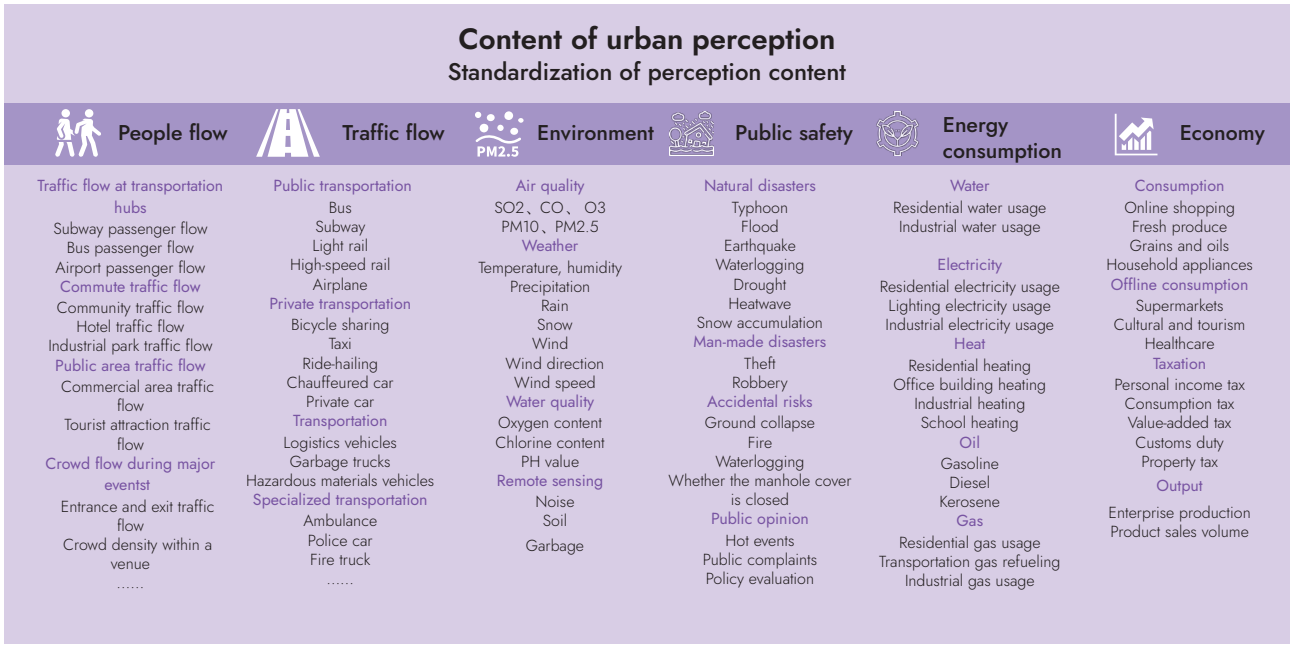


Figure3-4: Standardization of city sensing content
Source: Zheng Yu. Urban perception system[J]. Journal of Wuhan University (Information Science Edition), 2024, edited by author

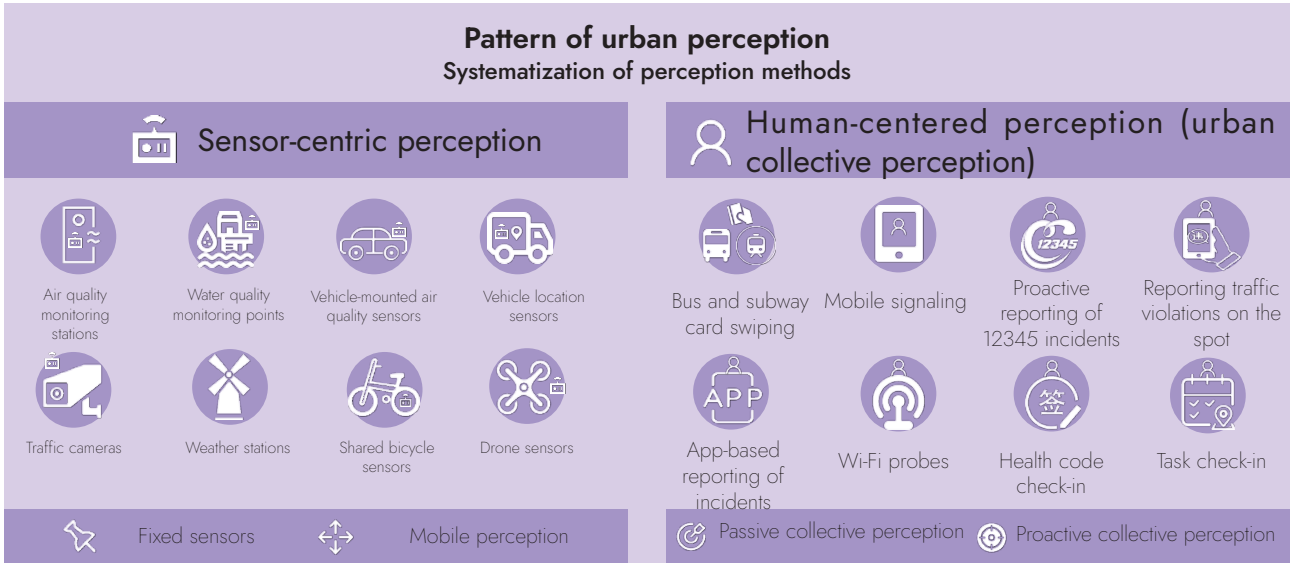


Figure3-5: Standardization of urban sensing methods
Source: Zheng Yu. Urban perception system[J]. Journal of Wuhan University (Information Science Edition), 2024, edited by author

approaches with typical characteristics. The sensor-centric perception modes include both fixed and mobile perception. The human-centric perception modes include both active passive group perception (Figure 3-5).

Most sensors and IoT devices belongs to the fixed sensing, where a sensor is installed in a fixed location and then continuously receives signals from it. If the sensor is installed on a carrier such as a drone or a mobile vehicle, and continuously senses conditions

in different geographic areas as the carrier moves, this falls into the mobile sensing category.

Sensor-centric perception offers high reliability and stable signal sources, but requires significant upfront investment and maintenance costs. It is suitable for perception scenarios with high requirements for real-time performance and accuracy. However, some content cannot be perceived through sensors, such as tourists' satisfaction with scenic spots and the harmony between property owners and residents. In such cases, human-centric perception approaches are needed.

Passive human-centric perception is the unintentional collection of data that can be used to understand urban patterns. These data points are gathered as people go about their daily lives without specifically intending to contribute to data collection. For instance, when people tap their cards to enter a subway station, they are not consciously collecting data for urban planning. However, when this data is aggregated, it can reveal patterns such as peak travel times and crowd density..

In the category of active human-centric perception, individuals consciously undertake tasks to collect information about their surroundings, with a clear understanding of the purpose and destination of this data. For instance, grid workers actively report damaged public infrastructure, and citizens utilize the 12345 hotline to report urban issues such as litter. These actions demonstrate how collective efforts can be harnessed to actively perceive urban dynamics.

Human-centric perception, without additional hardware investment, offers good flexibility, and this can work together with sensor-centric perception to seize the pulse of the city.

To host the urban sensing system, it is also necessary to build a corresponding urban sensing system (Figure 3-6), including sensing subject access and control layer, sensing data management layer, sensing service provision layer, to realize the synergistic linkage between people and sensors, additionally, to provide sensing data and equipment management services for the upper-level applications.

Perception entity access and management layer: this layer integrates video network and IoT platforms to connect with a variety of cameras and sensors. It handles protocol adaptation for both video and sensor data, and provides control mechanisms for these devices. The layer serves as a bridge between the perception data management layer, providing it with video and sensor data, and the perception service provision layer, receiving device access and control commands.

Perceived data management system: through the existing business system, it accepts data from perceived subjects such as people, social security, provident fund, housing information and residents' complaints. The data entry tool is used to access the data from the perceptual subject access and management layer, organizing the data by the five entities of people, places, objects, and organizations and their relationships, forming a standard data resource system, so that the perceptual data can be separated from the perceptual applications and can be shared in different applications. At the same time, the perceptual data layer also provides components for accessing, processing, analyzing and presenting perceptual data, as well as controls for controlling cameras and sensors, so that the business demand side can quickly build various types of perceptual applications.

Perception service provision layer: It

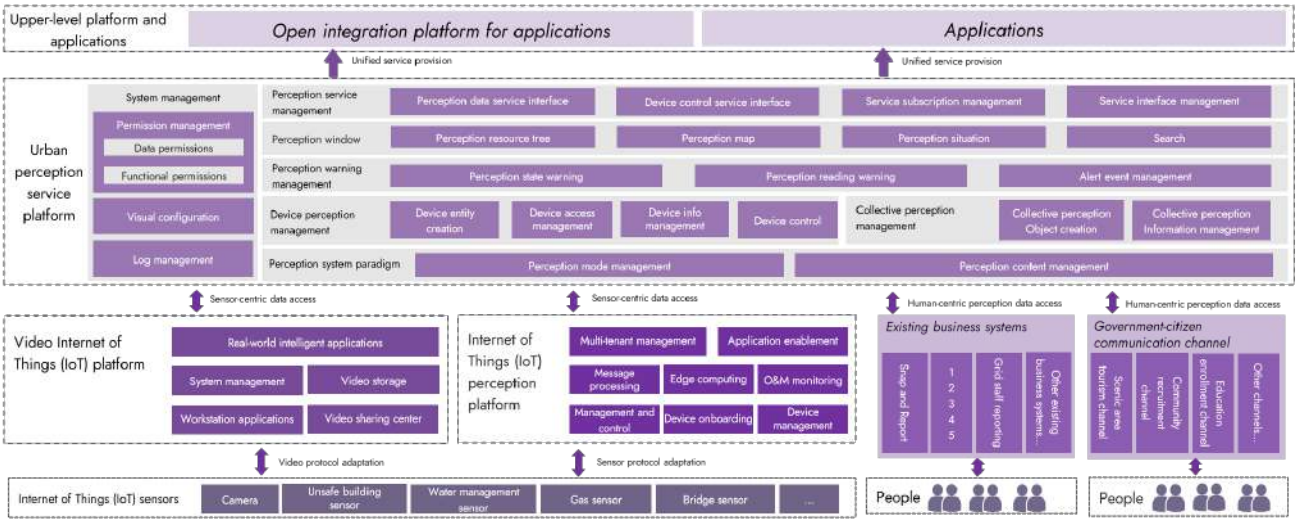


Figure3-6: The Framework of urban sensing system
Source: Created by author

includes perception system paradigm management, device perception management, group perception management, perception warning management, perception window, perception service management and platform management.

After completing the platform construction, it is necessary to focus on the operation mode of the city sensing system (Figure 3-7). First, government departments or smart city service providers shall identify applications to be built according to the key indicators of concern to the government, enterprises and residents, and specify the data and calculation logic required for each application. Further, based on the required data, the sensing requirements are proposed, including the content to be sensed and the sensing means to be adopted. These perceptual demands are unified into a perceptual system, and according to the perceptual equipment that has been constructed by each business department, the new perceptual equipment that needs to be added is planned in a coordinated manner to avoid duplicated construction. Such integrated planning work can be hosted by the relevant government departments (e.g., the Big Data Bureau or the Bureau of Economic and Information Technology), and an assessment can be carried out every six months.

Afterwards, these additional construction tasks can be undertaken by different enterprises separately, deploying sensors according to the principle of unification. The contractor buys operation services from the total operator of the urban sensing system and uses the unified urban sensing platform to access sensor data and control the new equipment, ensuring that the sensing data can be centrally and consistently deposited in the urban sensing platform and called by the upper-level applications. In addition, different sensing equipment construction and operation parties can also be based on the same platform for efficient collaboration to ensure data consistency across the board.

Government agencies have two avenues for obtaining sensing services from the urban sensing system. For basic sensing needs, like monitoring water level and flow rate, they can directly procure services from the system's overall operator. This provides a unified platform for device status, data access, and control. For more intricate requirements,

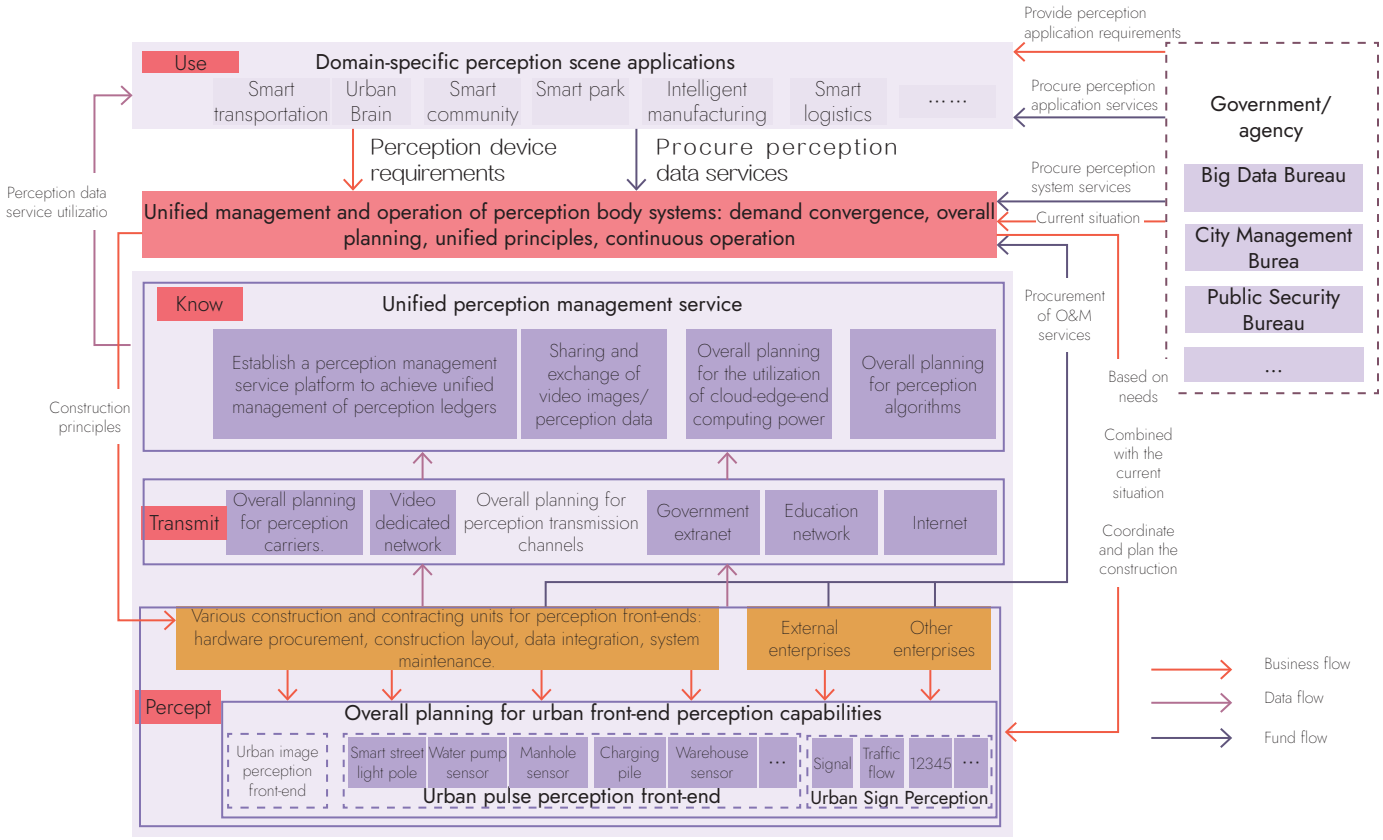


Figure3-7: Operation mode of city sensing system
Source: Zheng Yu. Urban perception system[J]. Journal of Wuhan University (Information Science Edition), 2024, edited by author

smart city application developers can purchase sensing services and build custom applications. Government agencies then procure technical services from these developers. This dual-tier model ensures comprehensive data integration, tailored service procurement, and seamless system operation, promoting the system's long-term sustainability and commercial viability.

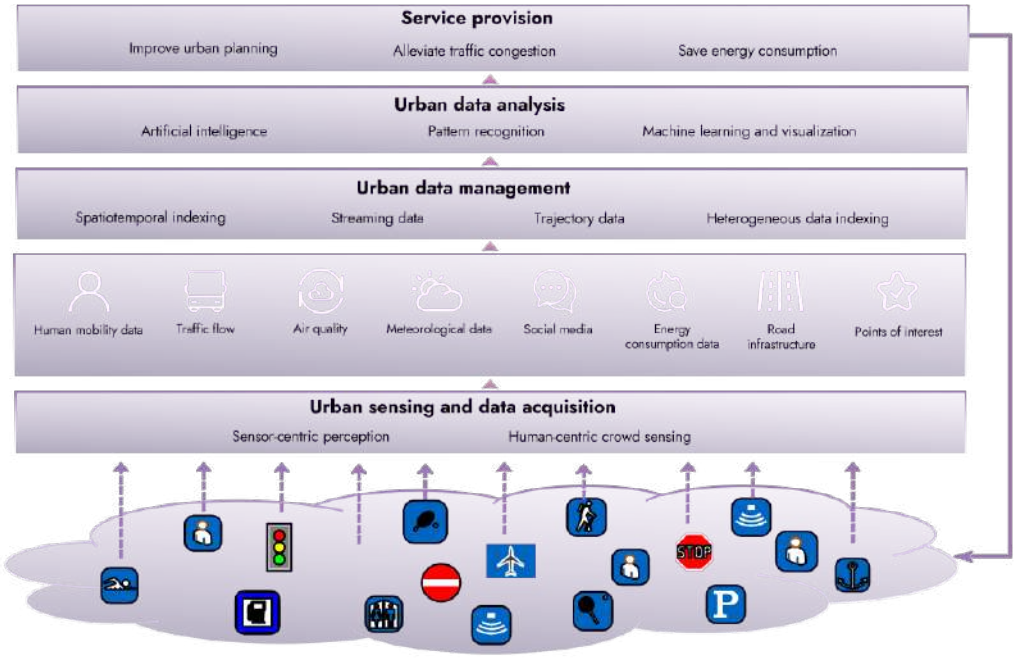
3.3.2 Integrated urban data sharing network

The goal of the Urban Data Sharing Network is to establish the digital foundation and intelligent base for urban governance, fully utilizing perceived urban information to power an open, modular, and standardized intelligent urban big data AI platform (Figure 3-8).

Based on the good practices of cities across China and guided by the urban computing theory system, a well-structured urban digital foundation provides a valuable reference for designing scientific and forward-looking framework. The urban computing theory system outlines a shift from business-centric to data-centric system architectures, emphasizing urban perception, data management, analysis, and service provision. A comprehensive urban digital foundation should incorporate modules such as data collection, governance, management, analysis, and visualization.

After completing the construction of the Digital Intelligence Base, the construction of the urban data resource system become the top priority, especially the public data generated in the process of providing public services by various government departments,

Urban Computing Theory



Unified Data Sharing in the City

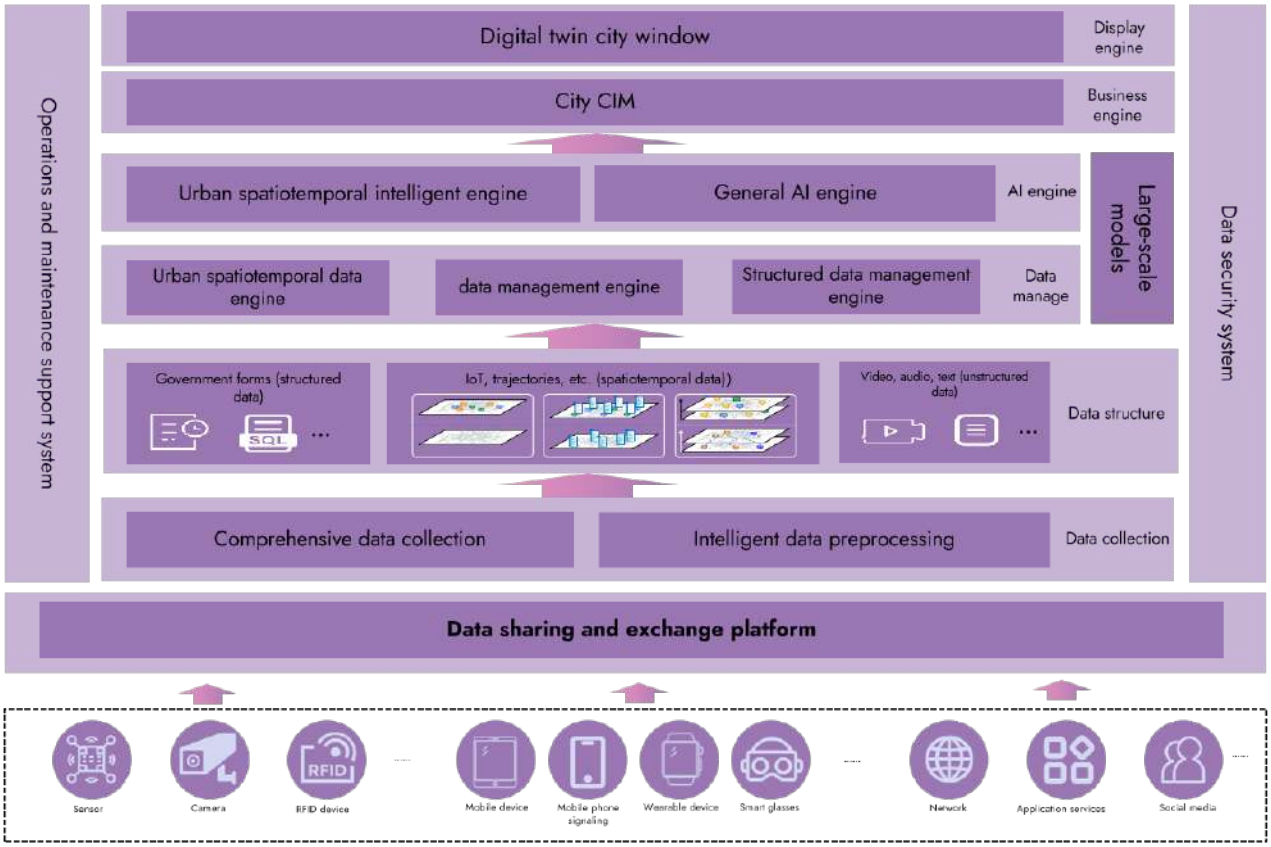


Figure3-8: Unified Data Sharing in the City
Source: Zheng Yu, Urban Computing, MIT Press

which is an foundation in the process of digital urban governance, and the government has a greater impetus and control of the management and opening of this type of data.

In this context, the main objective of promoting the construction of a public data resource system is to realize the elementation of public data. Current data governance methods are largely based on the principle of post-hoc, centralized, and manual processing. Namely, after data is generated in applications, data governance teams are responsible for data aggregation and sharing, which is time-consuming, labor-intensive, and difficult to scale. The pace of data governance cannot keep up with the speed of data generation, and the results of data governance are difficult to reuse and circulate on a larger scale. On the other hand, although automated extraction methods based on intelligent algorithms reduce the workload to some extent, they cannot guarantee the accuracy of data governance, and subsequent manual verification by professional teams is still required, which still cannot achieve the automated and large-scale generation of data elements.

The goal of public data elementalization for urban governance is to separate data from applications so that it can be shared accurately across applications. Data elements can be automatically generated and updated to create scale effects. Eventually, different data elements can be automatically connected to fully realize the value of the data.

To achieve the above goals, based on the general idea of human-computer intelligence and collaboration, the data element construction method based on the urban knowledge system can be used to focus on solving the elementalization of public data. First of all, the theory of data element construction based on urban knowledge system is proposed, which takes the five types of entities of people, places, things, objects, organizations, inter-entity relationships and their attributes as the atomic descriptions of data elements, similar to the “periodic table” of data, providing an effective and consistent basis for the expression of complicated data, and offering a theoretical foundation for the elementalization of public data. Theoretical basis. Secondly, a set of digital controls is developed to carry the theory of data element construction based on the urban knowledge system. Based on the digital control, various public applications can be flexibly configured to provide services to the public. The data generated by the control is automatically associated with the urban knowledge system, and the data is connected to each other, so that the data can be elementalized at the time of generation, which greatly reduces the cost and ensures the accuracy. Finally, intelligent learning and recommendation algorithms are designed to continuously improve the performance of the data element tool by using human-computer intelligence, so that users can use the digitized control to meet their business needs without the need to understand the knowledge system, greatly reducing the threshold for using the tool.

As shown in ① -1 and ① -2 of Figure 3-9, first, the urban knowledge system is constructed based on expert intelligence to form the theoretical foundation of public data elements. By deconstructing and abstracting a large amount of urban public business, a city knowledge system is derived with five categories of entities (people, places, events, objects, organizations), over 70 entity relationships, and over 600 attributes as the core. Using the entities, relationships, and attributes in the urban knowledge system as atomic descriptions, various types of urban businesses are expressed upwards, and they serve as components of public data downwards (like the "periodic table"

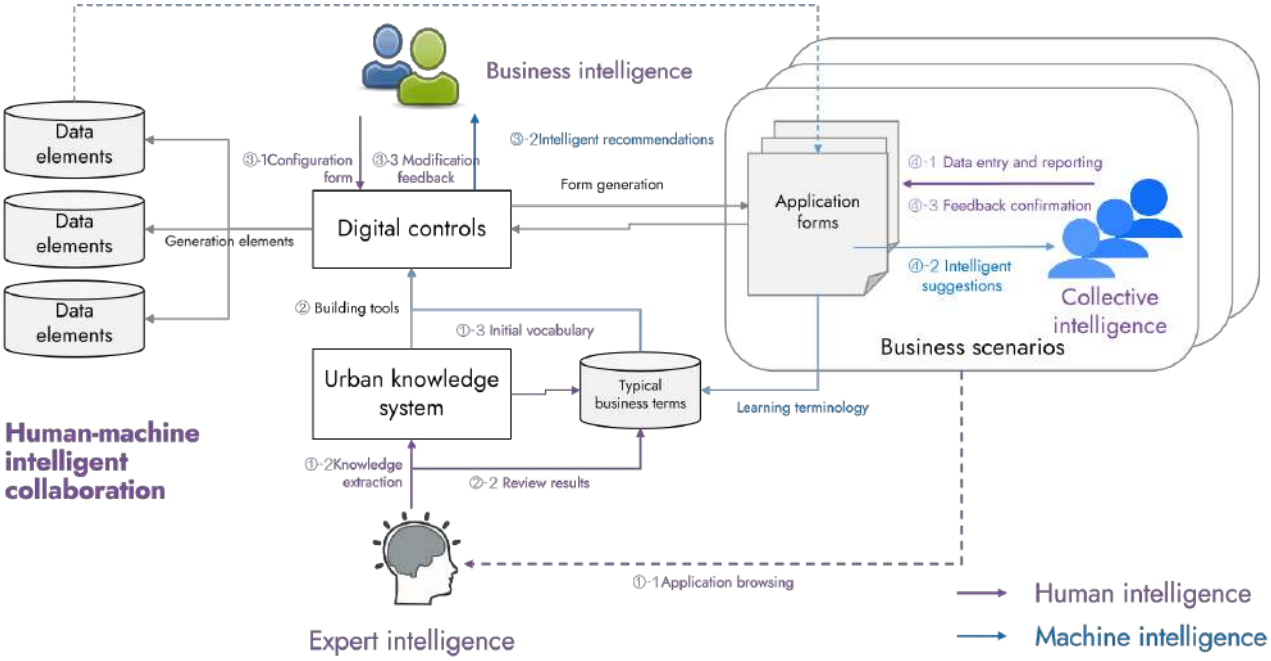


Figure 3-9: Overall Design of Public Data Elementization
Source: Zheng Y, Yi Xiuwen, Qi Dkang et al. A public data element construction method based on urban knowledge system

of data), forming a data element theory based on the urban knowledge system. This theory provides an effective and consistent expression foundation for complex data, enabling data and applications to be separated. Different data can be connected to generate a standardized data resource system, facilitating efficient and convenient data transactions and circulation. The content of the urban knowledge system is highly abstract and concise, with strong generality and comprehensibility, making it easy to understand and use, greatly enhancing the feasibility of building automated systems in the future.

Second, a set of digital controls is developed as a data element construction tool to carry the theory of data elements based on the urban knowledge system. The data element construction tool designs proprietary controls for various types of entity attributes, so that business personnel (usually information administrators of government departments) can flexibly configure various types of public application forms in combination with their own business knowledge to provide services to the public. As shown by the purple arrow ③ in Figure 3-9, in the process of configuration, business personnel add the corresponding controls to the application interface one by one according to the business logic, reflecting the inter-entity relationship through the addition order and spatial inclusion of controls, and modifying the description of the controls according to the needs of the scenarios (e.g., changing a person's "Name" to "Username"). (e.g. changing a person's "Name" to "Used Name").

Forms configured based on digital controls will become the interface for residents to input information in different scenarios, and the data entered through the controls will be associated with the urban knowledge system, so that the data will be automatically elementalized at the time of generation. In addition, in the process of using the digital control configuration application, machine

intelligence is utilized by establishing business terminology learning algorithms and control title intelligent recommendation algorithms to understand the user's desired intent (e.g., inter-entity relationships) based on the user's process of configuring the current interface and past configuration experiences. Intelligent recommendation of the collection of business terms that the user wants to use, and sorted by the combination of possibilities, significantly improve the user's configuration efficiency and experience, reduce the threshold of the use of digital controls so that the digital controls become an intelligent connector between the user and the urban knowledge system, without the need for the user to know and learn the urban knowledge system on the premise of the complexity of the business data converted into standardized and unified data elements.

3.3.3 Unified governance through one network

Urban governance is an important part of achieving the modernization of the national governance system. Over the years, governments at all levels in China have successively introduced relevant policies to accelerate the construction of smart cities and digital governments. By leveraging digital technologies such as cloud computing, big data, and artificial intelligence, they have made significant explorations in advancing urban governance mechanisms and transforming governance models. The "unified governance through one network" of urban governance is a typical model in this regard.

The "unified governance through one network" refers to the utilization of next-generation information technologies such as cloud computing, big data, and artificial intelligence for digital urban governance. It relies on real-time online data and algorithms to assist urban managers in accurately identifying issues, promptly responding to demands, comprehensively assessing situations, and proactively preventing risks. It focuses on achieving efficient collaboration both online and offline to address the issue and continuously enhance the modernization level of urban governance.

Specifically, "unified governance through one network" is a collaborative model that integrates the business platforms of various urban governance systems, manages the entire domain through an entity center, and consolidates governance forces. Through technological innovation, mechanism innovation, and organizational innovation, it achieves the goal of managing the entire city through one network, governing the entire domain through one center, and coordinating governance through one team. It aims to achieve the following three objectives:

Connectivity of data instructions (one network for governance systems): This involves connecting data, business operations, and the circulation of instructions across different business systems.

Connectivity of operational mechanisms (one network for governance institutions): This entails establishing an integrated command system that combines routine exercises and actual emergency response at the city, district/county, and street/town levels.

Connectivity of organizational management (one network for governance personnel): This involves building an efficiently collaborative governance team through institutional integration, delegation of authority, performance evaluation, and other means.

The current development trend of "unified governance through one network" can be summarized in the following five aspects

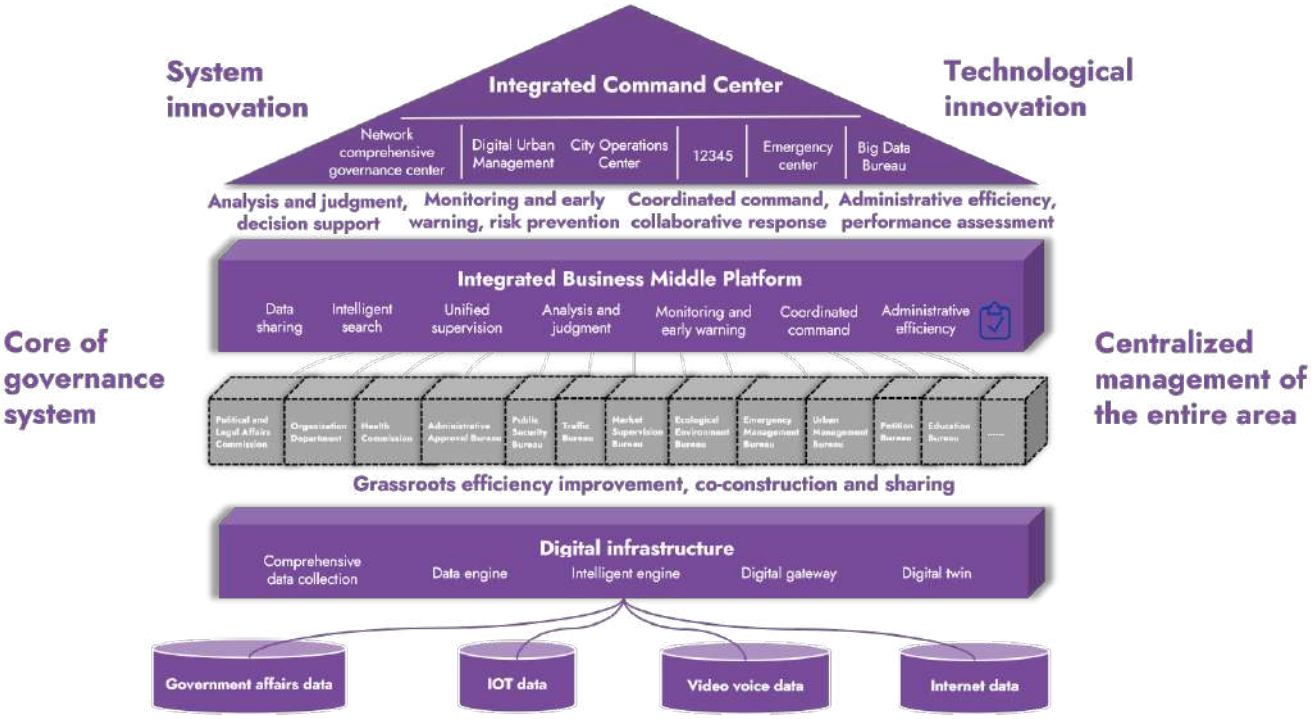


Figure 3-10: Unified Governance of the City
Source: Zheng Yu. One network for urban governance

(Figure 3-10). Firstly, comprehensive Planning. "Unified Management through One Network" is one of the most important parts of the city. It should be coordinated and planned within the broader context of smart cities, new infrastructure, and other major initiatives. Considering the present and future perspectives, it is important to design the strategic plan from the perspective of urban managers. Secondly, systematic Coordination: It is essential to promote cross-domain and cross-business collaboration and coordination among public security, emergency response, transportation, and other sectors. Adhering to the principle of holistic governance, the goal is to achieve integrated command and dispatch, as well as intelligent and efficient response. Thirdly, Penetrative Governance. The "Unified Management through One Network" system should span across multiple levels of governance, including the city, district/county, street/town, and community/village. This approach aims to establish an application system that transcends geographical and hierarchical boundaries, while simultaneously advancing government institutional and mechanism reforms. Fourthly, Refined Operations. Guided by the principles of effectiveness, practicality, and usability, the focus is on addressing "big issues" through "small points." By utilizing scenario-driven approaches, a refined operational mechanism is constructed, which leverages the synergy of large screens, medium screens, and small screens to improve efficiency while reducing the burden on primary level organizations. Fifthly, fortress-like Security. "Unified Management through One Network" is crucial for the overall development and security of cities. It requires the establishment of security system regulations, data sharing standards, and operational management mechanisms to build a comprehensive and three-dimensional security protection system.

Specifically, the "Unified Management

through One Network" platform provides urban managers with three main value enhancements: data analysis to support decision, monitoring and early warning to prevent hazards, and closed-loop coordination to improve efficiency. By leveraging cross-departmental data and integrating cross-departmental business processes, artificial intelligence technologies are utilized to accurately and efficiently address key and challenging issues in urban governance. The mobile platform integrates core functions of urban governance, enabling city managers to conveniently access real-time governance dynamics, monitor operational situations, make informed decisions, and remotely command and control operations.

Monitoring and early warning center: Centered on data indicators analysis, through AI algorithm of spatial and temporal data, focus on "analysis - warning - issuance" and real-time dynamic display, the monitoring and early warning system of municipal governance is built in the whole scenario, cross-sector, and real-time, featuring cross-sectoral business, multi-application model, accurate early warning algorithm, and fast business configuration, It is characterized by cross-departmental business, multiple application models, accurate warning algorithms, fast business configuration, and good decision-making assistance. Through the monitoring and early warning platform, it can improve the government's ability to perceive the city's operation status, enhance the government's fine management level, strengthen the government's intelligent disposal ability, and realize the transformation from "plugging the loopholes" after the fact to "preventing the risks" before the fact (Figure 3-11).

Analysis and judgment center: For government leaders, using government-owned data and data from third-party companies, it conducts intelligent analysis and judgment on business areas such as urban operation and management, public opinion surveys, economic development planning, policy planning, etc. It analyzes the social problems and causes of the problems shown by big data in-depth, and supplements it with the experience and professional approval of industry experts to regularly generate reports that show the historical status of key areas of concern, It regularly generates thematic analysis reports showing the historical situation, current progress and development trend of the key areas of concern, and provides targeted policy recommendations to assist city managers in effective decision-making in the areas of public opinion, government services, high-quality development, economic operation and administrative law enforcement (Figure 3-12).

Integrated command platform: As the main function of modernized municipal governance, at this stage, due to the existence of cross-functional and overlapping functions in some government departments, each department carries out governance work individually on the basis of the data and information at its disposal, so that information on the discovery of incidents is not effectively shared, multiple cases are filed, duplicated reports of incidents cannot be effectively screened out, and cross-departmental incidents are not dealt with in a timely and coordinated manner (Figure 3-13).

According to the responsibilities and powers of each region and department and the characteristics of matters to be dealt with, the linkage command center advances the construction of the command system in a hierarchical and classified manner and implements the operation mode of "1+N+N". That is, 1 total platform, the overall jurisdiction of the entire region of social governance work, positioning is to coordinate the linkage command, unified command and scheduling horizontal platform and vertical subordinate

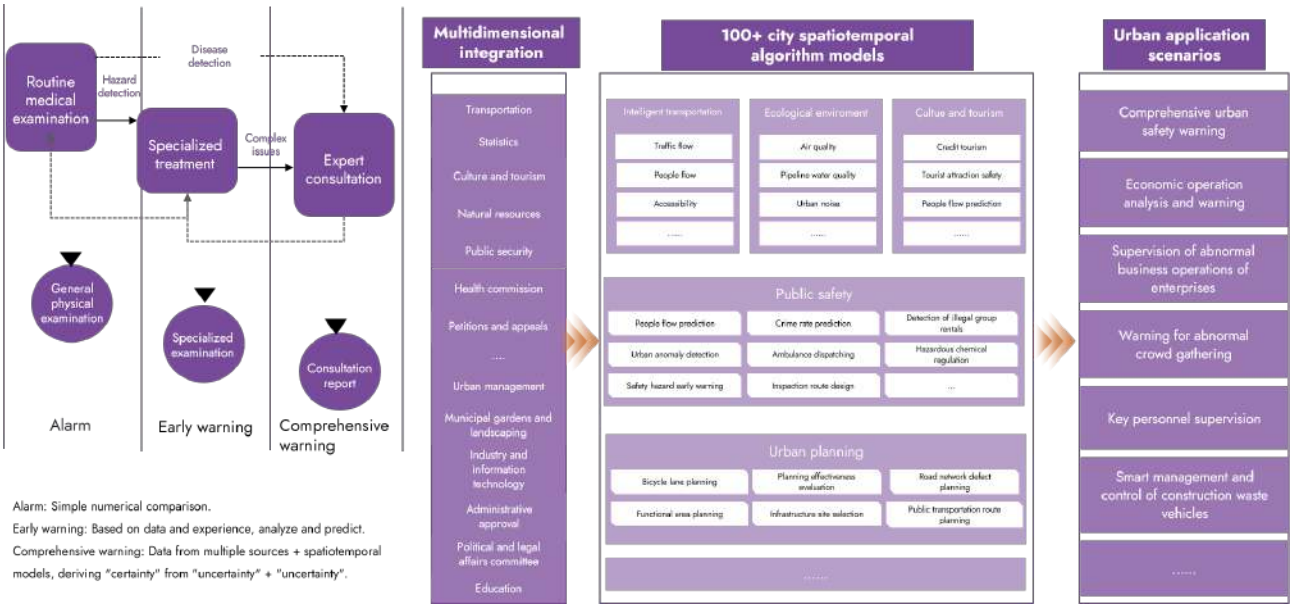


Figure 3-11: Monitoring and early warning center
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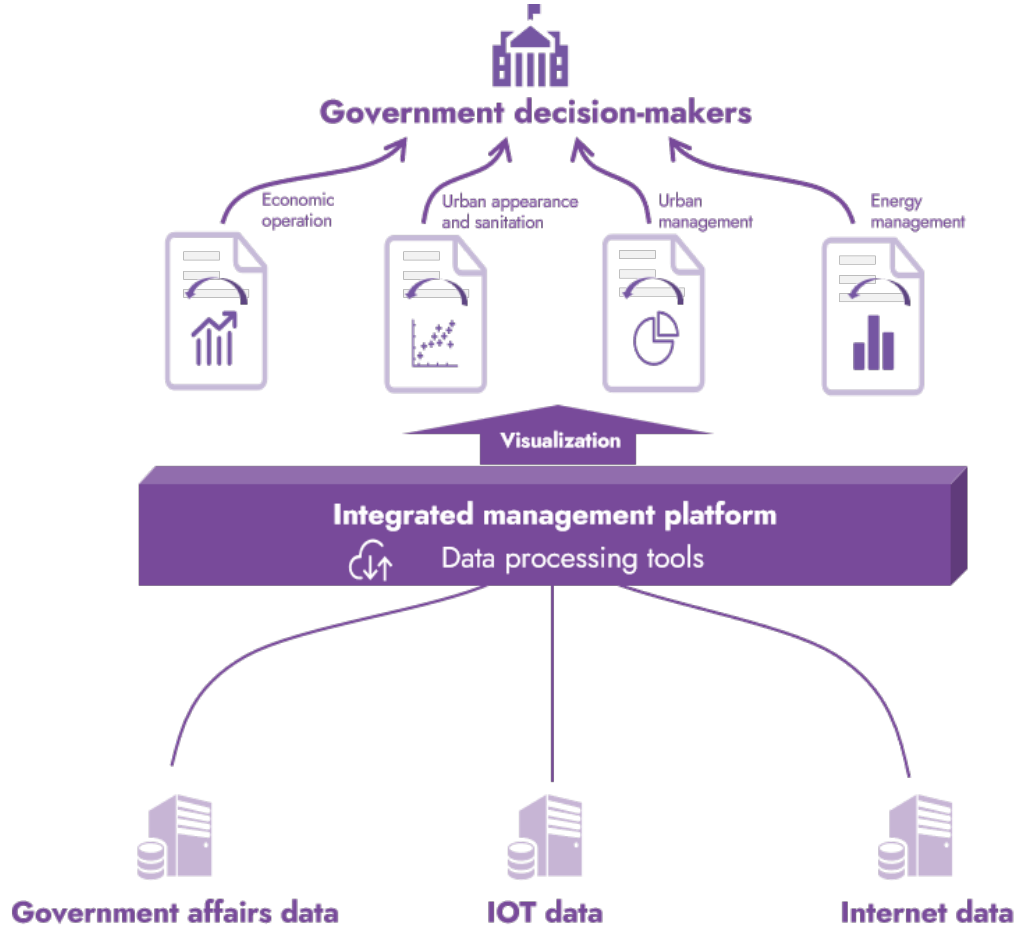


Figure 3-12: Analyzing and judging venter
Source: Created by author

platform; N departments and districts and counties platform (sub-centers), positioning itself as the entity command, mainly accepting matters within the scope of responsibilities at this level, matters assigned by superiors and key and difficult matters reported by subordinates, and accepting the total platform scheduling and unified command and scheduling of platforms at this level and at subordinate levels; N town and street-level platforms (workstations), positioned for disposal and processing, mainly accepting matters within the scope of responsibilities of their own level and matters referred to them by their superiors, accepting the dispatching of higher-level platforms and commanding and scheduling of platforms at their own level. The linkage command center also needs to include the function of administrative inquiry. This function relies on the real-time data of the event flow dispatch order of the linkage command center to realize the prompt promotion of government services, administrative law enforcement and other business processes of various government departments, and to improve the work efficiency of various departments. The system of “administrative inquiry” can carry out administrative inquiry on matters such as public consultation, service, complaint and departmental law enforcement, etc. The system is based on the convergence of multi-source data in the district. Based on the convergence of multi-source data in the region, it fully mobilizes and stimulates the vitality of data from all aspects of society. Based on the original assessment mechanism, combined with big data analysis, artificial intelligence and other technologies, it forms a multilevel supervision and evaluation system covering the entire process of administrative enforcement and public services, realizing “emphasis on the process, preserving the timeliness, looking at the results, and closing the loop”, and providing auxiliary support for each unit to optimize its work plan and enhance its administrative efficiency.

3.3.4 Unified teamwork platform for government collaboration

"One Network Coordination" is a significant carrier for promoting the modernization of the governance system and capacity of the local governments, as well as for facilitating administrative function transformation across all levels. By streamlining and coordinating cross-departmental business and internal management processes, and leveraging information technology, it continuously optimizes business workflows and strengthens inter-departmental collaboration. With a focus on platformization, mobility, integration, and intelligence, it supports vertical and horizontal linkages in government affairs, establishing a top-down command mechanism and a bottom-up feedback mechanism for the government.

As shown in the Figure3-14, the goal of "One Network Coordination" is to construct a unified and province-wide (city-wide) basic collaborative platform and a unified portal for the multi-level government system of "province, city, district, street, and community." By integrating and coordinating governments' work, it aims to achieve a unified terminal, unified login, and unified interface for various applications, avoiding redundant construction by different units, making rational use of government investment, and improving economic and social benefits. Based on the "Internet-based government collaborative office platform" system, the key concept of which is to provide users with a simple and intuitive interface while ensuring powerful and intelligent backend functions. This system will leverage AI to automate services and facilitate better communication and collaboration among government departments at all levels. The goal is to address challenges encountered in information sharing and collaborative work across different government departments

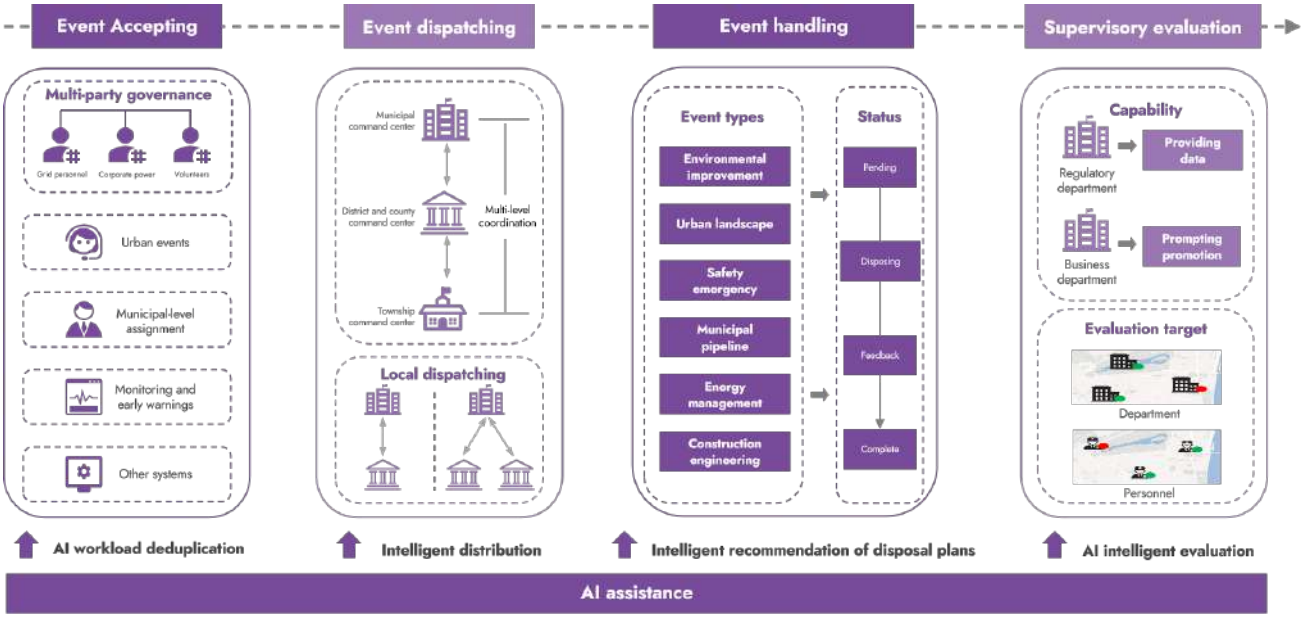


Figure 3-13: Linkage command center
Source: Created by author

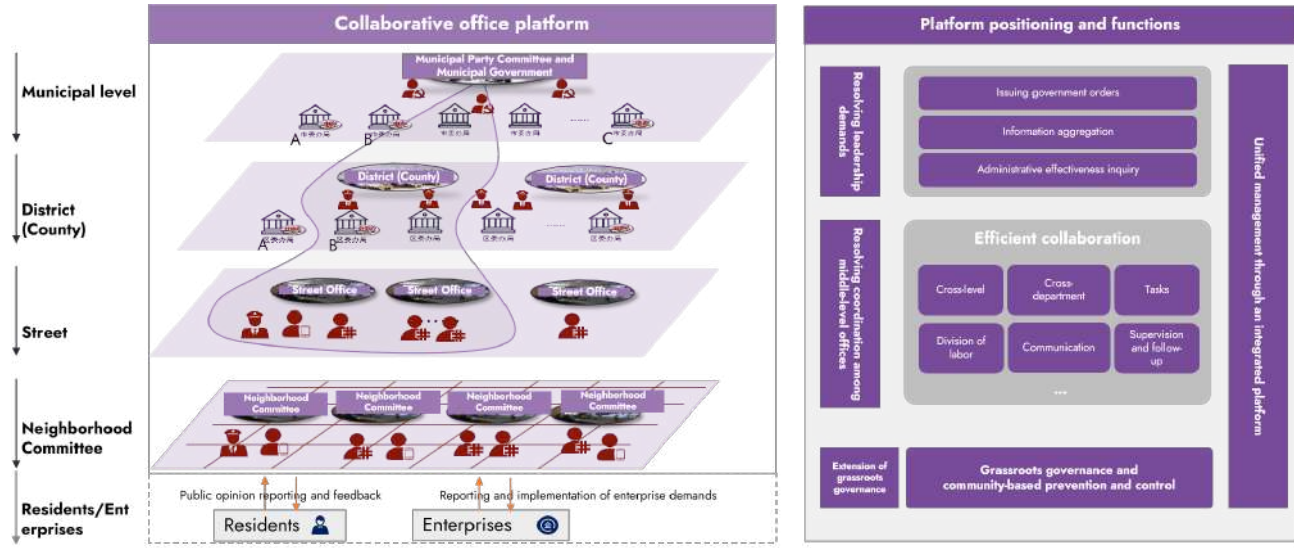


Figure 3-14: Overall design of Unified Teamwork Platform for Government Collaboration
Source: Created by author

and regions, such as inefficient information sharing, difficulties in business cooperation, and insufficient technical support.

The key concept of "One Network Coordination" is to connect a group of government staff to collaboratively complete a task. It focuses on five main government support capabilities: address book, messaging, calendar, tasks, and documents, providing support for policy dissemination, data reporting, and collaborative communication. At the same time, it builds an open platform for government collaboration and an application access specification system, supporting the access of applications

and systems from various units, and realizing unified user system, unified entry, unified login, and unified messaging capabilities. The overall structure supports multi-level linkage and top-down communication through the construction of one platform, three unifications, five cores, N scenarios, three terminals, and open capabilities, and meets diverse government needs in combination with rich government applications (Figure 3-14).

The "One Platform" realizes the construction of the underlying basic platform to support upper-level applications and scenarios (Figure 3-15). The "Three Unifications" achieve unified platform entry, unified user identity, and unified technical specifications. The "Five Cores" focus on address book, messages, schedules, tasks, and documents as core applications that span the entire process of scenarios. The "N Scenarios" is the various scenario applications that can be implemented based on the collaborative platform, such as audio and video conference management, intelligent data collection, and other scenario-based services. The "Three Ends" refer to platform support for PC, mobile, and web access and usage. The main capabilities include:

Address book (organizational portal): During coordinated command, it enables the rapid organization of cross-departmental and cross-level collaborative governance teams based on the address book.

Messages (communication portal): During problem identification, it allows for quick discussions and integration of issues to enhance event handling efficiency.

Tasks (task portal): In urban governance, it facilitates the management of tasks throughout their lifecycle, enabling hierarchical assignment and upward aggregation, thus ensuring trackability and timely follow-up of tasks.

Schedule (time portal): It provides a time-oriented perspective for overall scheduling, focusing on coordinated events such as command and primary level governance, and enables the reservation, utilization, and release of organizational resources.

Document collaboration (document portal): It enables multiple users to collaboratively share and edit important materials such as data briefings, meeting minutes, and event handling documents generated during urban governance.

3.3.5 One-stop government services through one network

Primary level governance serves as the cornerstone of the national governance system and plays a critically important role in consolidating national security and maintaining social stability. Currently, primary level governance has been encountering with numerous challenges, particularly in terms of information sharing between citizens and the government. There is an urgent need to address issues such as multiple data collection by various departments, repeated information filling by residents, and the complex and burdensome nature of primary level governance. In response to these challenges, the "One-Stop Government Services" initiative has emerged to integrate government applications that serve residents. However, with the further informatization and intelligence of resident services, the traditional "one-stop" service portal for residents can no longer meet the development needs of primary level governance.

Currently, data is at the core of the "One-Stop Government Services" system. It serves as a bridge between the government and the

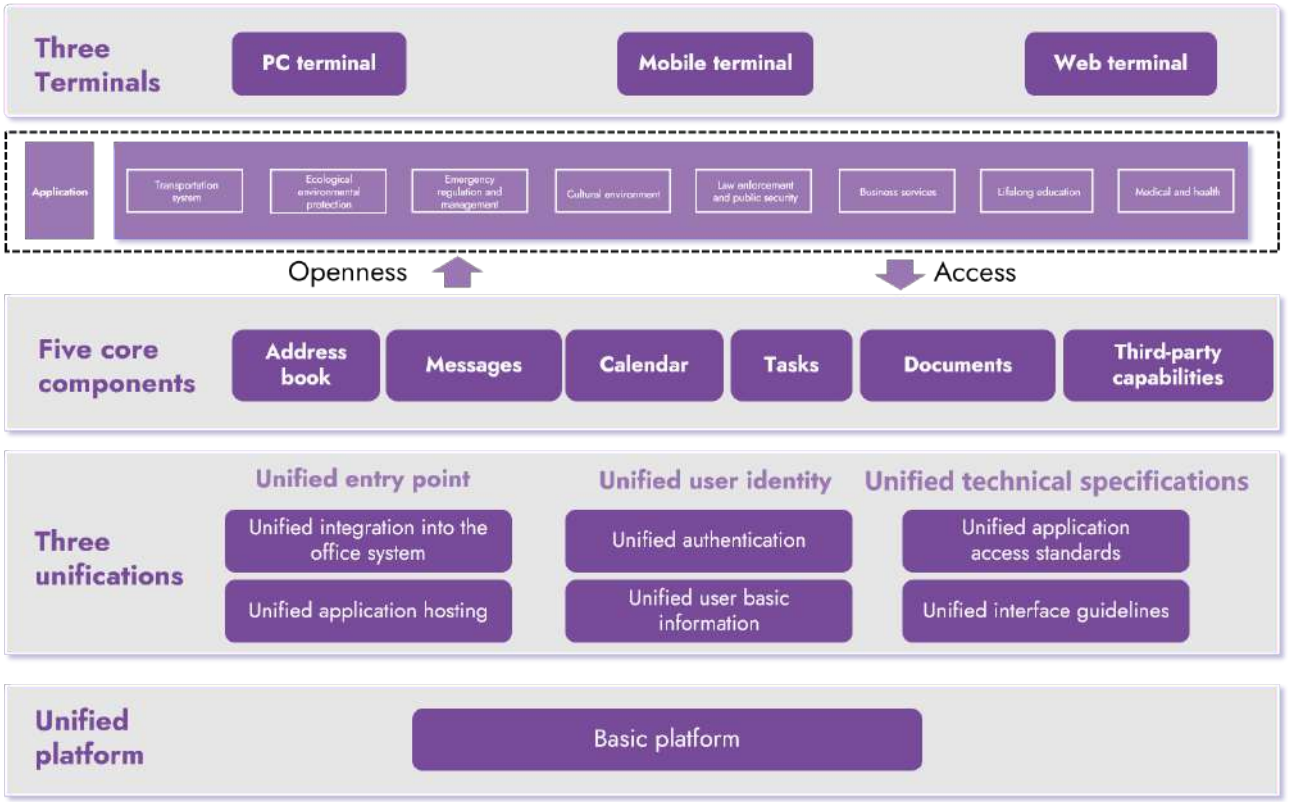


Figure 3-15: Functional structure of integrated collaboration
Source: Created by author

public. This system can flexibly and quickly provide various services based on different needs, enabling convenient communication between the government and the public without mutual disturbance. In this way, primary level management can be made more precise and efficient, and information can be shared timely among different levels. This not only reduces the burden on primary level staff but also empowers them to do their jobs better, while also providing a more accessible and standardized channel for the public to express their needs and protect their rights. Furthermore, this government-public information channel helps to form a complete data resource system, separating data from specific applications, and laying the foundation for data management and utilization. This can better support the nation's digital strategy..

As shown in the Figure 3-16, the government-citizen information channel of Integrated Online Government Services consists of four parts: The first part includes the government-side staff entrance and the community personnel management platform. The second part comprises the resident-side entrance (such as WeChat mini-programs) and the community service platform. The third part includes the common capabilities platform for primary level governance. The fourth part is the data layer.

Government administrators and primary level workers enter through the government-side portal, using the community personnel management platform to configure various service channels and management tasks, manage community residents, objects, and organizations, address resident grievances, and receive resident-reported information.

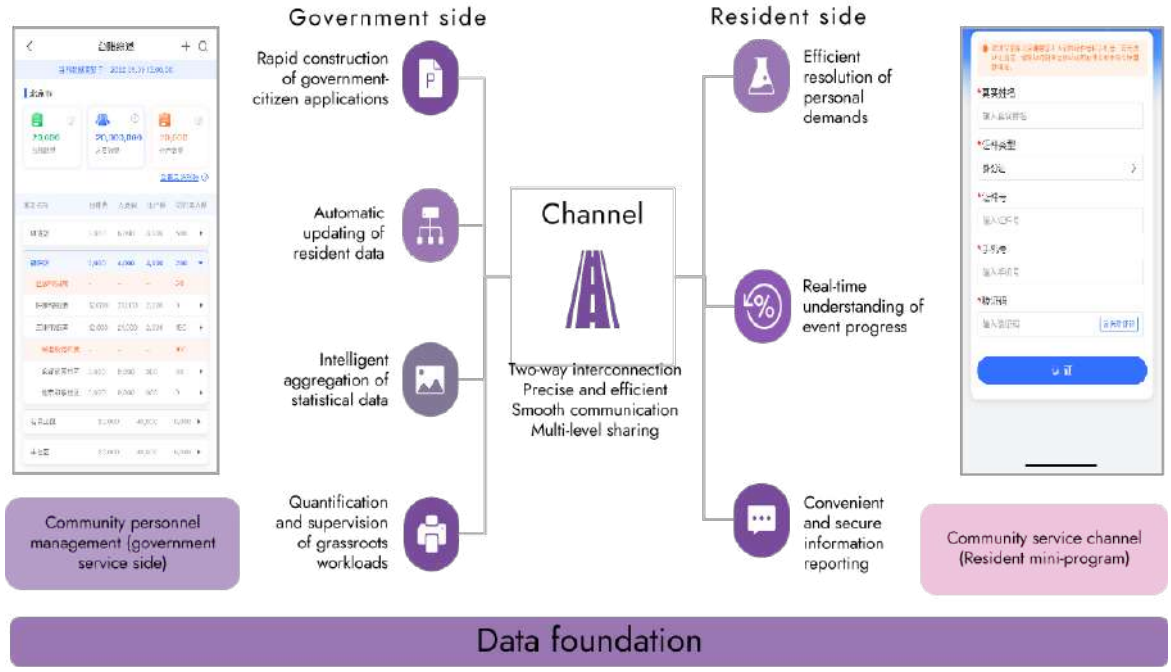


Figure 3-16: Composition of government-citizen information channel
Source: Created by author

Residents enter through the WeChat mini-program (or city app) portal, utilizing the community service platform to access services, submit grievances, upload data, and receive feedback. The common capabilities platform for primary level governance includes the common capabilities required by both the government-side and resident-side platforms, such as geographical hierarchy, entity ledgers, task systems, information exchange, and permission systems. The data layer facilitates the interoperability of information between the government and residents, the association of data between entities, and the accumulation of common data at the primary level.

The Figure 3-17 further illustrates the functional modules and business structure of the government-citizen information channel. It includes the government-side portal and management platform, resident-side portal and service platform, underlying common capabilities platform, and data layer. The underlying common capabilities platform is the core business of the "Integrated Online Government Services" middleware, consisting of five key atomic capabilities: geographical hierarchy, entity ledger, task system, information exchange, and permission system. The geographical hierarchy within the government-citizen information channel provides nine levels of geographical basic data and encoding ("province-city-district-street-community-building-unit-door-plot number"), as well as services for address filling and parsing.

The entity ledger provides tools for the long-term management of four types of entities: people, objects, locations, and organizations. The task system offers a flexible and configurable collaborative task system that spans across departments and levels, enabling efficient handling of complex and ever-evolving smart city affairs. Information sharing facilitates the opening of service channels for residents to report information and establishes channels for primary level government departments to issue notifications.

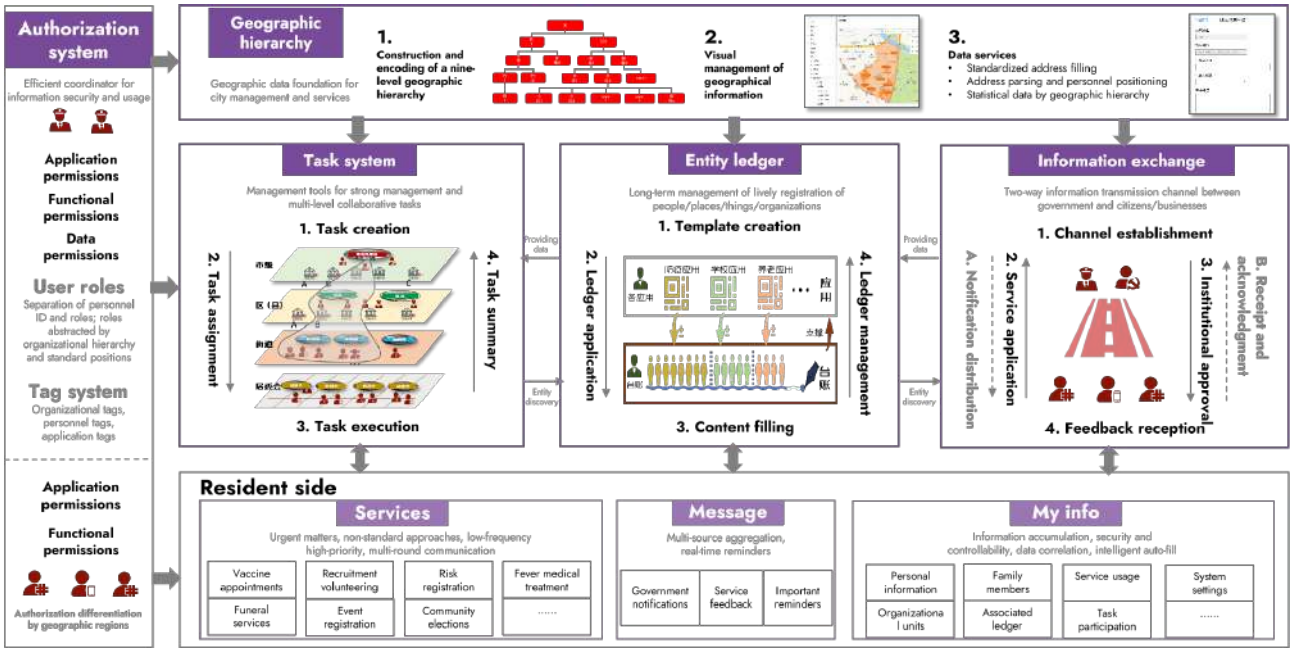


Figure 3-17: The framework of unified government services for business and residents
Source: Created by author

The permission system implements access control to different information platform functions, applications, and data based on user identities, allowing government workers and residents to access them accordingly.

The construction of a government-citizen interaction information channel within the "One-Stop Government Services" platform can significantly enhance the management and service efficiency of government leaders at all levels, improve the happiness and participation of community residents in community governance, and bring tremendous social value to primary level governance. For managers at all levels, it enables them to quickly grasp the primary level governance situation and the real-time progress of various tasks, facilitating top-level decision-making and avoiding redundant financial investment. Managers can easily view and retrieve various real-time statistical data within their jurisdiction, and automatically generate visual reports with high accuracy, eliminating the need for previous layer-by-layer reporting and manual statistics, and no longer requiring waiting for tasks to be fully executed, greatly improving the efficiency of leadership decision-making.

For primary level workers, it can meet their needs for rapid construction of government and citizen applications, automatic updating of community residents' data, intelligent summarization of primary level statistics, and quantitative supervision of primary level work, thus reducing the cost of communication with superiors or subordinates.

For community residents, it can satisfy their needs for efficient resolution of personal demands, real-time feedback on processing progress, convenient and safe reporting of information, and rapid access to public community information and convenient services, thus enhancing their enthusiasm for participation in urban governance and their happiness index.

3.4 Continuous operation and

scenario innovation of digital urban governance services

After completing the construction phase of digital urban governance, how to better operate and continue to provide intelligent services is a goal being explored globally, and the next step in digital urban governance will be to embark on the path of digital operation and services by promoting the innovation of the appropriate digitalization system and the synergistic development of innovative operation, operation and maintenance modes and digitalization.

3.4.1 Challenges and objectives of service operation

Currently, there are numerous and diverse business scenarios in urban governance, primary level governance, and other areas. Existing capabilities are unable to provide rapid support and response, and there is a lack of platforms and capabilities for quickly configuring and building scenario applications. At the same time, the development cycle of new systems is long and the costs are high. Given limited government fiscal funds, it is difficult to sustain investment and construction in response to various informatization needs. The underlying mid-platform, once built, cannot be continuously iterated and updated according to business needs, and lacks a closed-loop operation model.

Based on the above situation, how to achieve sustainable development of digital urban governance is the top priority. To promote the sustainable development of digital urban governance, three main challenges need to be addressed:

(1) The contradiction between the application data standards in industry fields and the unified data element system

Data and software applications are currently highly interdependent, and data elements generated by different applications cannot be automatically connected and quickly reused. At the same time, the generation of data elements relies on the heavy data governance process, which is difficult to form automatically and at scale. Therefore, it is imperative to facilitate the reusability of data across different software applications and enable large-scale automated data generation.

(2) The contradiction between the common mid-platform and application closed loop

There is a disconnect between the customized content of business systems and the generic mid-platform, making it difficult to link common services and data. Therefore, it is essential to explore a way to abstract and extract commonalities from these personalized businesses to achieve better collaboration and resource sharing among different businesses.

(3) The contradiction between the need for timely demand response and the long development cycle and high costs

Different technology vendors adopt different technology frameworks, making it difficult to define unified specifications and high learning costs for reuse under different frameworks. At the same time, there is a lack of business-oriented (rather than technical) platforms or tools for quickly combining and building scenario applications, and there is a need to solve the problem of low-cost and rapid construction of cross-system application scenarios.

Given the current state of smart city development and its associated challenges, The focus shall be on activating existing digital infrastructure. This involves transforming business mid-platforms and data mid-platforms to deliver genuine business-oriented services

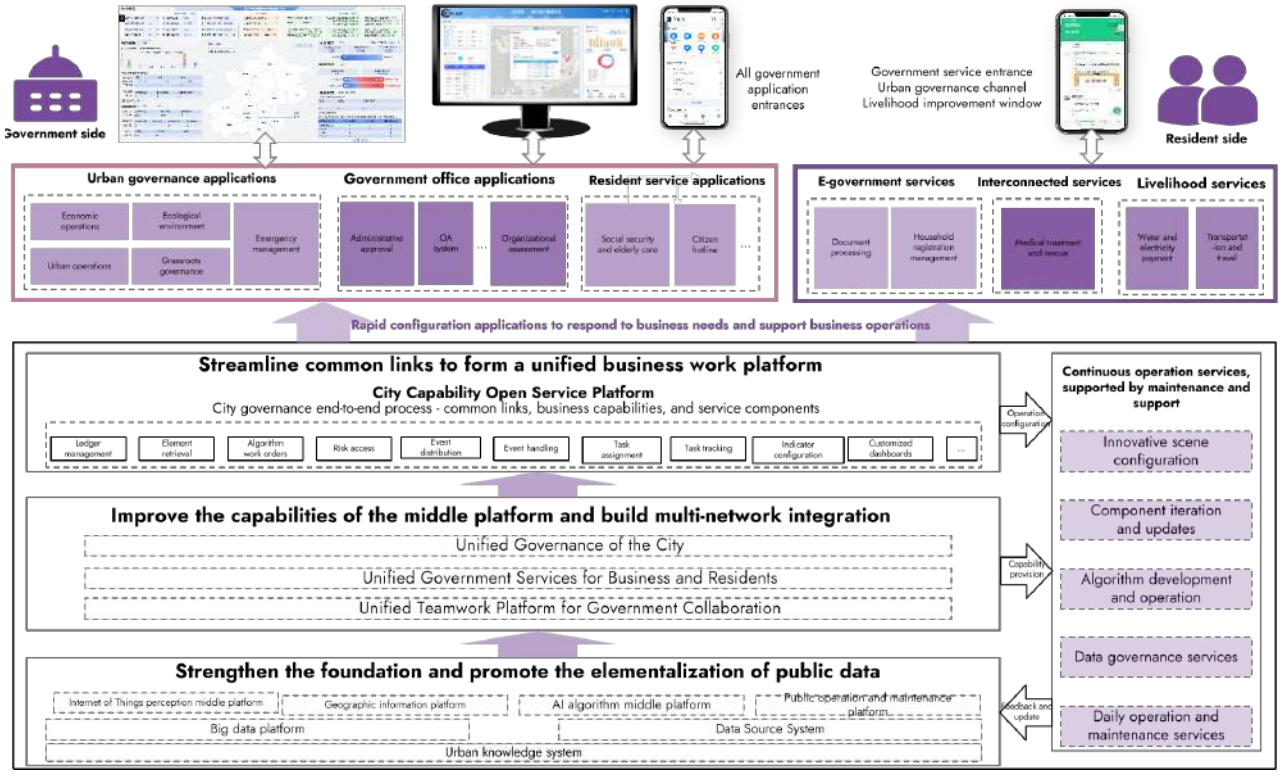


Figure 3-18: Overall design of digital urban governance operation
Source: Created by author

and applications. By empowering business departments to effectively leverage these platforms, the value of the existing assets can be maximized, the innovative scenarios can be continuously created , and operational services can be provided.

Specifically, the workflow can be divided into the following four parts that shown in Figure 3-18:

(1) Compacting the basic base and promoting the elementalization of public data. Make full use of the digital infrastructure already established in the city, improve the support capacity of the digital base, and realize the perception of urban status and sharing of urban data on one network.

(2) Coordinate and improve the capacity of the center and form a multi-network integration system. Construct three central platforms, namely, one network unified management, one network synergy, and government-public interoperability, so as to form the interconnection of the underlying capabilities.

(3) By identifying common business processes and establishing an open service platform for urban capabilities, and effectively sediment common service components. This will lay the foundation for rapid scenario construction and continuous operation services, thereby addressing a large number of temporary and fragmented demands..

(4) Continuous operation service and scene innovation. Provide rapid construction services for scene applications to address various needs, new/iterative component services, reasonable allocation of algorithmic power, and multi-party collaborative continuous operation to form a sustainable

operation service model.

Ultimately, through the above four parts of the work, the strategic goal of digital urban governance will be promoted as a whole, the regulatory capacity of the digital government will be enhanced, the level of urban governance "one thing" will be improved, and the issue of sustainable development will be resolved.

3.4.2 Construction services for application scenarios

Despite advancements in the technology behind integrated networks, their application in real-world urban management remains limited. The complexities and constant evolution of urban governance make it challenging for current information systems to keep up. In essence, while the concept of the integrated network is provided, the reality of implementation is far more complex. As shown in the Figure 3-19, primary level urban governance is a constant juggling act of various urgent tasks. These tasks emerge rapidly, demanding a wide range of solutions and often requiring immediate action, usually characterized by the following three major features .

(1) Diverse and complex

With the rapid urbanization process, cities are facing a growing number of emerging governance challenges, including delivery management, shared bicycle regulation, and community elder care. Moreover, existing governance tasks have become more granular, leading to a proliferation of specialized services. The development of separate applications for each of these services is both costly and inefficient. The resulting fragmentation of services can also confuse residents and hinder their access to government services.

(2) Temporary emergencies, short-term urgencies

Many urban governance tasks arise from sudden and unexpected events, demanding immediate and temporary responses. For instance, the COVID-19 pandemic necessitated primary level workers' efforts such as risk personnel screening, management, and transfer for quarantine. A hospital fire could trigger public safety inspections, while flooding or other natural disasters might require emergency rescue operations and resource allocation.

Given the urgency of these tasks, frontline departments often have little time to prepare. Even if governments were willing to invest in information systems, developing them quickly enough would be challenging. During these crisis situations, both government workers and residents often find themselves repeatedly performing the same tasks. Moreover, as government departments gain a deeper understanding of their operations, urban governance work evolves, requiring constant modifications to information systems. This heavy reliance on custom development can be costly. Once these emergencies subside, these governance tasks become less of a priority, leading to a significant decrease in usage. This creates a pattern of short-term, high-frequency, and urgent demands, followed by periods of low utilization. Developing a separate system for each of these temporary needs would result in significant resource waste.

(3) Varying practices across different region

Due to significant variations in regional characteristics within a city, the types and focuses of urban governance tasks carried out in different areas can differ greatly. For example, in some old urban residential communities, most of the infrastructure is

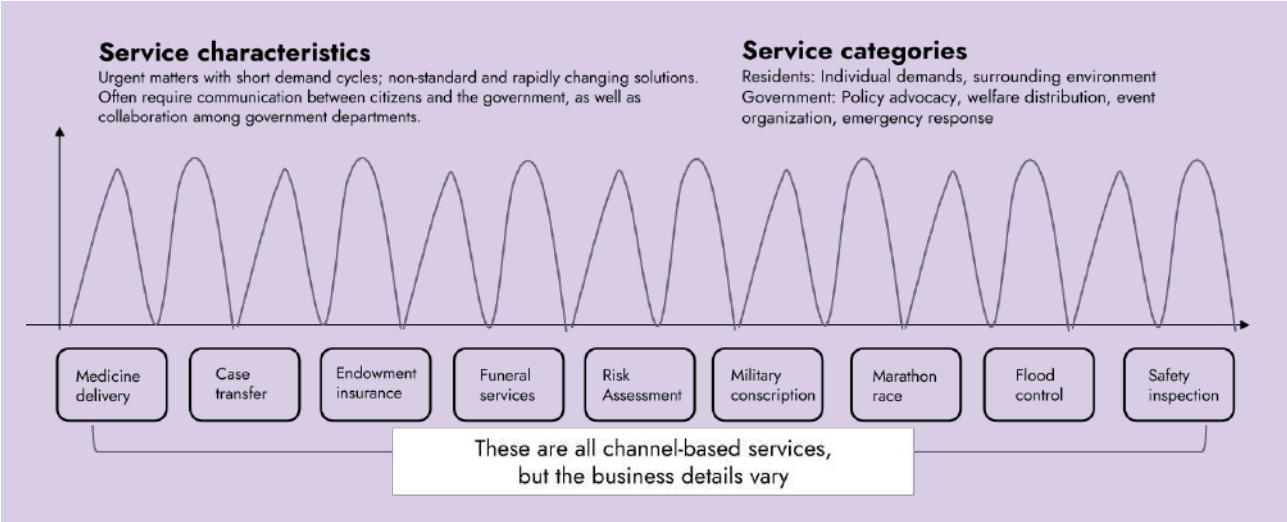


Figure 3-19: Characteristics of urban governance business
Source: Created by author

exposed outdoors, making safety inspections of water, electricity, and gas pipelines an important part of urban governance. However, in newly developed communities, these issues are almost non-existent, and safety monitoring tasks are undertaken by corresponding enterprises. Even when facing the same urban governance task, the disposal methods and processes can vary due to different resource endowments in each region. For instance, in providing health check-up services for the elderly, some communities have developed online mini programs that provide services to the elderly through login authentication, appointment registration, and record-keeping of their health history. Some communities only use WeChat groups to send notifications and use Excel spreadsheets to record registration information. Other communities prefer using paper forms and targeted door-to-door delivery. There are also significant differences in the disposal process. In some communities, anyone who registers can participate without the need for review. In others, the elderly can only qualify for a health check-up after primary level workers confirm their eligibility online. Some communities require sending the list of applicants to the community hospital in advance for confirmation before accepting the elderly's health check-up applications. These methods all have their own rationality, and it is necessary to respect the actual situation of primary level units. It is challenging to establish a standardized process or mechanism. Consequently, developing a single, generic information system to cater to the varied needs of all communities is difficult.

Based on the characteristics of urban governance business, although various cities have established mid-end platforms, the capabilities of existing platforms cannot fully cover all types of business requirements. This leads to the inability to directly use the established platforms, and issues such as consistent page styles, smooth operations, and seamless business connections between multiple systems. Furthermore, many temporary and fragmented demands require technology vendors to provide long-term on-site customized development services. This has resulted in the digitalization of urban governance ultimately evolving towards the independent and self-contained construction of several business systems, forming the independent development of various "N applications" in different fields.

In order to activate the urban business mid-end platforms and the data mid-end platforms, and enable business departments to truly utilize them, it is necessary to focus on the common business links of smart cities. This involves providing service capabilities that can be directly used by business departments (services that can be combined and linked across multiple stages), as well as providing service capability configuration. This transforms the common capabilities of the mid-end into open component services that can be flexibly configured and freely combined. Ultimately, through the three methods shown in the Figure 3-20, the barriers of traditional independent development of "N applications" are broken, enabling technology vendors to efficiently and conveniently access them and allowing business personnel to use them simply and quickly

(1) Construct a standardized version of the urban governance workspace:

Data elements are instantiated, which allowing the business personnel to directly use data warehouse data based on a map window, customize views according to business scenarios, and directly apply platform functions through the urban work window to meet temporary and fragmented business needs, eliminating the need for continuous maintenance and data development by the technical team. Government staff can autonomously and flexibly use the system's capabilities and services. Focusing on the core work of government management and serving city residents, five atomic capabilities have been abstracted and refined from a large number of actual business scenarios: entity resource management, map window, data resource management, search, and application management. These capabilities enable government staff to quickly handle a large number of frequent and fragmented demands in the city through flexible configuration and free combination, significantly improving their work ability and efficiency, enabling primary level staff to execute tasks efficiently, middle-level staff to solve problems independently, and high-level staff to make precise decisions, thereby activating every government employee.

(2) Establishing a unified management platform for capability open services through business component encapsulation and low-code configuration tools:

This platform enables the service-oriented transformation of business capabilities from various mid-end platforms. By adopting a service-oriented construction method based on urban governance scenarios, and leveraging a unified platform and framework, it allows the fast and personalized service customization for business users. This approach facilitates the rapid service configuration of common capabilities.

(3) Construct applications for urban governance scenarios, the following method can be employed:

Standardized basic component services - by utilizing standardized basic component services such as permissions, messaging, and data query services, the interconnection between users and data can be achieved without breaking the small business loops. This helps to enhance work efficiency (Figure 3-21).

By implementing the above methods, the ultimate goal is to enable the external access to the capabilities from various mid-end platforms. This aims to create a digital government business application ecosystem, continuously build innovative scenarios, rapidly customize business interfaces and interaction logic, and achieve end-to-end business loops. This approach caters to the

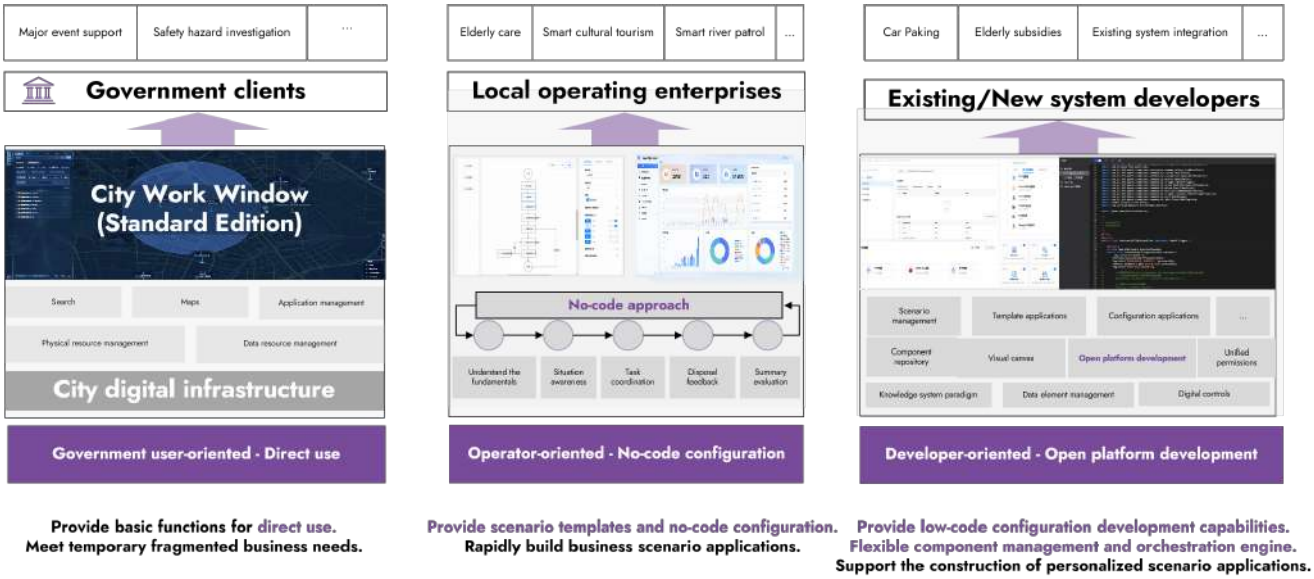


Figure 3-20: Breaking the barriers of "N Applications" in urban governance
Source: Created by author

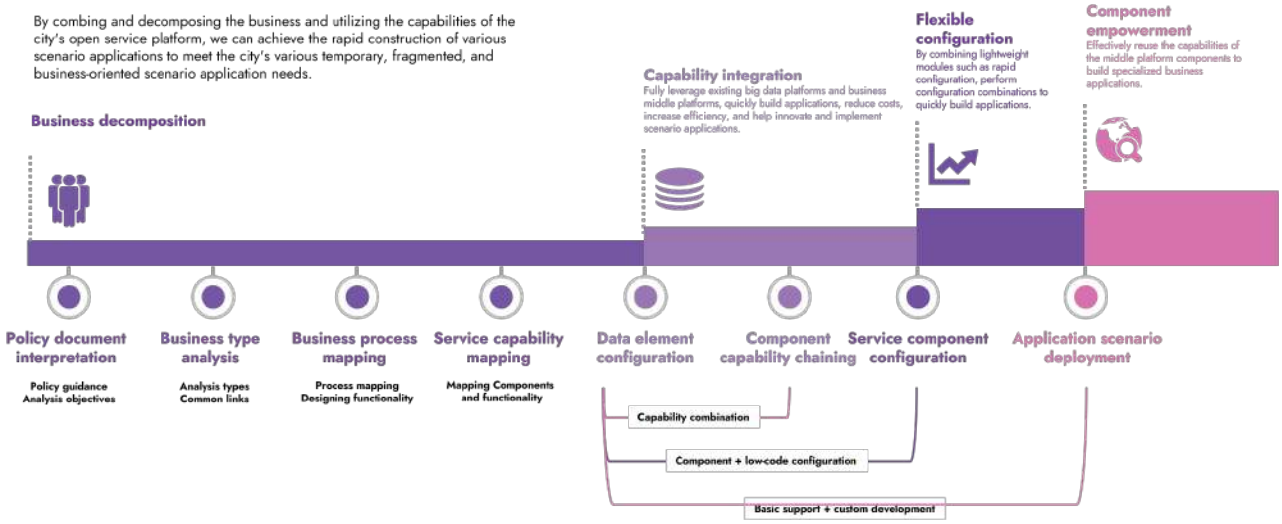


Figure 3-21: Construction method for urban governance scenario applications
Source: Created by author

diverse temporary, fragmented, and business-oriented application needs in cities. The specific structure and platform positioning can be seen in Figure 3-22.

(1) Application access portal (external to internal)

The platform provides application access APIs and program development SDKs to third-party developers, enabling them to register applications, perform environment integration, and access unified authentication in a unified and streamlined manner.

(2) Central hub for capability openness (internal-external integration)

The platform collaborates with internal service providers to offer secure, trustworthy, and

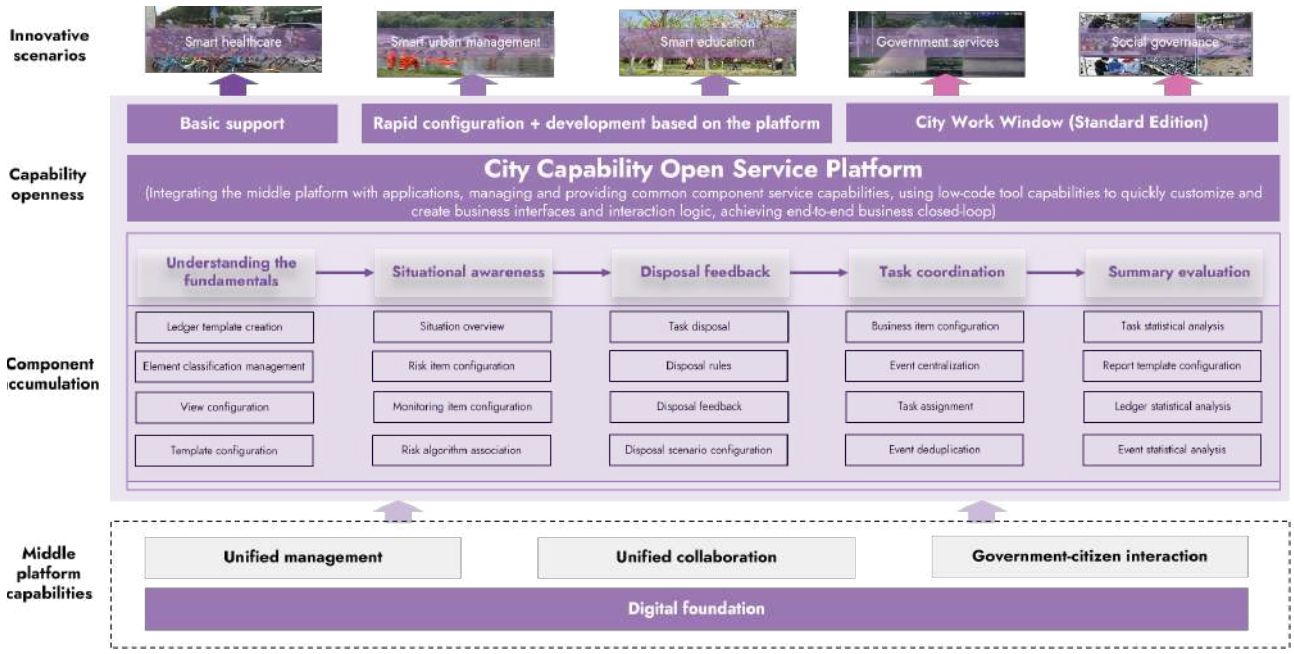


Figure 3-22: Overall design of urban capability open service platform
Source: Created by author

high-quality capability service resources. It continuously expands the scope and boundaries of capability service openness, and also connects with external service demand parties to enhance service invocation efficiency and reduce the barriers to service invocation.

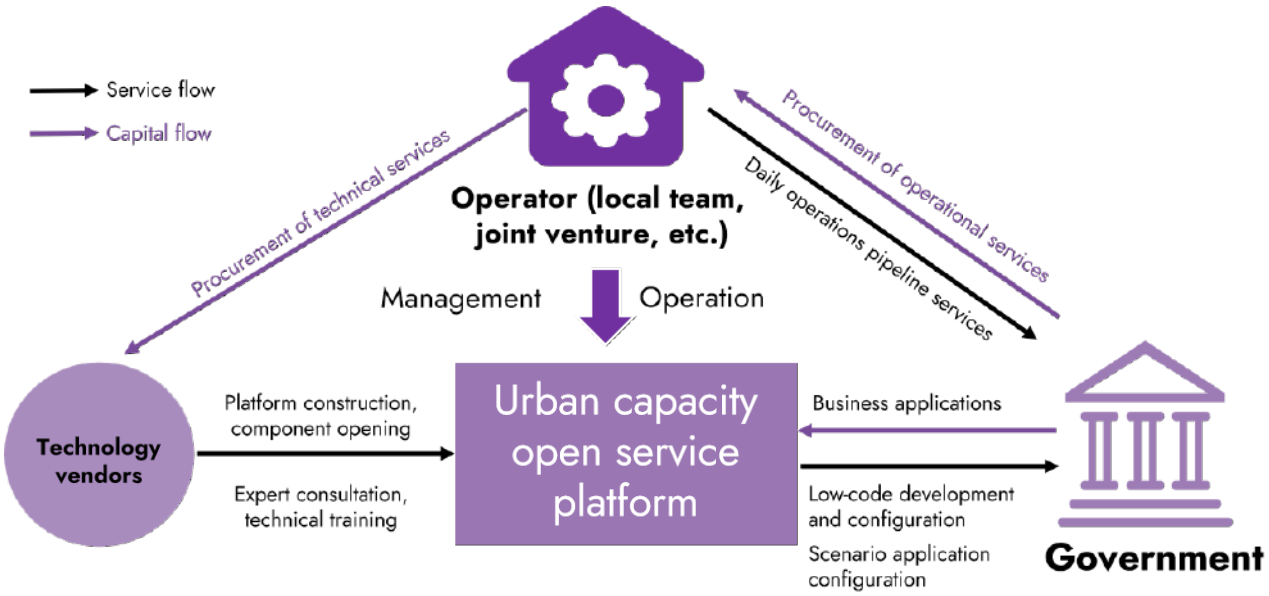
(3) Data provision portal (Internal to External)

A unified and standardized public data open platform is established to ensure data security and control. Public data is categorized and opened in a graded manner. The platform gradually extends from public data to social data and sets differentiated openness conditions for different data resources. This approach promotes the integration and development of public and social data resources in an orderly manner, thereby enhancing the utilization efficiency of data resources.

3.4.3 Maximizing reuse and forming a sustainable service operation

After completing the foundational steps of data integration, mid-end platforms construction, and capability exposure, digital urban governance requires continuous provision of operational services and innovative application scenarios to adapt to evolving business needs. This necessitates a shift from the traditional, time-consuming, and costly project-based model to a sustainable operational service model that can be adjusted based on local conditions.

Through collaboration between technology companies, operation teams, and government entities, future digital urban governance will become more technologically advanced and adaptable to local needs. Governments will procure services from operation teams, including ongoing development of new application scenarios, refinement of data elements, and enhancement of mid-office components. Concurrently, a classification and grading system will be implemented for government staff based on their roles and responsibilities. Local operation teams will work hand-in-hand with technical experts to accomplish these tasks. The ultimate goal is to establish a new system for digital urban governance that adheres to unified standards, offers open services, and is capable of self-updating and sustainable development (Figure 3-23).



Technological ecosystem, localized services

Unified standards | Open services | Self-updating | Sustainable development

Number	Operation service type	Operation service sub-item
1	Temporary, fragmented application configuration (temporarily meeting business needs, not customized - such as securityinvestigation tasks, emergencies, major event support, etc.)	
2	Scenario construction services	
3	Contacting services for internal and external system	
4	Data elements service	Data element construction and maintenance
5		Knowiedge system maintenance
6	Algorithm development and operation	Video algorithm development
7		Multi-source fusion algorithm development
8		Agorithm managamment operation and maintenance serwices
9	Component development and operation	
10	Daily operation and maintenance services	

Figure 3-23: Design of the operational service model for digital urban governance
Source: Created by author

04

Case Studies

Chapter 4 Case Studies

This chapter focuses on the ten major digital urban governance scenarios mentioned in Chapter 2, covering a wide range of aspects such as primary level governance, data operation, traffic governance, ecological protection, healthcare, e-government and people's livelihood services, and provides five city and five enterprise case studies to provide Chinese strategies and solutions for other cities around the globe to leverage digital innovation in urban governance.

4.1 Urban cases

4.1.1 Pinghu City: the application of "GanZhiHui + Event Hub" in urban governance

1. Background

During the process of building a smart city, Pinghu City in Zhejiang Province identified several issues in its "perception network" construction and primary level governance. These include the mismatch between perception network construction and holistic intelligent governance, disorganized development of perception devices and platforms, weak collaboration and data sharing, redundant device installation, and inconsistent data standards between perception projects and government services, leading to weak analytical capabilities. In primary level governance, problems include dispersed reporting channels for urban governance incidents, inconsistent responses from departments, difficulties in cross-department coordination, low efficiency in collaborative processes, and poor vertical communication.

To address these challenges, Pinghu City developed a comprehensive smart governance platform that integrates multi-level information collection, data, algorithms, models, and knowledge resources. Utilizing the event center, this platform facilitates multi-level, cross-departmental collaboration, supporting modernized governance capabilities and enhancing the city's services. This new model promotes deeper integration, unified coordination, and intelligent services in urban management.

2. Main contents

CTOS manages various urban resources and applications, providing a unified interface and collaborative work channels, thereby building an intelligent hub for government information. This creates an interconnected smart city network that spans across levels, regions, and sectors. In practical applications, CTOS empowers data utilization to optimize resources and generate additional revenue streams. It also plays a crucial role in primary level governance, urban management, and flood prevention by leveraging the intelligent event center and the IoT-based perception platform to achieve efficient resource integration and unified management of events across the city.

Guided by major applications, the system promotes integrated reforms based on the principles of "data integration, sector integration, and department integration." It innovatively constructs the "1+1+8+N" smart city development framework, which consists

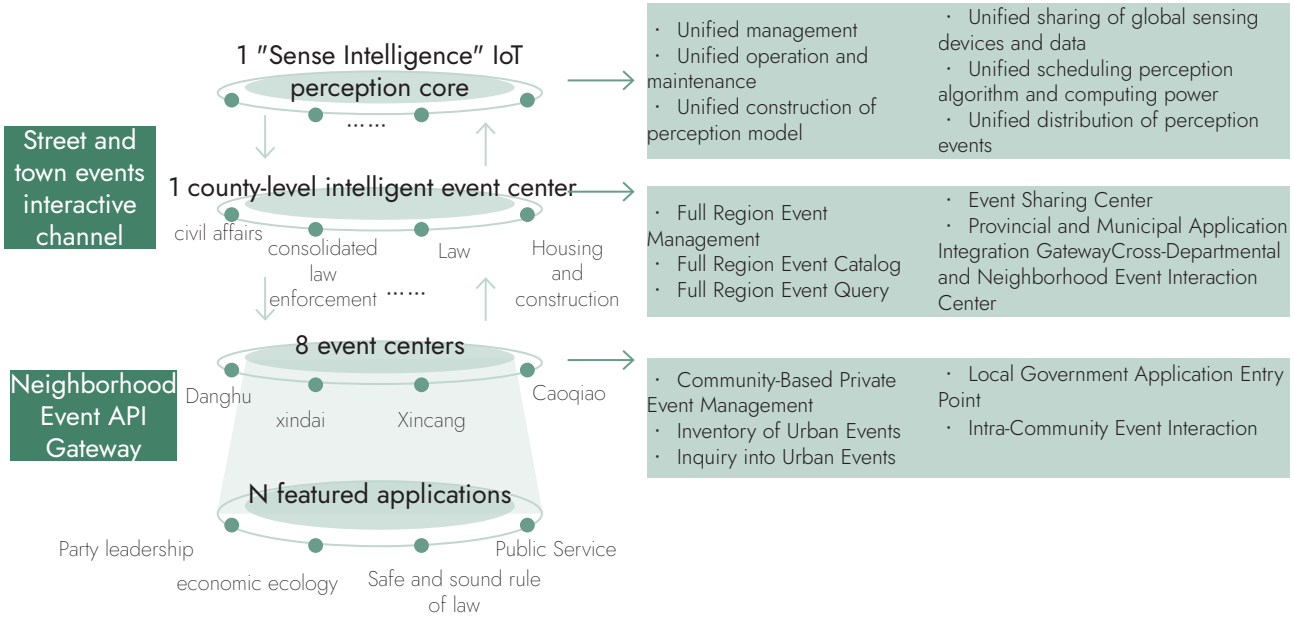


Figure 4-1: "1+1+8+N" smart city development framework
Source: Provided by Pinghu City data bureau

of one core IoT perception platform, one city-wide intelligent event center, eight sub-event centers, and numerous specialized primary level applications. This framework aims to advance comprehensive intelligent governance across the city.

The "core" focuses on building the IoT perception platform as the cornerstone for intelligent governance and resource coordination. The "center" refers to the city-wide intelligent event center, responsible for overall event coordination and management. Eight sub-event centers are established in various districts, ensuring smooth communication and event handling citywide. Additionally, the system integrates numerous specialized primary level applications, which are continuously iterated, jointly developed, and shared.

This model enables a comprehensive and scalable approach to smart city governance, with each component working together to ensure a high level of integration, efficiency, and innovation across multiple urban sectors (Figure 4-1).

At the implementation level, the most critical aspect is the construction of the "Sense Intelligence Hub" platform, which integrates the foundation of intelligent governance with the core for resource aggregation and coordination. This platform consolidates all perception resources and data while establishing a city-level computational power and algorithm configuration center. The goal of this initiative is to provide AI analysis capabilities for video data across the city and offer intelligent support for primary level governance.

Building on the "Sense Intelligence Hub" platform, a city-wide intelligent event center has been established, which connects provincial, municipal, and district-level gateways. This system facilitates the seamless flow of major applications from higher levels and the efficient, multi-channel, closed-loop handling of events at lower levels. The system supports interactive coordination, command through a unified screen, and unified network management, ensuring high efficiency and collaboration in event processing. The data flow process between the core IoT platform

and the intelligent event center is outlined in the diagram provided.

This setup allows for real-time data interaction across levels and ensures that event management is streamlined, effectively enhancing the city's governance capabilities.

Additionally, in Pinghu City's eight towns and districts, "sub-event centers" have been established to provide SaaS-based services. These centers integrate essential applications for public services, urban development, public safety, emergency management, social security, and economic ecology. This standardized approach to building primary level event centers lays a solid foundation for future expansion.

To encourage citizen participation in smart city development and enhance the satisfaction of government services, the "Snap-and-Report" mobile platform was launched. This platform serves as a tool for both citizens and primary level staff to report issues, as well as to receive, process, and provide feedback on tasks. Through this platform, citizens' needs and feedback can be collected and consolidated in real time, enabling the identification of genuine service demands and achieving a fully closed-loop management process for comprehensive intelligent governance.

Finally, this solution is dedicated to building multiple application scenarios for digital urban governance, referred to as the "N application scenarios." By developing a list of "city-level common applications + town/district-specific applications," the "Sense Intelligence Hub + Event Center" rapidly empowers 39 featured scenario applications. These include "Smart Landscaping," "Urban Flood Prevention," and the "Ten Situations Map," among others.

3. Innovations

(1) Institutional and mechanism innovation

The system shifts from human-driven coordination to application-driven workflows, creating a multi-dimensional perception network that integrates all sensing resources and data. The platform supports 39 operational scenarios, including real-time video processing and event management, with a 98% incident resolution rate. A centralized digital event center was developed, enabling multi-department coordination and rapid issue resolution.

(2) Methodological innovation

The city optimized its project management lifecycle for digital urban governance, providing end-to-end services across various departments. Pre-implementation, it ensured data and sensing resource integration, while post-implementation, it guided the consolidation of data onto the public platform and ensured compliance with smart city standards.

(3) Implementation network innovation

The CTOS urban operating engine was developed, comprising five horizontal and two vertical layers, including infrastructure, data lakes, application platforms, and business portals. This model improves the integration of data, devices, algorithms, and applications, enhancing governance efficiency. CTOS can be replicated across different administrative regions, forming an interconnected smart city network.

(4) Implementation results innovation

CTOS empowers multiple sectors such as city management and flood prevention, allowing for the shared use of perception resources without additional infrastructure. It also accelerates application development

cycles, significantly reducing time-to-market from months to weeks, enhancing resource utilization, and improving governance efficiency.

4. Achievements

Since January 2023, the "Sense Intelligence Hub + Event Center" solution has achieved notable economic, social, environmental, and management benefits:

(1) Economic benefits

It is estimated that project budgets are reduced by 20% annually. For example, in 2023, through shared video and sensing resources, Pinghu City avoided redundant projects, saving over 50 million yuan directly and more than 100 million yuan in total.

(2) Social benefits

CTOS improves various aspects of smart city services, such as governance, economic development, urban management, and public transportation. It simplifies cross-departmental government services, enhances transportation policies, and provides tailored educational and employment opportunities, all of which contribute to a better business environment.

(3) Environmental benefits

Smart algorithms for air quality, oil smoke, parking violations, and floating waste detection have improved environmental management. Systems for monitoring air pollution, restaurant emissions, traffic, and water quality have reduced pollution and protected the city's ecosystem.

(4) Management benefits

With over 60,000 perception devices installed citywide, the system has improved data sharing and analysis. The intelligent event center accelerates decision-making, allowing departments to respond efficiently to incidents, boosting governance automation and intelligence.

Relevances to SDGs

The construction of the CTOS urban operating engine has generated new economic growth opportunities by fostering the development of high-tech, IT-intensive industries. This transformation supports the shift of the urban economy towards knowledge-based and innovative models, driving efficient, low-cost, and sustainable economic growth. By improving the quality of urban economic development and creating a favorable public service environment, this initiative contributes to the achievement of SDG 9: Industry, Innovation, and Infrastructure.

Through the construction of the CTOS engine, a unified city-wide platform for video, IoT, and public data resource management was established, reinforcing the city's infrastructure. The platform provides strong support for scientific decision-making in areas such as flood prevention, sewage treatment, river inspections, comprehensive law enforcement, pollution control, emission reductions, and smart eldercare. These efforts align with SDG 11: Sustainable Cities and Communities, promoting sustainable urban development.

5. Conclusion and reflection

During the implementation of the CTOS engine in Pinghu City's smart city construction, the city achieved unified management of various resources and applications, building a cross-level, cross-region, and cross-sector smart city network. However, several challenges emerged, including issues with operational mechanisms, data aggregation, coordinated

dispatch, and security management.

(1) Operational mechanism challenges

The initial information systems were developed independently, leading to inconsistent progress and fragmented data storage, which hindered data sharing. To address this, Pinghu City reinforced overall smart city planning by adhering to principles of coordination, integration, and data sharing. The city introduced a pre-approval process for projects, covering areas such as public sector projects and information systems in state-owned enterprises. Pinghu became the first county-level city in the province to implement a unified oversight mechanism for all government-side projects. Multiple departments, including the Security Bureau, Development and Reform Commission, and Data Bureau, were brought together to review the content, technical route, budget, and security aspects of projects, ensuring alignment with the city's comprehensive smart city plan.

(2) Data aggregation challenges

The city faced issues with a large number of vendors, varying device models, inconsistent standards, and difficulties in resource sharing. To overcome this, unified access standards and sharing rules for perception devices were established, resulting in 16 standard norms, including the "IoT Device Identification Standards." By introducing secure networking standards, the city interconnected government, video, and specialized business networks. Furthermore, by adopting a "digital twin" approach, perception devices from different manufacturers were decoupled from their models, allowing centralized control through a single platform.

(3) Coordinated dispatch challenges

In primary level governance and government services, fragmented reporting and processing systems, along with barriers between departments, hampered coordination and efficient handling. To resolve this, city-wide dispatch and event process configuration standards were introduced. A tool for configuring event workflows was developed, enabling rapid setup of business processes and applications. This allowed local officials to handle all tasks on a single platform, enabling data-driven event management and dynamic reporting, providing a solid foundation for decision-making in smart city collaboration.

(4) Security management challenges

Challenges related to unclear operational permissions, scattered data management, weak security monitoring, and risks in data sharing were addressed by implementing seven key data security measures, including classification and control, data auditing, encryption, and secure data perception. A unified data resource system was created to centralize data storage and management, significantly improving security, utilization, and multi-dimensional analysis capabilities.

Through these measures and lessons learned, Pinghu City achieved breakthroughs in dispatch coordination, enhancing automation and intelligence in city management. This provides valuable digital resources and technological support for innovative applications in areas such as primary level governance, environmental monitoring, and disaster response.

4.1.2 Guilin City: digital technologies empowering Li River ecological governance

1. Background

The Li River originates from Mao'er Mountain, the highest peak in South China, located

in the junction of Xing'an County and Ziyuan County in Guilin, Guangxi Zhuang Autonomous Region, China, at an altitude of 2,141.5 meters. Known as Guilin's mother river, the Li River spans 214 kilometers and covers a basin area of 12,000 square kilometers, affecting six counties and six urban districts with a total population of around 3.6 million people. The Guilin karst landscape, spanning 253.8 square kilometers on both sides of the river, has been listed as a UNESCO World Natural Heritage site.

Over the years, the Li River and its surrounding areas have faced various environmental challenges, such as illegal constructions, excavation, farming, and operations, as well as sanitation issues. Due to the extensive area involved, the protection and management of the Li River have encountered numerous challenges, including cross-level, cross-regional, cross-departmental, and cross-system collaboration difficulties. Traditional monitoring methods often suffered from delayed data collection, information silos, and slow response times. Thus, digital governance methods became necessary to address these issues.

In recent years, both the central government of China and local authorities in Guilin have placed great emphasis on ecological governance of the Li River. Their vision is to elevate ecological protection into a digital era, with the overarching goal of achieving "Smart Mountains and Wise Waters, an Ecological Li River." This initiative seeks to enhance the efficiency and effectiveness of ecological protection and management of the river, integrating advanced technologies such as 5G into every aspect of environmental protection, tourism services, operations, and supervision. The ultimate aim is to build a comprehensive, intelligent system for the protection and management of the Li River, enabling real-time ecological and tourism management, enhancing enforcement measures, and ensuring the effective governance of the river's ecosystem.

2. Main contents

The total investment in this project is 3.16 billion yuan, including 50 million yuan from the central budget and 2.66 billion yuan from other sources. The project is divided into 20 sub-projects, including the Digital Li River Data Hub, a Visual Command and Dispatch Center, a Digital Li River Sand Table, a 5G Application Cloud Platform, the construction of 5G New Energy Bamboo Rafts, and a Metaverse Tourism Platform. The Guilin Li River Tourism Investment and Operation Co., Ltd. has entered a strategic cooperation agreement with the China-ASEAN Information Harbor Co., Ltd., while Guilin Dongxin Cloud Technology Co., Ltd. is responsible for implementation. The project timeline spans from July 2021 to December 2023.

The project's overall architecture follows a "1 Center + 1 Hub + N Applications" model. The "1 Center" refers to the Li River Cloud Computing Center, comprising green computing infrastructure like cloud hosting, storage, and security. The "1 Hub" refers to the Digital Li River Smart Hub, comprising business services, data services, and a visual command and dispatch center. "N Applications" represent the four application systems of ecology, regulation, services, and operations.

By March 2022, foundational infrastructures such as the smart hub, green computing, the 5G green intelligent private network, and the visual command and dispatch center were completed. By December 2022, the deployment of ecological applications, including the Li River holographic digital sand table, large-scale ecological safety monitoring, and services for monitoring water quality,

mountain conditions, and biodiversity, was completed. By June 2023, law enforcement and regulation functions were enhanced through 5G+ technologies, and mobile law enforcement equipment was deployed. By December 2023, data integration and system interconnection across multiple departments (including public security, judiciary, ecological environment, and others) will be finalized, along with the rollout of service applications such as the Li River ecological publicity platform and digital twin ecological experience modules.

3. Innovations

(1) Enhanced data sharing and cross-department collaboration

To address the challenges of data sharing among departments, the Guilin municipal government established a special leadership group. This group coordinated the aggregation of monitoring data and videos related to the ecological protection of the Li River into a unified data hub. Eleven municipal departments signed data-sharing agreements that specify the data content, update frequency, and connection methods, facilitating the seamless exchange of air quality, water quality, forestry vector data, satellite imagery, and ecological enforcement information. This cross-departmental collaboration allows law enforcement agencies to quickly detect and respond to ecological damage, significantly improving the accuracy and efficiency of law enforcement.

(2) Smart law enforcement and judicial applications

This project integrates modern technologies such as big data, cloud computing, and artificial intelligence with the law enforcement and judicial systems for ecological protection of the li river. By leveraging digital tools for online enforcement, the project enhances the governance capabilities of the li river scenic area.

(3) Innovative legislative oversight of ecological protection

To empower legislative representatives in monitoring, collecting public opinions, and promoting legal awareness, this project has developed a "Legislative Oversight" module, with a mobile app to support it. The system covers 12 counties and districts, 307 representative platforms, and 9 primary level legislative contact points, enabling 6,576 representatives to participate in real-time, online supervision of the ecological protection efforts of the Li River (Figure 4-2).

4. Achievements

(1) Ecological benefits

The platform enables round-the-clock monitoring of water quality, biodiversity, boat navigation, and scenic spots. The water quality of the main stream of the Li River has consistently maintained Class II standards, while the forest coverage in the Li River basin exceeds 80%. The ecological quality index of the Li River from 2021 to 2023 remained at the highest level (85.86, 86.45,

Figure 4-2: Digital Li River 5G Fusion Ecological Protection and Utilisation Comprehensive Platform
Source: Guilin Li River Scenic Spot Management Committee

86.55 respectively) and continues to improve annually.

(2) Social benefits

The tourism service applications of the platform have boosted hotel reservations, dining, transportation, advertising, and local product sales, benefiting between 250,000 to 300,000 people employed in related industries.

(3) Economic benefits

The Metaverse application for tourist attractions, such as Elephant Trunk Hill, attracts around 70,000 visitors per day, driving the development of new tourism business models and diversifying the industry. In the first half of 2024, Guilin welcomed 78.05 million tourists, a year-on-year increase of 10.58%, generating 94.73 billion yuan in tourism revenue, a 12.21% increase from the previous year.

Relevances to SDGs

The platform directly supports SDG 6: Clean Water and Sanitation by ensuring 24-hour monitoring of water quality across the Li River and its tributaries. Additionally, it creates job opportunities in the high-tech and environmental sectors, contributing to SDG 8: Decent Work and Economic Growth. Through intelligent ecological protection, the project aids SDG 11: Sustainable Cities and Communities. The use of new energy bamboo rafts reduces pollution, supporting SDG 13: Climate Action, while biodiversity monitoring protects endangered species in the area, promoting SDG 15: Life on Land.

5. Conclusion and reflection

During the implementation and operation of the Li River Digital Ecological Governance Platform, two key challenges emerged: multi-departmental coordination and data sharing, as well as the comprehensive utilization of multi-scenario applications.

(1) Multi-departmental coordination and data sharing challenge

The platform requires the integration of ecological and natural resource data from various districts and departments across the Li River basin. However, inconsistent data standards and the need for coordination among multiple departments present significant challenges. In response, Guilin's municipal government took a proactive approach, establishing a special leadership task force to ensure high-level support. Eleven municipal departments signed data-sharing agreements, while technical teams formed a working group to establish unified metadata standards, gradually overcoming information silos and enabling seamless data integration and sharing.

(2) Comprehensive utilization of multi-scenario applications challenge

As a comprehensive platform designed to empower the digital governance and protection of the Li River, the project involves significant investment. Maximizing the platform's utility across various application scenarios remains a challenge. To address this, the project expanded into new areas such as smart law enforcement and judicial supervision, and developed virtual tourism applications powered by AR, VR, XR, AI, cloud, blockchain, and digital twin technologies. These innovations have diversified and digitized Guilin's tourism industry, offering visitors an entirely new experience.

Looking ahead, Guilin plans to extend the platform's capabilities by creating a digital

twin for the Yulong River, a tributary of the Li River, and introducing enhanced flood monitoring and early warning systems.

4.1.3 Yantian District, Shenzhen City: the application of the smart urban management information system in digital urban governance

1. Background

Since its establishment, Yantian District in Shenzhen has implemented both the "Boutique Strategy" and the "Feature Enhancement Strategy," rapidly developing into a modern coastal urban district. However, as the city expanded, urban management challenges became more prominent. The passive, delayed, and static management methods could no longer meet the needs of refined urban management.

To address these issues, Yantian District explored modern paths for urban management, building a Smart Urban Management Information System powered by IoT, big data, and AI. The system integrates five core functions—perception, analysis, service, command, and supervision—aiming to significantly enhance the precision, standardization, and intelligence of urban management.

This digital solution strengthens the use of next-generation information technologies like IoT, big data, and AI. It integrates digital urban management, command and dispatch, and public services into one smart system. This provides robust technical support for urban management sectors such as public environment, landscaping, urban order, and city infrastructure, effectively improving urban perception, data analysis, public interaction, command and control, and regulatory oversight.

2. Main contents

(1) Establishment of six major systems

The system comprises six major application systems, nine sub-systems across various urban management sectors, and a unique district-wide daily sanitation inspection system. This forms the "1116N" smart urban management model, covering 24/7, fully integrated and intelligent monitoring and supervision of digital urban management and municipal sanitation.

(2) Closed-Loop management process

The system's core is a seven-step closed-loop process for addressing urban management issues, enabling information synchronization, collaborative work, and coordinated supervision across departments. It also supports detailed management systems for sanitation, park management, waste sorting, and public services.

3. Achievements

The system significantly enhances urban management efficiency and event handling capabilities, reducing manual labor. For instance, the time for detecting and resolving urban management incidents dropped from 12 hours to 4 hours. From its launch to May 31, 2024, the platform handled around 232,400 incident cases, 19,800 component cases, and 141,500 sanitation cases, achieving a resolution rate of 99.77%. Citizen involvement through the mobile app ensured that public issues were promptly addressed, with satisfaction rates exceeding 99.5%.

Leaders and experts from the Ministry of Housing and Urban-Rural Development have highly praised Yantian's Smart Urban Management System, calling it the "most advanced, complete, effective, and

Figure 4-3: Yantian District Intelligent Urban Management '1 1 1 6 N' Mode Chart
Source: Shenzhen Yantian District Urban Management Bureau

implementable" smart application system in the country, making it a benchmark for smart urban management nationwide. In October 2019, the Ministry organized a visit for over 120 leaders from urban management units across the country to observe and study the system. Additionally, the system was recognized with the China Geographic Information Industry Excellent Engineering Gold Award in 2020 and the National Excellent Surveying and Mapping Engineering Bronze Award in 2021.

Relevances to SDGs

This proposal emphasizes the creation of an open innovation space centered on people, citizen participation, and social collaboration, as well as the generation of public and unique value. It focuses on enhancing urban management efficiency, starting from citizen needs, and strengthening user engagement through mobile platforms to achieve sustainable economic, social, and environmental development.

Upon project completion, it has improved the overall level of information technology in the Yantian District, driving the development of IT infrastructure, data governance, sanitation operation services, and a series of upstream and downstream industries. This aligns with the realization of Sustainable Development Goal 9 (SDG9) related to industry, innovation, and infrastructure.

By integrating information resources from various channels, it facilitates the in-depth development of departmental business, macro decision-making, workflow and method improvements, and enhances inter-departmental collaboration capabilities. This collaborative effort aims to improve urban management efficiency and is dedicated to achieving Sustainable Development Goal 11 (SDG11) concerning sustainable cities and communities.

Utilizing information technology and digital methods, it enables the electronic, networked, and transparent management of urban operations, thereby reducing or eliminating the use of traditional paper documents, lowering costs and resource consumption, and enhancing resource utilization efficiency. This promotes energy savings and fosters

green, low-carbon development, contributing to the realization of Sustainable Development Goal 13 (SDG13) on climate action.

4. Conclusion and reflection

During the implementation of this digital solution, the main challenges encountered were technical issues and societal acceptance. The Yantian District effectively addressed these challenges using the following methods:

(1) Technical challenges

The system involves complex technical integration and data processing, utilizing a significant amount of foundational topographic data and geocoding data. The geographic information platform required in-depth adaptation to the business systems. To achieve this, the technical team conducted thorough research on leading vendors in the market and engaged in extensive communication and adaptation, ultimately selecting the most suitable products to ensure the system's stability and reliability.

(2) Societal acceptance

The adoption of new technology necessitates active cooperation from both citizens and employees. In the early stages of the project, inspection personnel collected data while navigating through the city's streets and alleys, identifying issues related to sanitation and damaged components. During this process, some merchants and citizens expressed misunderstanding. To address this, promotional efforts were implemented through text messages and public accounts, enhancing public and employee understanding and acceptance of the smart city system, thus alleviating concerns and discomfort regarding the introduction of technology.

Reflections

(1) Strengthening data sharing and service capabilities:

By integrating urban management data, we established a comprehensive database for urban management and ensured timely updates of data according to standards. This promotes interconnectivity and open sharing of public data resources across multiple departments, facilitating vertical and horizontal data flow.

(2) Enhancing government command and decision-Making capabilities:

Real-time monitoring of urban operational conditions, while ensuring connectivity with various streets and departments, establishes a coordinated mechanism. This approach helps uncover inherent patterns and characteristics of urban operations, enabling early warning systems and addressing persistent urban issues.

(3) Deepening urban management assessment and evaluation capabilities:

By aligning with the latest urban management assessment policies from various regions and integrating the evaluation systems of different industries within urban management, a comprehensive assessment framework for urban management is about to be built.

In the future, Yantian District will continue to deepen its smart city management information system, leveraging AI optimization, inter-departmental collaboration, and AI-assisted decision-making to empower digital urban governance.

(1) AI optimization:

Further enhancing the application of AI technology in urban management through various intelligent collection methods, such

as mobile vehicle-mounted 360-degree collection and drone surveillance. The "Five-in-One" event handling process, featuring automatic discovery, automatic positioning, automatic warning, automatic dispatch, and automatic statistics, will efficiently support the complete management of events.

(2) Inter-departmental collaboration:

Strengthening information sharing and collaborative efforts among departments by constructing a "professional + mechanism + big data" service model for urban operational management. This approach aims to transform urban management services, fostering a cooperative environment with strong coordination among various stakeholders.

(3) AI-assisted decision-making:

By analyzing data from various sectors, including event management, sanitation, and landscaping, AI technology will provide decision-makers with data support and intelligent analysis, assisting in more scientific and accurate urban management decision-making.

4.1.4 Anji County, Huzhou city: the application of a one-stop smart travel platform in urban traffic management

1. Background

During the development of a smart urban traffic system, Huzhou Anji County identified challenges such as fragmented services, multiple platforms with limited functionality, and an inability to meet the public's need for seamless "one-window" service throughout their travel journey. Additionally, transportation companies operated independent information systems, preventing data sharing and resource integration, while governmental departments faced barriers to real-time collaboration and coordination. Issues with traffic monitoring, vehicle tracking, and identity verification also highlighted the need for improved industry safety regulation. Addressing these issues through a one-stop smart travel platform became a priority.

Huzhou Anji County employed advanced mega data and AI matching algorithms, integrated with cloud computing and IoT technologies, to bring together various public transportation methods. This created a smart travel ecosystem, empowering digital innovation and forming three core scenarios: "one-stop service, integrated operations, and one-window regulation." The platform focuses on four sub-scenarios: "intercity travel, local travel, travel support, and value-added services," featuring over 8 applications. Intercity travel integrates customized and long-distance transportation, as well as tourism charter services, while local travel offers multiple options such as buses, car rentals, and ride-hailing. Travel support focuses on digital management of charging and parking, and value-added services extend to various fields to provide comprehensive services to both citizens and tourists.

2. Main contents

The one-stop smart travel platform optimizes service resources, improves business operations, and strengthens government governance, significantly contributing to modern urban management. It addresses public transportation challenges, boosts the tourism economy, and promotes resource integration and information sharing within the transportation industry, reducing operating costs for businesses. Additionally, the platform enhances public transportation data systems, strengthens industry safety oversight, breaks down information barriers, and fosters cross-departmental collaboration, laying a solid foundation for constructing a smart, safe, and

efficient modern urban governance system. The implementation of this plan is divided into three phases:

Phase 1: Establish an expandable and reusable ecosystem, optimizing information and business flows, enhancing comprehensive management and emergency response. This phase aims to create a public travel platform that improves information service quality, enables precise travel planning, station arrival predictions, and road condition monitoring, increasing public trust.

Phase 2: Strengthen industry supervision by consolidating enterprise data to assist in decision-making and resource allocation. Transportation data is integrated and standardized to ensure closed-loop management of data quality, enabling production collaboration and decision support.

Phase 3: Integrate transportation data and streamline regulatory processes to build a core information network, merging data from multiple businesses into a unified system. Focus on key business points, launch applications centrally, and enhance overall information capabilities, serving governance, public welfare, and decision-making. The goal is to construct an efficient, safe, and environmentally friendly smart transportation system that supports urban development and public travel.

In 2023, this project was recognized as an excellent case in Zhejiang Province's digital economy development.

3. Innovations

Reform of public transportation services: Meeting the high-frequency travel needs of the public.

Innovative mechanisms: Promoting standardized participation through market-oriented and socialized approaches.

Strengthened smart traffic management: Facilitating the integration of intelligent city management.

4. Achievements

The one-stop smart travel platform offers customized transportation services, such as "custom buses" and "school buses," with 372 routes between Anji and Hangzhou-Huzhou, serving over 307,500 passengers and running more than 90,000 trips, averaging 270 passengers per day. The "custom bus" service meets personalized travel needs for students, commuters, and tourists, enabling intelligent reservation and management. The "school bus" service operates on 35 routes, serving over 413,000 students. Operational hours have been reduced by 50%. The integration of business operations has cut project duplication by over 10 projects, saving more than 20 million yuan in development costs. The vehicle fleet has been reduced by 10%, with idle vehicle rates down by 50%, and operational efficiency increased by over 20%. Optimized urban intersections now have 20 improved turning signals, enhancing traffic flow. Over 1,000 automatic warnings for illegal parking have been issued, resulting in a reduction of over 45% in parking fines.

The platform allows citizens to easily book services via mobile phone, catering to high-frequency travel needs such as medical appointments, airport and high-speed rail connections, and shopping. The platform leverages digital optimization through a traffic control center, collaborating with departments like the Traffic Bureau, Transport Bureau, Public Security Bureau, and Urban Management to improve intersection signals and enhance urban traffic efficiency.

Long-term benefits

Enhanced urban transportation efficiency: Reducing congestion and pollution while boosting the city's overall appeal and competitiveness.

Promotion of intelligent transportation industries: Stimulating industrial development and upgrading.

Improved public quality of life: Offering personalized travel services while strengthening the trust and interaction between government and citizens, laying a foundation for social harmony.

Relevances to SDGs

The platform optimizes traffic resource allocation, improves service efficiency, reduces operating costs, and promotes healthy industry growth. It provides better employment opportunities and working conditions for transportation workers, contributing to SDG 8: Decent Work and Economic Growth. Additionally, the platform helps reduce congestion and emissions through diverse travel options and efficient traffic management, improving urban environments and supporting SDG 11: Sustainable Cities and Communities. By enhancing the overall efficiency of the transportation system and promoting low-carbon travel, it supports SDG 13: Climate Action, helping mitigate climate change and protect the planet's ecosystem.

5. Conclusion and reflection

During the construction of the one-stop smart travel platform, challenges such as misalignment between gateway construction standards and system deployment, insufficient data security and privacy protection measures, and difficulties in data sharing were identified. These issues were addressed as follows:

Gateway construction standard misalignment: By analyzing the differences between gateway standards and system deployment, appropriate solutions were found to push forward cloud migration and ensure smooth system integration with the public data platform.

Data security and privacy protection: A data security monitoring subsystem was implemented to strengthen monitoring and protection during data transmission and storage, ensuring data integrity and confidentiality.

Data sharing: Collaboration with the public data platform's technical team enabled successful real-time data transmission and sharing.

4.1.5 Fuyang District, Hangzhou City: the application of "cross-hospital recognition of examination and test results" in urban governance

1. Background

During the promotion of health system reform and the development of the "Healthy Fuyang" initiative in Fuyang District, Hangzhou, several challenges were identified. These included duplicate and excessive tests, and reliance on tests for income ("using tests to subsidize medical services"). These issues not only burden patients but also consume valuable medical resources. Additionally, differences in test result standards between hospitals, difficulties in accessing data during consultations, and risks in quality control when sharing information make mutual recognition of test results a key challenge in healthcare reform.

To promote digital transformation in the healthcare sector and improve governance in Fuyang District, digital tools have been

utilized to establish three main systems: "recognition standards, digital applications, and institutional guarantees." This aims to resolve the challenges of mutual recognition of test results across different medical institutions within the region. The goal is to make healthcare more time- and cost-efficient for patients, ensure medical practices are standardized and rational, improve the efficient use of medical resources, and foster a more harmonious doctor-patient relationship as part of a future-oriented digital healthcare reform.

2. Main contents

(1) Establishment of test and examination recognition standards

Following the principles of "meeting public needs, high-frequency use, and controllable risks," the program identifies project names and codes in batches, outlining rules and technical standards for direct recognition, non-recognition, and recognition time limits. The goal is to create "one set of rules for each project." A committee of medical, legal, and administrative experts from the provincial, city, and district levels oversees the application, review, implementation, and evaluation of recognition projects to ensure quality control.

(2) Development of a test and examination recognition platform

The platform integrates data from four key departments: Health, Medical Insurance, Human Resources, and Citizen Card Systems. It also connects the business systems of medical institutions at all levels, standardizing the upload of test and examination results into a structured data pool. This enables doctors to quickly access previous reports, limits redundant testing and payment procedures, and sends notifications to patients about recognition status, project reductions, and fee waivers via SMS.

(3) Redesign of institutional guarantees

Four regulations have been restructured, including the "Diagnosis and Treatment Process for Test and Examination Result Recognition and Sharing." Simplified ordering processes for recognized tests have been introduced, and intelligent controls for recognition have been implemented. Eleven new policies have been issued, including measures for medical insurance incentives and special rewards for healthcare staff, ensuring that doctors and hospitals are fairly compensated. Additionally, the Fuyang District government funds a "Recognition Liability Insurance," which covers potential disputes arising from mutual recognition through commercial insurance, alleviating concerns for doctors.

3. Innovation

The "Inter-Hospital Test and Examination Result Recognition" program in Fuyang District leverages digital innovation to ensure the effective functioning of the three main systems: recognition standards, digital applications, and institutional guarantees.

(1) Data sharing

The system architecture is based on an SOA (Service-Oriented Architecture) model, using loosely coupled interfaces, standardized data conversion, unified security protocols, and automatic process management. This allows for mutual recognition and interoperability between hospitals without disruptions from changes on either side, based on standards such as HL7, DICOM, and IHE.

(2) Cloud-based image retrieval

Test and examination images are stored in

the cloud, and can be retrieved from smart devices like computers and mobile phones without loss of quality.

(3) Network security

Following the principles of "public needs, high-frequency use, and controllable risks," standards and protocols for mutual recognition projects are clearly defined. A multi-level committee ensures the quality of recognition projects through standardized project applications, reviews, implementation, and evaluations.

4. Achievements

(1) Provincial and municipal expansion

The program has received strong support from provincial and municipal leaders for its success in reducing patient costs and optimizing medical resource usage. By the end of 2022, the district-level model had been promoted across the entire province under the name "Zhejiang Medical Recognition" and was recommended by the Central Reform Office for nationwide adoption. To date, 320 tests and 116 examinations have been mutually recognized across Zhejiang Province. In Hangzhou, all district and county medical institutions and community health service centers have adopted the system.

(2) Time and cost savings for patients

For example, by recognizing chest CT results, each avoided test saves patients more than two hours of time and about 36 yuan in medical costs (assuming each test costs 180 yuan), while the medical insurance fund saves 18 yuan per test. From July 2021 to November 2023, over 790,000 tests were mutually recognized in Fuyang District, saving the medical insurance fund and patients over 41 million yuan. In Hangzhou, over 1.45 million tests are recognized annually, saving more than 55 million yuan, and in Zhoushan, 220,000 tests are recognized annually, saving over 9.2 million yuan.

(3) Broadening of shared applications

The mutual recognition of test results has expanded beyond the healthcare system. In December 2021, Fuyang District launched the "One Test, Multiple Certificates" application, which integrates health check results with those required for driver's licenses, health certificates, and disability evaluations. This allows citizens to obtain multiple certifications through a single test. Additionally, medical test results have been extended to the issuance of disability certificates, creating a "smart disability evaluation" system that provides remote, hassle-free evaluations.

Relevances to SDGs

The "Inter-Hospital Test and Examination Result Recognition" program in Fuyang District promotes process redesign, the establishment of standards, institutional reforms, network integration, and data sharing. It builds a digital channel for mutual recognition between hospitals and doctors, reducing unnecessary medical expenses and shortening patient waiting times. By enhancing transparency and ensuring policy guarantees, the platform helps protect patients' right to information, prevents repeated medical orders, and mitigates risks for doctors and hospitals, contributing to SDG 3: Good Health and Well-being and SDG 10: Reduced Inequalities.

5. Conclusion and reflection

During the implementation of Fuyang District's "Inter-Hospital Test and Examination Result Recognition" program, several challenges were identified, such as inconsistent standards for test results between hospitals, difficulties

Figure 4-4: Hangzhou inspection and test mutual recognition and sharing of the city's promotion of the scene of reality
Source: Hangzhou Fuyang District Data Resources Management Bureau

in retrieving patient data during consultations, and complexities in expanding the system across regions. Fuyang District addressed these issues as follows:

(1) Inconsistent standards for test results between hospitals

The district developed 11 policies and 277 recognition protocols. During the construction of the recognition platform, it standardized project coding systems across medical institutions, ensuring that data uploads were standardized and of sufficient quality for mutual recognition.

(2) Difficulties in data retrieval during consultations

The district upgraded bandwidth and network infrastructure at provincial, city, and district medical institutions, ensuring seamless connectivity across the three-level healthcare network. It also modified legacy systems at medical institutions and restructured process norms, streamlining the data retrieval and recognition process, allowing doctors to quickly access patients' recent medical records and examination reports.

(3) Complexity of cross-region expansion

The district adopted a top-down approach, driven by higher-level departments, to implement the program step-by-step across multiple levels and ensure effective coordination and implementation.

4.2 Enterprises cases

4.2.1 Ant Group: Alipay digital platform empowering urban public services

1. Background

As global urbanization accelerates, the increasing urban population has led to higher demand for public services. Traditional public service processes are often cumbersome and inefficient, significantly lowering public satisfaction. Additionally, social equity and inclusivity have diminished, leaving the needs of the elderly, vulnerable groups, and remote populations easily overlooked.

To improve the quality of public services, Ant Group has focused on deeply integrating information technology with government services, aiding governments in building efficient, transparent, and convenient "digital government" ecosystems.

Objectives

(1) Improve service efficiency and convenience

Develop a responsive and efficient public service system through an online platform that provides 24/7 services. This allows citizens to access needed services anytime, anywhere. By integrating cross-departmental service processes, it reduces the need for in-person visits and improves the user experience.

(2) Promote resource allocation optimization

Break down information silos and ensure data interoperability, reducing redundant constructions and waste. By transitioning from digital to intelligent services, this enhances the quality of services.

(3) Increase social inclusivity

Leverage digital technology to promote equal and inclusive access to public services. By serving governments and businesses, it also better serves the public, including vulnerable groups, enabling them to access more convenient, inclusive digital services and helping bridge the digital divide.

(4) Build "digital government"

Through deep integration of IT and government services, it helps governments establish a high-efficiency, transparent, and user-friendly "digital government" ecosystem.

2. Main contents

In the field of public services, there are numerous services with varying standards and stability. To improve efficiency and user experience, Alipay has developed platforms for direct services like utility payments and a citizen center, while focusing on building a Public Service Gateway for API access and a digital platform for service integration.

(1) Public service gateway

The Public Service Gateway adapts to various interfaces from public service institutions. It standardizes the diverse service interfaces of over 10,000 partners, ensuring stability and security. By reducing service integration time from weeks to hours, it guarantees swift access to a wide range of services.

(2) Digital platform

The digital platform enhances operational efficiency for complex service systems by decomposing services into manageable components. Through service management and operations, the platform helps users quickly find the services they need from among thousands of options. The platform also emphasizes service inspection and evaluation, continuously improving services in partnership with stakeholders.

(3) AI technology

In public services, the numerous offerings and official terminologies often make it difficult for users to locate the right service. AI has been introduced to address this by providing humanized interactions and business guidance through large language models. This enables quick service location and assistance, reducing barriers to government procedures. It also supports innovative service models like real-time assistance and one-sentence processing.

Ant Group has partnered with Digital Jiangxi to develop "Xiao Ganshi," a digital assistant for Jiangxi's mobile governance platform, Ganfu Tong. "Xiao Ganshi" integrates consultation, acceptance, and processing of various services. Through multiple forms of interaction—voice, text, etc.—it creates a virtual, face-to-face service experience. With AI and large model-driven knowledge production, "Xiao Ganshi" serves as a walking "government knowledge base." As of now, "Xiao Ganshi" has served 7.08 million people, accounting for 16% of the total real-name registered users. Its backend supports over 40,000 frequently asked questions across key areas like social security, healthcare, housing funds, and education, enhancing the accessibility and efficiency of public services (Figure 4-5—4-7).

(4) OCR recognition

The water and gas sectors commonly rely on meter readers who visit households to record usage, causing frequent disturbances to users. To address this issue, Alipay introduced an OCR (Optical Character Recognition) technology-enabled self-reading mini-program. This innovative solution allows users to take photos of their gas meters and submit them directly through the app. The mini-program then employs OCR to recognize the meter readings and notify the gas company for billing. As a result, users can receive their bills and complete payments within minutes, significantly reducing the frequency of meter readers' visits from every two months to a maximum of once a year.

(5) Blockchain technology

In the realm of public utility payments, a significant portion of transactions involves users who authorize automatic deductions from their accounts after signing contracts. Traditionally, the time interval from deduction to bill settlement is much longer than that for active payments, leading to a considerable number of user inquiries regarding unrecorded payments. To enhance efficiency and reliability, Alipay, in partnership with others, implemented a blockchain-based automatic deduction system. This application not only leverages the trustworthiness and security of blockchain technology but also reduces the bill reconciliation time from days to seconds.

By digitizing services across electricity, water, gas, and heating sectors, Alipay provides users with a suite of online services including account inquiries, payments, and automated bill deductions. This transformation eliminates the need for users to regularly visit utility service centers, which often require long wait times—what used to take an hour now takes only a second. It also addresses issues related to service hours and unexpected charges, enhancing user convenience and satisfaction while contributing to energy conservation and emissions reduction.

Through its collaboration with Alipay, utility service providers have been able to reduce the costs associated with sending paper bills and operating physical service centers, thereby improving overall operational efficiency. Currently, this partnership has extended to the vast majority of public utility organizations with digital capabilities across the country, encompassing 7,000 partner entities and serving approximately 250 million households (Figure4-8—4-9).

3. Innovation

(1) Online payment

The Alipay Life Payment platform, as the first digital payment solution in the public utilities sector in China, has successfully transitioned payment processes to online, automated, and paperless formats, marking the beginning of Alipay's digital service journey.

(2) One-stop service

Since 2018, 31 provinces have integrated the "One-Stop Service" concept into Alipay, allowing 600 million citizens to handle "one task at a time." This digital transformation has not only enhanced administrative efficiency but also opened new avenues for innovation in urban governance. Digital services can effectively improve urban infrastructure management and citizens' quality of life.

(3) Digital government development

Alipay actively collaborates with provincial and municipal governments in their digital government initiatives. In 2023, Alipay launched the "Alipay Appointment Service" mini-program, working with 23 provincial and

Figure 4-5、4-6 & 4-7: Xiao Ganshi App
Source: Ganfu Tong App

Figure 4-8 & 4-9: Online payment
Source: Alipay App

municipal big data bureaus. It has enabled online appointments, ticket retrieval via facial recognition, and real-time queue updates for over 1,000 offline service centers, enhancing the digital and intelligent level of public services and facilitating the integration of online and offline governmental services.

(4) Intelligent transformation

Starting in 2023, Alipay has been actively involved in building a digital society by providing technical support and co-developing services, continually seeking breakthroughs in the realm of social public services. This effort aims to drive the transformation of public services from digitalization to intelligence, resulting in a more personalized experience for citizens and businesses.

(5) From universal usability to wide accessibility

Alipay leverages technology to offer diverse options and possibilities for different demographic groups, ensuring that the rights of vulnerable groups, the elderly, and women are not overlooked. The company is committed to lowering the barriers to digital technology, allowing more people to benefit from the equality and inclusivity that technology can provide.

4. Achievements

(1) Changes in citizen behavior and attitudes

- Increased self-service: citizens are more inclined to use electronic devices for self-service tasks such as online applications, inquiries, and payments, thereby reducing dependence on traditional service counters.

- Heightened expectations: The digitization of services has led to improved efficiency, raising citizens' expectations for the responsiveness and convenience of public services, with a demand for more personalized and precise offerings.

- Enhanced participation awareness: Digital platforms provide more feedback channels, making it easier for citizens to engage in policy discussions and service evaluations, thereby strengthening their sense of social responsibility and ownership.

(2) Changes in government practice

- Process optimization and integration:

Government institutions have simplified service processes through digital transformation, enabling cross-department data sharing and enhancing service efficiency and collaborative capabilities.

• Data-driven decision making: There is a greater reliance on data analysis to guide policy formulation and service improvements, achieving precise measures and optimized resource allocation.

• Increased transparency: The online platform publicly shares service processes, policy information, and government data, thus enhancing transparency and credibility in government operations.

• Continuous innovation: The adoption of new technologies, such as AI and blockchain, is encouraged to improve service quality and security, promoting ongoing innovation in government service models.

(3) Changes in social attitudes

• Reconstruction of trust mechanisms: While initial technological issues may raise doubts, efficient and transparent services can gradually rebuild and deepen public trust in the government over time.

• Building an inclusive society: The widespread adoption of digital services emphasizes accessible design, striving to eliminate the digital divide and promote equitable participation across all social strata.

Relevances to SDGs

The digitization of public services, through the promotion of innovative applications of information technology and infrastructure development, enhances service efficiency and accessibility, contributing to inclusive and sustainable economic growth, aligning with SDG 9: Industry, Innovation, and Infrastructure. Digital services help bridge regional and socioeconomic gaps, providing more opportunities for remote and vulnerable groups to access services, thereby reducing inequalities and supporting SDG 10: Reduced Inequality. By delivering efficient public services (such as e-governance), improving urban management and quality of life, the initiative contributes to sustainable urban development, aligning with SDG 11: Sustainable Cities and Communities. The collaboration in providing paperless electronic billing in utility payment services fulfills low-carbon responsibilities, advocates for green living, and contributes to a reduction of 157,000 tons of carbon emissions annually, supporting SDG 13: Climate Action.

5. Conclusion and reflection

Given the vast and diverse population across Chinese cities, the variation in user habits, cultural levels, government policies, and the extent of information technology infrastructure presents significant challenges to systematic development. Alipay has addressed this by establishing industry monitoring centers and alarm platforms that engage multiple parties in collaborative governance of services. Furthermore, it has strengthened technical support and empowerment for partners, encouraging collective advancement.

With a large and diverse population, Alipay must consider the varying cultural backgrounds of a massive user base, along with the need for public services to accommodate users across all age groups. This complexity increases the challenges of implementing digital services exponentially. To enhance user experience and service success rates, Alipay employs large demographic models for personalized service presentation and utilizes AI smart assistants to guide users systematically in service transactions,

addressing the diverse needs of different groups. Through continuous investment in research and development, Alipay promotes technological innovation, enabling citizens to more rapidly experience the inclusive value of digital public services.

4.2.2 JD Technology: the application of the Beijing Economic Development Zone governance chain platform in urban governance

1. Background

The Beijing Economic-Technological Development Area (also known as BDA or Yizhuang) spans an expansive jurisdiction of 60 square kilometers and has a permanent population of 290,000 residents. It leads Beijing in four key industries—next-generation information technology, high-end automotive and intelligent connected vehicles, biopharmaceuticals and health, as well as robotics and intelligent equipment—consistently driving industry upgrades and innovation.

However, alongside rapid development, the BDA faces several challenges, including fragmented management of urban governance elements, insufficient intelligent risk monitoring, barriers to cross-departmental collaboration, poor coordination in handling events, weak data analysis for decision support, and slow response and high costs in system development. As a result, the BDA must accelerate its digital transformation by building a unified data governance framework, integrating advanced intelligent technologies, optimizing cross-departmental collaboration, enhancing event handling capabilities, deepening data analysis applications, and increasing the flexibility of system development to modernize urban governance comprehensively.

2. Main contents

(1) Integrated governance elements

The "Governance Element Center" of the "Governance Chain" platform builds a unified urban governance ledger, moving from "decentralized autonomy" to "integrated management." The key lies in deeply integrating the urban knowledge graph into city governance.

(2) Proactive governance monitoring

The "Perception Monitoring Center" aggregates data from various sensors, monitoring equipment, and social data sources. With AI algorithms such as deep learning and computer vision integrated into the platform, it automatically analyzes key information in surveillance footage, including facial recognition, license plate recognition, and abnormal behavior detection, creating a comprehensive, multi-dimensional risk monitoring network.

(3) Coordinated governance entities

The "Task Collaboration Center" breaks down traditional governance information silos and departmental barriers, enabling efficient communication and collaboration across departments and levels. Flexible task configuration, automated task allocation, and real-time execution tracking significantly improve the speed and effectiveness of handling governance tasks, while also enhancing interaction and trust between the government and the public.

(4) Closed-loop governance process

The "Event Management Center" employs a full-process, closed-loop event management mechanism, ensuring seamless handling of events from identification, notification, and resolution to feedback. With efficient system connections and close interdepartmental cooperation, all events are handled promptly and properly, reflecting high responsiveness and effective problem resolution.

(5) Intelligent governance analysis

The "Analysis and Reporting Center" conducts in-depth analysis of urban governance events, risks, and elements using a distributed big data processing framework and real-time streaming technology. Through distributed storage and parallel computing, the system efficiently processes regulatory data from multiple sources, including video streams, sensor data, and operational information.

3. Innovation

In the process of utilizing multimodal large model technology to achieve efficient closed-loop urban governance, data integration and system interfacing have emerged as critical challenges. To address issues related to data heterogeneity, data silos, and security, a unified data standard, data middleware platform, and data anonymization system were established. Additionally, to tackle system interface incompatibilities and meet the demands for stability and real-time processing, adapters were developed, phased implementation was adopted, and the data transmission mechanism was optimized. Monitoring and emergency response mechanisms were also established. Strengthening the technical team, continuously iterating and optimizing the platform, and enhancing training and communication were key strategies. These measures collectively helped overcome technical obstacles, enabling the successful application of multimodal large model technology in urban governance and significantly improving governance efficiency.

4. Achievements

(1) Regulatory innovation

The BDA Governance Chain platform facilitated the innovation of regulatory models, transitioning from manual to intelligent regulation, which enhanced both the efficiency and accuracy of oversight while promoting the development of a shared governance system.

(2) Improved public services

For citizens, non-contact regulatory methods have enhanced transparency in public services, particularly in areas like food safety, enabling real-time monitoring of services and increasing trust and security.

Figure 4-10: Governance Chain Platform - Governance Element Centre
Source: Jingdong Technology Contribution

(3) Public participation

The BDA Governance Chain platform has increased public participation in social governance, encouraging citizens to jointly maintain a clean and well-managed living environment, thereby improving overall quality of life.

Relevances to SDGs

The non-contact regulatory technology of the BDA Governance Chain platform has been widely applied in urban management and community services, significantly reducing environmental pollution incidents such as construction vehicle spillage, river pollution, unclean roads, and overflowing garbage. This improves urban safety and contributes to achieving SDG 11: Sustainable Cities and Communities. Additionally, data sharing has enhanced government transparency, promoting SDG 16: Peace, Justice, and Strong Institutions.

5. Conclusion and reflection

In current operations, governance elements such as "people, places, events, items, organizations" face challenges related to non-standardization, system isolation, and duplicate data collection, which hinder management efficiency and the full realization of data value. To resolve this, it is necessary to establish a unified governance element knowledge system based on national, regional, and industry standards. This will ensure consistency in the definition and regulation of elements. Additionally, the development of knowledge system management tools will allow for unified setting of element attributes and immediate standardization of data upon generation, laying a solid foundation for data integration and analysis.

Breaking down information silos and promoting system interoperability through the creation of unified data exchange standards is key to improving data utilization. Furthermore, implementing standardized data collection and processing procedures will ensure that data is consistently regulated from source to application, reducing redundancy and inconsistencies while improving data quality.

To ensure the continuous optimization and adaptability of governance element management, a long-term management mechanism must be established. This includes regular review and updates of the knowledge system, tool optimization, enhanced system collaboration and data sharing, and the implementation of data quality monitoring and evaluation. These measures will enable the creation of an efficient, unified, and standardized governance element management system that supports informed decision-making, drives business innovation, and fosters sustainable development.

4.2.3 Ordos Digital City Technology Co., Ltd.: the application of "DuoduoPing · MaShangShenghuo" (a combination of administration and technology) in urban governance

1. Background

In promoting digital urban governance, Ordos City Digital Technology Co., Ltd. identified several primary level management issues, including "diverse tasks, excessive errands, lack of incentives, challenges in co-governance, difficulties in supervision, and slow implementation." To address

these challenges, they aimed to empower government services, social governance, economic development, and public services through digital transformation, forming an efficient and intelligent governance model that supports sustainable urban development.

2. Main contents

(1) Efficient governance via code-based management: addressing the challenge of primary level workload reduction

By scanning QR codes, various applications such as information collection, public engagement, and convenient services can be seamlessly accessed. Modules such as "City Code," "Outdoor Code," "Snap and Report," "Vendor Code," "Immediate Response," "Petition Assistance," "Code-based Consultation," and "Super Administrator" enable real-time, efficient primary level governance.

(2) Positive incentives via material points: addressing the challenge of empowering primary level personnel

To tackle the issue of primary level units having limited authority and difficulties coordinating with supervisory departments, material points serve as a catalyst to motivate all levels of personnel. This boosts the enthusiasm of frontline staff and enhances the assessment of primary level officials, forming a comprehensive incentive mechanism that includes material rewards, job security, and annual bonuses.

(3) Moral points for social harmony: addressing the challenge of moral governance implementation

Moral points are assigned to residents based on their daily behaviors, with a dynamic system of rewards and penalties. Positive actions accumulate "positive energy" points, while negative actions reduce them. Residents can redeem their points for prioritized access to public resources such as education, healthcare, elderly care, and cultural services, fostering a harmonious and upward-moving social atmosphere.

(4) Digital economy for financial self-sufficiency: addressing the funding challenge

Leveraging the governance functionalities of the "DuoduoPing" digital platform, the system explores the value of data and expands its business model to capitalize on traffic economics. This enhances social governance efficiency without additional fiscal input while generating economic benefits.

3. Innovation

(1) Using digital tools to overcome primary level governance challenges

The "DuoduoPing" digital platform employs digital methods to implement "QR Code+" intelligent governance, creating a comprehensive digital application for primary level management. It simplifies complex community governance, communication, and conflict resolution.

(2) Streamlined management to improve governance efficiency

The platform facilitates direct communication between party officials and citizens and removes hierarchical barriers between departments and primary level units. Leaders can directly monitor public grievances, ensuring prompt responses and efficient problem resolution, thus enhancing public satisfaction.

(3) Empowering primary level to optimize governance mechanisms

By combining point-based incentives with performance evaluations, the "DuoduoPing" platform transforms administrative tasks into voluntary departmental services. This integration maximizes departmental participation in primary level governance.

(4) Financial support for long-term governance

The platform converts data generated during the digital governance process into assets, using state-owned enterprise profits as the primary funding source for digital governance. This "digital finance" model supports a sustainable governance cycle, ensuring multi-faceted support and continuous development.

4. Achievements

The "DuoduoPing" platform has attracted 1.3043 million users citywide in Ordos, including 385,000 in the Kangbashi District. The highest daily peak traffic exceeded 400,000 clicks. In Kangbashi District, officials received 905,500 evaluations, addressing over 60 daily issues on average. The platform has transformed law enforcement patrols from "broad coverage" to "precision-based" management.

With the goal of creating "community grid managers for all," the platform uses small point-based incentives to drive large-scale urban governance. This deep integration of digital technology and social management fosters a moral and fair society, encouraging citizens to participate actively in urban governance. This results in a harmonious balance between spiritual and material progress.

5. Conclusion and reflection

The implementation of the "DuoduoPing·Code Life" digital platform faced challenges such as technical difficulties, low user engagement, cross-departmental collaboration, and sustainable development issues. These were addressed through the following strategies:

(1) Technical development

Enhance technological research and investment, introduce advanced technology and equipment, ensure the platform's stability, compatibility, and security, and establish a maintenance mechanism for regular updates and optimization.

(2) User engagement

Increase awareness and promotion of the platform to enhance user understanding and acceptance, while providing quality services to build user trust.

(3) Collaborative coordination

Establish clear cooperation mechanisms, defining the rights and responsibilities of all stakeholders, coordinating interests and resources, and fostering communication and collaboration across departments.

(4) Sustainable development

Explore diversified business models to enable the platform's self-sustaining capabilities. Strengthen talent development and recruitment to ensure continued innovation and service quality.

4.2.4 Onewo Inc.: "full-domain intelligent operation" innovates in urban governance

1. Background

Onewo inc., Recognizing the inefficiency and gaps in services caused by fragmented outsourcing of public services, has integrated the systematic thinking of property

management and process management capabilities into urban governance. This approach breaks the boundaries of the traditional "fragmented operations" model, aiming to achieve integrated and intensive management of municipal services.

Leveraging onewo's "artificial intelligence of things" (AIOT) solution and "business process as a service" (BPAAS) solution, onewo smart city adopts a comprehensive intelligent operations perspective, using data-driven methods to transform operational workflows. It provides the government with digital operation subscription services and customized intelligent service solutions.

2. Main contents

Focusing on building new smart cities, onewo 's comprehensive intelligent operations solution highlights the intelligent service genes of "integrated consolidation, multi-scenario interconnection, full-chain operations, and full-ecosystem integration." This solution establishes four core capability modules—process and operation standards, software and hardware products, digital operations, and supplier integration—achieving a systematic deconstruction and integrated restructuring of various urban space business lines.

To address the high costs, coordination difficulties, and limited means in urban governance, onewo's comprehensive intelligent operations solution offers a reference path to enhance urban governance and improve public service quality:

Utilizing a city-wide comprehensive governance approach, the solution redefines and restructures separate business lines, such as municipal facility maintenance, sanitation, and landscaping. By integrating urban spaces, it breaks down the boundaries between "administrative districts, streets, communities, and residential areas," enabling the reuse of labor, facilities, and other resources. This effectively overturns the traditional "fragmented operations" model, achieving integrated and intensive management of municipal services.

A full upgrade of various hardware facilities is implemented to ensure interconnectivity, building a highly efficient cloud-edge-device-human collaborative platform for comprehensive intelligent operations. By embedding standard operating procedures (SOPS) into an intelligent work order system and establishing a multi-scenario intelligent recognition network, the platform forms a "neural network" that reaches the endpoints of urban operations, enabling quick response and resolution of issues.

The solution offers a comprehensive "plug-and-play" system of intelligent terminals, including aiot sensing devices and intelligent mechanical operation equipment. Through the internet of things (IOT) and ai platforms, these devices achieve ubiquitous interconnection and intelligent coordination, enabling precise awareness of service scenarios. This helps seamlessly link the front and back offices while providing accurate data analysis and business planning to efficiently improve the quality of urban service operations.

3. Innovation

(1) A new model of comprehensive intelligent operations: integration, intelligence, operations, and co-building

Through continuous practice and iteration, onewo upgraded its "property city" model to version 2.0 In 2022, known as the "comprehensive intelligent operations" model. The core idea is to view the city as a "large property" and integrate the systematic

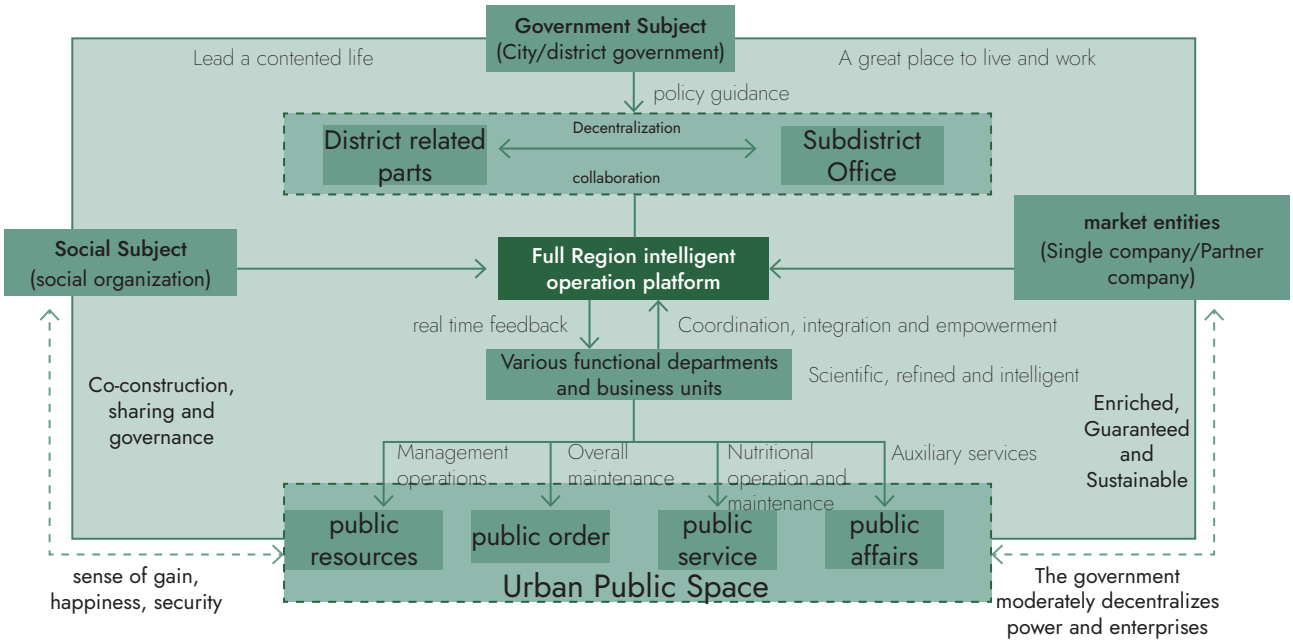


Figure 4-11:"full-domain intelligent operation" model
Source: Provided by Onewo

thinking and process management capabilities of property management into urban governance. This re-engineers the production and organization processes of urban public services.

The core characteristics of the "comprehensive intelligent operations" model are integration, intelligence, operations, and co-building. In summary, integration includes space consolidation, business line integration, and supply chain integration. This optimized resource allocation enhances quality and efficiency.

(2) Multiple spaces + multiple scenes + multiple products to meet diverse and differentiated urban governance needs

Onewo smart city currently focuses on three major categories of urban spaces, namely new cities and new districts, streets/built-up areas, and other spaces (including but not limited to tod, rivers, parks, islands, etc.), And provides solutions with different combinations of business modules to meet diversified and differentiated urban governance needs. Meanwhile, it has developed diversified intelligent products from three dimensions, namely service output, technology output and management output, to build up intelligent operation capability in the whole region.

(3) Enhancing urban issue identification and prediction efficiency with ai algorithms

Onewo's ai algorithm engine significantly boosts the efficiency and accuracy of identifying and predicting urban issues. By integrating ai algorithms with fixed and vehicle-mounted cameras, the system enables smarter management and operational efficiency improvements. The use of ai and big data analysis allows for the intelligent detection and remote supervision of non-compliance events, making the collection of city appearance issues more efficient.

The system's powerful computing foundation and algorithm programs can automatically identify various urban management issues such as illegal street vending, improper

parking of non-motor vehicles, street-side drying of items, and overflowing trash bins. These issues are instantly detected and reported to the integrated intelligent operations platform for timely response and resolution.

4. Achievements

From the perspective of technological innovation and operational efficiency, ai algorithms have played a critical role in identifying and predicting urban issues. For example, the ai inspection solution based on lingstone servers integrates multimodal learning and federated learning mechanisms, making it possible to deploy more algorithms and significantly reduce human labor, time costs, and enhance management efficiency while lowering boundary constraints.

The "onewo" full-domain intelligent operation model breaks through the functional boundaries of urban workers by adopting integrated management and streamlined operational processes, improving the quality and efficiency of services. It promotes planned operations over reactive, incident-driven responses. The model also increases the efficiency of city-wide dispatch systems, allowing for faster response times and lessening the workload of local government administrations. Overall, this approach results in more efficient, precise, and concentrated urban management, significantly enhancing the sense of safety, satisfaction, and happiness among residents.

Relevances to SDGs

The full-domain intelligent operation model directly benefits all residents in its service area by providing refined governance and warm, human-centered services, resulting in a greater sense of happiness, safety, and fulfillment. " Onewo" continuously invests in operation equipment and facilities, increasing the mechanization rate to make work easier and more efficient for frontline workers. The unified provision of uniforms and tools creates a more dignified work environment. Strict operational standards ensure a safer, more secure workplace. Additionally, internal training programs are designed to help employees improve their skills and increase their income, contributing to sdg 8: decent work and economic growth.

5. Conclusion and reflection

During the implementation of the "all-domain intelligent operation" model in urban governance, several issues in traditional city governance were identified and addressed:

(1) High costs, coordination challenges, and limited tools in city governance

To address the high costs, coordination difficulties, and reliance on singular tools, this model reorganizes and streamlines segmented operations like municipal infrastructure maintenance, sanitation, and green space management. By integrating spaces and breaking down spatial boundaries between administrative zones, streets, neighborhoods, and residential areas, the model allows for the reuse of labor and resources. This leads to more unified and efficient urban management.

(2) Insufficient hardware support

The solution also involves fully upgrading hardware facilities and enabling interconnectivity. The "cloud-edge-device-human" collaborative full-domain intelligent operation platform is constructed. This includes embedding business sop standards into the intelligent work order system and building a multi-scenario intelligent recognition network. This serves as the

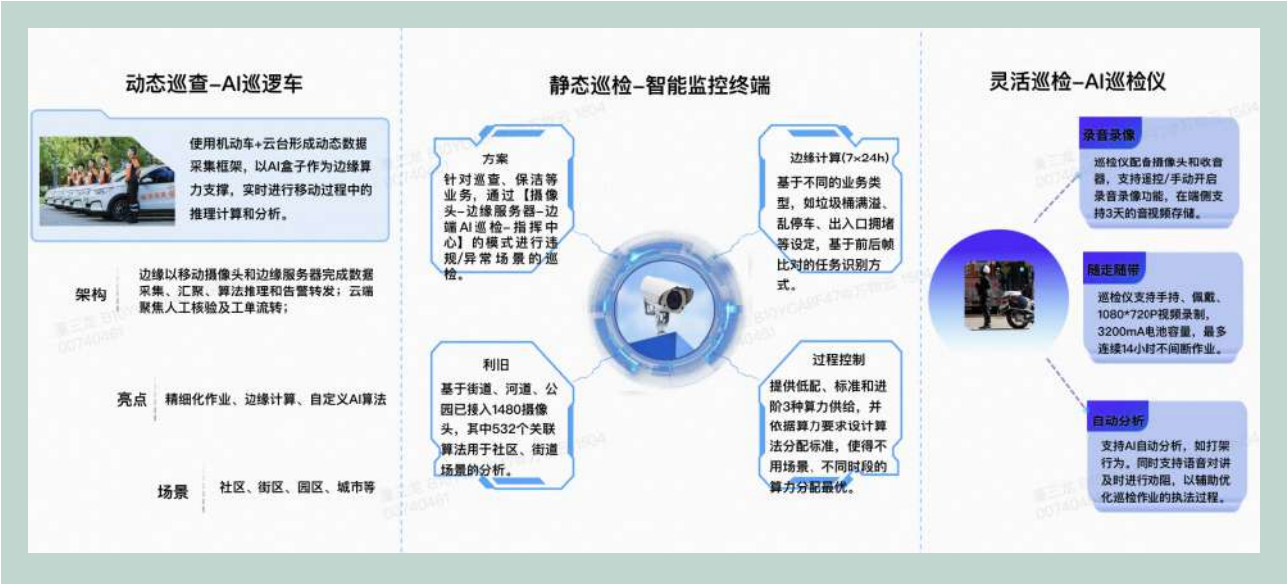


Figure 4-12: Schematic of Onewo's Inspection + Monitoring
Source: Provided by Onewo

"neural network" that reaches the operational endpoints of urban services, allowing for fast response and problem-solving.

As of december 31, 2023, " onewo" has deployed 98 urban service projects across 26 cities. Its business has expanded into various city spaces such as new towns, built-up areas, and specialized spaces (including tods, rivers, parks, and islands), offering diverse module combinations to address varying governance needs.

Looking ahead, " onewo" plans to continue developing more diverse intelligent products through three dimensions: service output, technology output, and management output, to further enhance its full-domain intelligent operational capabilities.

4.2.5 Shenzhen Smart City Technology Development Group Co., Ltd: digital twin technology empowers the renovation of old urban residential communities, promoting sustainable urban regeneration

1.Background

On a land area of less than 2000 square kilometers, Shenzhen manages a population of over 20 million people, with a significant portion residing in urban villages. The insufficient supply of high-quality housing has significantly impacted the quality of life for city dwellers. Therefore, urban regeneration, focusing on renovating old urban residential communities, is crucial for enhancing the city's resilience and improving residents' living standards. In recent years, the Shenzhen government has been working tirelessly to address the housing challenges faced by megacities, making full use of limited resources for urban renewal, comprehensively improving urban governance, and significantly enhancing residents' sense of gain, happiness, and security. Gradually, a people-centered, livable new city is being built.

Shenzhen Smart City Technology Development Group Co., Ltd. is committed to empowering the entire lifecycle of housing management, from project approval and construction supervision to completion acceptance, property management, and housing rental registration, with digital twin and artificial

intelligence technologies. By utilizing CIM technology, the company aims to transform offline applications for common matters by citizens and enterprises into online services, thereby improving the efficiency of urban operations.

2. Main Contents

(1) A pilot project is underway to leverage NLP-powered large language models to streamline plan review for construction projects, reducing errors and rework, saving resources, and ultimately promoting sustainable urban development.

(2) By employing digital twin technology, the entire construction process of engineering projects can be overseen, which helps to minimize the material and labor waste, improve construction quality, and ensure the timely completion of urban regeneration initiatives.

(3) Promote the adoption of prefabricated construction by leveraging digital technologies. This involves shifting much of the construction process to factories, reducing on-site work and resource consumption, and ultimately contributing to the city's goal of achieving near-zero carbon emissions.

(4) Develop a collaborative platform for the management and disposal of construction waste, maximizing resource recovery and minimizing environmental impact, thereby supporting sustainable urban regeneration.

(5) Enhance urban resilience by leveraging AI and digital twin technology for smart early warning of building safety hazards, significantly reducing the risk of major accidents.

(6) Utilize CIM technology to streamline housing rental registration processes, fostering a more people-centered urban environment.

3. Innovations

(1) Pilot key business systems

Prioritize the construction of urgently needed systems, such as CIM-based affordable housing applications and AI-assisted plan review systems.

(2) Parallel construction of all business systems

Simultaneously develop 10+ business systems centered around core operations such as project approval, construction site supervision, and housing security, integrating technologies like digital twins, CIM, and AI for platform construction and data governance.

(3) Full-scenario system integration

Upon completion of individual information systems, establish horizontal integration of projects and properties throughout their lifecycles using project codes and property codes. Simultaneously, achieve vertical integration of technology platforms, data governance, and business applications based on business scenarios. Ultimately, realize full-scenario business system integration, achieving a synergistic effect where the whole is greater than the sum of its parts.

4. Achievements

(1) Intelligent plan review enhances approval efficiency and design quality, promoting sustainable urban development

Leveraging Natural Language Processing and large language models to improve the plan efficiency: the plan review time is shortened by 30%, and design errors across different

disciplines are reduced by 50%, and the housing design quality are improved. By reducing design changes and rework, energy consumption is lowered, contributing to sustainable urban development.

(2) Full-lifecycle supervision of construction processes enhances urban regeneration quality

Based on CIM technology, the entire construction process of over 10,000 ongoing projects is monitored, covering project approval, industry regulation, market supervision, and on-site inspection. This provides a comprehensive view of projects, personnel, equipment, high-risk engineering, and supervision enforcement, linking on-site, market, and examination for effective quality improvement.

(3) A collaborative platform for construction waste disposal promotes net-zero carbon transition

Based on CIM technology, the platform enables intelligent management of the entire lifecycle of construction waste, including cross-regional transfering, source tracing, and final disposing, devoted to urban net-zero carbon transition.

(4) Smart early warning of safety hazards in existing buildings strengthens urban resilience

Over 600,000 buildings in Shenzhen are managed through a CIM platform. AI is utilized to monitor building safety. When a building is identified as dangerous, the system links it to affected parties, assesses the potential impact area, analyzes the causes, and enables closed-loop management for the discovery, assessment, and remediation of structural safety issues, enhancing the resilience of existing buildings.

(5) CIM technology empowers collaboration, participation and common interests among over 10,000 property communities, improving residents' living experiences

A city-wide property information platform has been built to facilitate information sharing, service processing, communication, and feedback among government regulatory departments, property service companies, owners' associations, and individual owners. This promotes the evaluation of livable community construction across the city.

(6) Digital twin technology accelerates the renovation of the old urban residential communities and enhances urban livability

Over 1,000 old urban residential communities renovation projects in Shenzhen from 2021-2024 are managed through a digital twin platform, facilitating the renovation process, improving the living environment, and enhancing urban quality, benefiting over 500,000 households.

(7) Online housing rental registration improves residents' well-being

Over 4.9 million households have completed online housing rental registration, achieving "equal treatment for renters and buyers." Online services are also provided for public housing fund withdrawal, property repair fund application, affordable housing application and queuing, enterprise qualification application, and project approval, benefiting both citizens and businesses.

5. Conclusion and reflection

In the process of leveraging digital twins to revitalize old urban residential communities and drive urban regeneration in Shenzhen, some challenges have been discovered in urban governance, such as misalignment

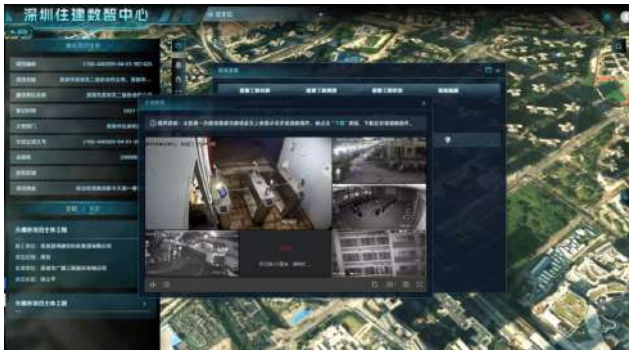


Figure 4-14: Smart digital housing center of Shenzhen
Source: Provided by Shenzhen Smart City Technology Development Group Co., Ltd

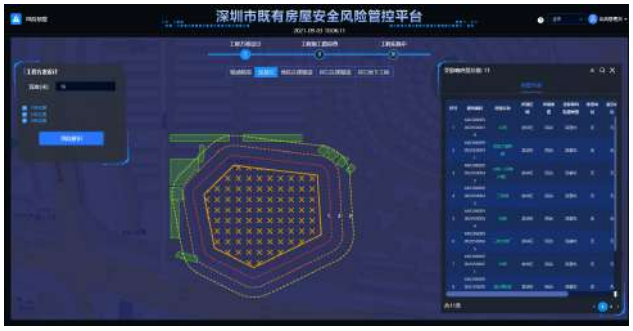


Figure 4-15: Shenzhen Existing Housing Safety Risk Control Platform
Source: Provided by Shenzhen Smart City Technology Development Group Co., Ltd

between technology and policy and insufficient regulatory capabilities.

(1) AI-assisted plan review combined with BIM modeling can significantly improve design accuracy. However, BIM models are not currently mandatory deliverables, and government promotion of BIM for construction projects to improve design quality may increase project costs.

Solution: By selecting industry-leading enterprises to create BIM pilot projects and providing subsidies, while simultaneously exploring the legalization of BIM, these challenges can be addressed.

(2) Citywide inspections of hazardous buildings are labor-intensive and require innovative digital supervision methods.

Solution: By utilizing satellite imagery, InSAR subsidence monitoring, and drones, AI can be supported in identifying hazardous buildings, improving efficiency.

05

Recommendations

Chapter 5 Recommendations

In the context of rapid advances in digital technologies such as big data, IoT, blockchain, and AI, cities around the world are actively promoting the application of digital technologies in urban governance, exploring new models of digital urban governance. In October 2023, during the commemoration of World Cities Day, UN Secretary-General António Guterres emphasized that cities are engines of economic growth and innovation that hold the key to achieving the 2030 Agenda and the SDGs. According to the "Smart City Index 2024" published by the International Institute for Management Development (IMD) in Lausanne, Switzerland, the global smart city landscape continues to evolve. Among the 142 cities evaluated, one fifth of the top 20 smart cities are Chinese (including Hong Kong, Macau, and Taiwan). Overall, China has accumulated extensive experience in digital urban governance and made significant progress.

However, although digital urban governance enables sustainable urban development, it also leads to the emergence of a series of complex risks. It is crucial to recognize the impact of these risks on individuals, organizations, and even society as a whole. It is essential to uphold the principle of "coordinating development and security" and actively mitigate emerging risks associated with digital urban governance during the process of technological empowerment.

Digital urban governance is a common challenge for countries around the world. This chapter proposes a Global Initiative for Digital Urban Governance, calling on all nations to uphold the concept of a community with a shared future for humanity and to continually focus on dialogue, trust building, process commitment, and mutual understanding. In the future, the application of emerging technologies will bring new transformations in urban governance, and globally distributed urban governance and cross-regional data collaboration will also increase.

5.1 Implementation pathways for digital urban governance in China

The application of technology within a specific organization can lead to positive or negative outcomes. In some institutional arrangements, interactions between multiple stakeholders add complexity to the technology implementation process. The Chinese government has numerous functions, and the benefits offered by digital technologies vary significantly. Among these, process reengineering, structural optimization, and data sharing are particularly complex. According to the "Digital China Development Report (2023)" released by the National Data Bureau of China, a nationwide integrated government service platform has been built to serve more than 1.4 billion people and over 100 million businesses. The platform has over 1 billion verified users, and government data sharing services have been accessed over 500 billion times, with over 90% of government services available online nationwide. This indicates that China has made significant progress in digital urban governance.

5.1.1 Principle, strategic planning, and emphasis on leadership

(1) The people-centered principle

To address issues such as citizens' need to prepare numerous documents, resubmit documents, and the involvement of multiple approval departments with lengthy processes, China has consistently adhered to a citizen-first perspective in digital urban governance. From a citizen-centered perspective, an integrated online government service platform and offline service counters have been established, promoting the reengineering of government service processes, structural optimization, and public data resource sharing. This allows citizens to easily manage services online and visit a single office offline, significantly enhancing their efficiency and satisfaction. By upholding the people-centered principle in digital urban governance, China has enabled citizens to complete administrative services in a single visit, effectively meeting their growing demands and expectations.

(2) National strategic planning

At the national level, a series of guiding documents and plans have been issued to coordinate the overall strategic direction of digital urban governance, providing important guidance for local governments to advance digital urban governance. The "Overall Layout Plan for Building Digital China" stipulates that the construction of Digital China will be carried out according to the "2522" framework: consolidating the "two foundations" of digital infrastructure and data resource systems; promoting the deep integration of digital technologies with the "five-in-one" sectors (i.e., economy, politics, culture, society, and ecological civilization); strengthening the "two capabilities" of digital technology innovation systems and digital security; and optimizing the "two environments" for national and international digital development. The NDRC, the National Data Bureau, and other relevant departments jointly issued the "Guiding Opinions on Deepening the Development of Smart Cities and Promoting Comprehensive Urban Digital Transformation." National strategic planning provides clear direction and basic guidelines for local governments, allowing them to advance digital urban governance based on their unique resources and development characteristics.

(3) Emphasis on high-level leadership

Digital urban governance is regarded as a key strategic initiative, often personally promoted by a city's top leaders, including the mayor. The digital leadership capabilities of these key leaders are crucial for digital urban governance, encompassing technical skills from their professional backgrounds and experiential capabilities acquired while working in IT departments. The emphasis on high-level leadership is typically reflected in defining the strategic planning and framework of digital urban governance, holding regular meetings to promote digital urban governance, and visiting digital projects on site to understand progress. The attention paid by key leaders not only increases policy support and resource allocation for digital urban governance but also helps coordinate interdepartmental dialogue and collaboration, thereby ensuring the successful implementation of digital urban governance.

5.1.2 Mechanism for collaborative advancement in the implementation of digital urban governance

The implementation of digital urban governance involves a complex collaborative process between governments at different levels and different government departments,

as well as between the government and enterprises. To promote optimal resource allocation and effectively implement digital urban governance, China has established a series of mechanisms, including goal setting, task forces, and "Enlisting and Leading." These mechanisms have effectively facilitated coordination and cooperation among the various stakeholders in digital urban governance.

(1) Goal-setting mechanism.

Goal setting involves joint discussions about the strategic objectives, task characteristics, and the environment facing local governments to determine what needs to be done and what goals need to be achieved over a specific period. It is a dynamic process in which objectives and tasks are broken down step by step and communicated to subordinate government levels and departments. China has set various targets to achieve digital urban governance through five-year plans or annual plans, including both quantitative and qualitative indicators. For example, in Shanghai, the "14th Five-Year Plan for the Comprehensive Promotion of Urban Digital Transformation" issued in October 2021 defined the objectives for advancing digital transformation in the city, establishing 16 indicators such as the number of benchmark scenarios for "efficiently completing a task" and "efficiently handling a task." Through the goal-setting mechanism, priorities for achieving digital urban governance are clarified, providing motivation and direction for government departments to work together toward these goals and strengthening accountability in the collaborative advancement of digital urban governance.

(2) Establishing a special work team.

A Special Work Team is a temporary organization created within the government to implement major and urgent non-routine governance tasks. Its main characteristic is its specialization based on task objectives, replacing the traditional specialization of organizational functions. To achieve digital urban governance flexibly and efficiently, most city governments in China have set up Special Work Teams, using personnel from various government departments to integrate resources and responsibilities, thereby reducing the costs of interdepartmental collaboration. For example, the "City Brain" Special Work Team established in Haidian District, Beijing, consists of 16 permanent units, 13 mechanism support departments, and several departments absorbing specific tasks, leading the construction of the "City Brain." In September 2023, Yuzhong District, Chongqing, set up a Special Work Team for the Digital Urban Operation and Governance Center, focusing on the tasks of "perception and detection," "risk prevention and control," and "emergency response." (Figure 5-1)

Figure 5-1: The Special Work Team of the Digital Urban Operation and Governance Center, Yuzhong District, Chongqing
Source: Integrated Media Center of Yuzhong District, Chongqing

(3) Enlisting and leading mechanism for enterprises.

The government usually selects companies with digital transformation experience or advantageous resources as the lead

implementers of specific application scenarios through open bidding or competitive methods, thereby promoting the efficient implementation and advancement of digital urban governance projects. The Enlisting and Leading mechanism enables the transparent identification and attraction of technology enterprises with extensive construction experience, helping to motivate them to be competitive, drive market innovation, and establish benchmark demonstration application scenarios for digital urban governance. At the same time, this mechanism provides participating enterprises with a platform to showcase their technical capabilities, thereby promoting cooperation between the government and participating enterprises. For example, in September 2023, Shanghai released the first batch of Enlisting and Leading demonstration creation units for urban digital transformation (in the living sector), including 15 project units as integrated scenarios and 59 project units as featred scenarios (Figure 5-2).

Figure 5-2: “Top Ten Benchmark Case” Enlisting and Leading for the City Brain in Pudong New Area, Shanghai
Source: The Paper

5.1.3 Corrective action mechanism in the implementation of digital urban governance

In the process of promoting digital transformation in urban governance, execution deviations may occur, whereby digital technologies are applied but fail to fundamentally solve real-world problems, or even lead to negative outcomes such as excessive costs and resource waste. To address this, China has put in place corrective mechanisms for the implementation of digital urban governance, such as the role of Chief Data Officer, evaluation-driven development, and co-production initiatives.

(1) Chief data officer mechanism

The chief data officer is responsible for formulating and implementing data strategies within government departments and supports administrative activities such as regulatory oversight, public services, and decision-making by enhancing the data capabilities of government departments. The successful implementation of digital urban governance relies on personnel who understand both technology and business to drive and participate in the process. As a position specifically established for government data management, the chief data officer’s primary responsibility is to ensure that the application of digital technologies is closely aligned with the government’s business needs, thereby mitigating execution deviations in digital urban governance. The “Guangdong Province chief data officer system Pilot Work Plan,” issued on April 23, 2021, marked the beginning of the development of the chief data officer mechanism in China, with Guangzhou being the first city to implement this mechanism. Since then, many cities have created chief data officer positions, providing strong organizational support for digital urban governance.

(2) Evaluation-driven development mechanism

To solve problems such as insufficient problem orientation and lack of iterative upgrades in the development of digital urban governance application cases, the Chinese government uses performance evaluation as

a tool to address the shortcomings of these cases. First, a scientific evaluation indicator system focuses on problem orientation and performance orientation, taking into account economic value, administrative value, citizen value, and social value. Second, a standardized evaluation workflow consisting of evaluation teams composed of digital transformation authorities, third-party research institutions, and participating units uses objective quantitative data or other qualitative data generated during urban operations management and government services for assessment and analysis purposes. Third, there is a diversified approach to transforming the evaluation results, which involves using the evaluation outcomes of application cases as part of the annual performance review of departments or linking them to funding for digital transformation projects, using the results as a basis for business optimization.

(3) Co-production mechanism

Co-production is a regular, long-term relationship between professional service providers and service users or other community members, with all parties contributing to the process. Citizens contribute their professional knowledge, information, and other resources to participate in the provision of public services, including by getting involved in the planning, design, management, submission, and evaluation stages of digital urban governance, thereby enhancing the effectiveness of public services. For example, for the evaluation stage, Chinese cities have launched the "Good & Bad Evaluation" system, allowing the public to assess the quality of public services. Additionally, the Chinese government actively conducts extensive social surveys, holds discussion meetings, and increases citizens' participation in urban governance through channels such as leadership message boards and citizen hotlines (Figure 5-3).

Figure 5-3: The "Good & Bad Evaluation" system for public services in Xi'an City
Source: Xi'an Municipal Bureau of Administrative Approval Service

5.2 Emerging risks in digital urban governance

Digital urban governance can enable the realization of sustainable urban development goals, but the application of digital technologies also carries risks. These risks arise throughout the life cycle of digital urban governance systems, including during the design, development, application, and evaluation processes. To further enhance the performance of digital urban governance and improve the level of sustainable development of a city, different stakeholders need to take effective measures.

5.2.1 Objective risks

Objective risks are the risks that may arise from the security and stability of the hardware, software, network, and data of digital systems adopted in different urban fields.

(1) Technical loopholes

Digital systems may have technical loopholes at their infrastructure layer, platform layer, and business layer, and clients that may be easily affected by cyberattacks. With the increasing

prevalence of malware, ransomware, phishing, denial of service attacks (DDoS), and other cyberattack methods, cyberattacks initiated by criminals using technical loopholes can lead to service disruption, system paralysis, and pose a threat to privacy, organizational operations, and even national security. For example, in 2017, the WannaCry ransomware exploited a loophole in the Windows operating system to launch cyberattacks worldwide, attacking more than 200,000 computers in 150 countries and regions, including China, and affecting key industries such as communications, finance, and healthcare in the United Kingdom, Spain, and other countries, resulting in billions of dollars in economic losses.

The main strategy to address technical loopholes is to improve the resilience of systems to cyberattacks. Developers and users of critical digital systems across different areas of a city can patch loopholes and reduce the impact of attacks through technical means such as adversarial system testing, regular system updates, implementation of backup systems and databases, encryption of critical information, and deployment of network firewalls. Meanwhile, administrators should also formulate contingency plans to deal with attacks and system failures, so that they can respond quickly and reduce the impact of cyberattacks on system operations.

(2) Algorithmic black box problem

The black box of an algorithm refers to the situation in which the internal working mechanism of the algorithm is not transparent, making its operation difficult to understand by users and other external stakeholders. Deep learning and other AI algorithms involve complex data processing and logical decision-making processes, and the computer language is difficult for the public to understand, resulting in unpredictable and unexplainable results from the algorithm, which can lead to incorrect knowledge and decision-making information, with a negative impact on individual and organizational decision-making. In particular, when biasing factors such as biases in algorithm training datasets and subjective biases of algorithm developers are present, an opaque algorithmic decision-making process may amplify the impact of these biases and make the decision results appear unfair to specific groups or individuals. For example, in 2016, Propublica's investigation into the U.S. predictive policing algorithm COMPAS revealed that the algorithm exhibited systematic racial bias in its evaluation of criminals, with black people twice as likely as white people to be incorrectly labeled as criminals, sparking widespread questioning of predictive policing algorithms in the U.S.

The main strategy to deal with the algorithmic black box problem is to improve the transparency and interpretability of algorithms. To improve the transparency of algorithms, regulators should clarify the responsibility of algorithm developers using laws and other institutions, stipulating that developers should disclose key explanation files, to reduce information asymmetry between them and users. In addition, technical standards for algorithms should be formulated, and algorithm developers should be actively guided to develop technically interpretable models or apply visualization technologies to present the decision-making logic of algorithms.

(3) Data security

If the data system is not properly protected physically and technically, its data collection, storage, processing, transmission, destruction, and other data management processes may be exploited by criminals. As a result, a large amount of data related to citizens'

privacy, commercial secrets, and even state secrets may be leaked, lost, misappropriated, and tampered with, potentially leading to privacy infringement, economic losses, and even harm to national security and social stability. For example, in 2017, the U.S. credit reporting company Equifax was hacked, leading to a large-scale data breach. The private information of 140 million U.S. users, such as their names, addresses, birthdays, social security card numbers, driver's license numbers, and other private information, may have been leaked. In addition, during this attack, the credit card information of approximately 200,000 unsuspecting users who used Equifax's assessment system was directly leaked. Equifax had to spend US$1.4 billion to upgrade its security systems and pay out large compensation to affected customers.

The main strategy to address data security risks is to improve data protection institutions and technologies. First, data managers should establish security management institutions for the entire life cycle of data, which can clarify data access rights and regulate data processing behaviors through data classification rules and technical standards for classification management. Second, data managers should also strengthen technical protection measures for data security, using blockchain encryption processing, access control, or other technical means to restrict access to key data, enhance the confidentiality and integrity of sensitive data, and reduce security risks.

5.2.2 Social risks

As digital systems are applied to different areas of a city and used by people, there are risks that the systems will have negative impacts on individuals, organizations, and even society.

(1) Violation of privacy

In the process of collecting, storing, processing, and transmitting data, some digital system administrators may collect, use, and disclose private information, such as identity information, biometric information, and Internet behavior records, without the consent of individuals or in violation of privacy law, making it impossible for users to make informed choices about the use of such services and triggering public skepticism toward digital systems. For example, in 2021, the Hangzhou court heard and ruled on China's first privacy violation case related to facial recognition. The Hangzhou court ruled that Hangzhou Wildlife World had violated the law by over-collecting facial features and other biometric information from ticket purchasers, making it clear that over-collection of biometric information by an enterprise is a violation of privacy. This case has sparked a heated public debate in China over the continued violation of privacy by commercial and other digital systems.

To address the risk of privacy violation, government regulators should conduct system compliance checks in accordance with laws, regulations, and technical standards on the protection of personal information to ensure that systems operate according to the principle of data minimization (i.e., the minimum amount of data necessary to meet business requirements) and desensitize sensitive information. Regulators should also clearly specify the information disclosure obligations of system developers, requiring them to establish a clear privacy policy and inform users of it, thereby ensuring that users' right to information is not violated.

(2) Digital divide

The digital divide refers to differences in the use of digital technologies and in access to information between different social groups and between different geographical areas.

Economically poor and remote areas cannot afford the cost of digital infrastructure, and members of digitally disadvantaged groups, such as older people, low-income earners, and those with low education, often lack the capacity to use digital devices. This creates barriers to access to information for people in these areas and groups and prevents them from taking advantage of the opportunities offered by digitization, which exacerbates inequalities in terms of economic opportunities, public services, and other aspects. According to the International Telecommunication Union, despite global progress in digital infrastructure coverage and other aspects, 2.6 billion people in the world still do not have access to the Internet, and in low-income countries there is on average only one broadband subscriber for every 100 people. The low level of Internet infrastructure and the citizens' low ability to use the digital devices have affected their economic development and income growth in these countries.

To address the digital divide, governments should increase the construction of digital infrastructure in economically underdeveloped and remote areas. They should also strengthen cooperation with enterprises and social organizations to provide citizens with education and training programs on how to use the Internet and develop digital content adapted to different cultural backgrounds, to reduce differences in the use of digital devices and access to information between different regions and groups. It is also necessary to strengthen international cooperation to help underdeveloped countries build Internet infrastructure and increase the public's ability to use information technology, to jointly promote the bridging of the digital divide on a global scale.

(3) Abuse of digital power

With the widespread application of digital technologies, public and private organizations that control digital platforms are in possession of a large amount of data on users' privacy and behavior. These organizations can induce and influence user behaviors through their monopoly on the data collection and analysis process, giving them digital power over users. As data from different urban areas become increasingly concentrated on various platforms, the power contrast between individuals and platform controllers increases. If the digital power of platforms is not limited by laws and regulations, abuses of digital power risk disrupting the existing political and social order. For example, in 2018, the media reported that Cambridge Analytica, a political consulting firm, had used data from 50 million Facebook users to analyze and deliver targeted political advertisements in the run-up to the 2016 U.S. election, which is believed to have had a significant impact on Trump's victory. Cambridge Analytica's analysis of social media data successfully influenced voters' voting behavior, demonstrating the potential of digital power to affect the national political order.

To address the abuse of digital power, it is necessary to put in place a solid regime of digital power constraints and a collaborative governance structure involving different stakeholders, such as governments, businesses, and citizens. Policymakers should formulate appropriate data protection laws and regulations as well as technical standards on data protection applicable to different industries, taking into consideration the legitimate rights of different stakeholders, to prevent platforms from collecting and analyzing sensitive data. Active supervision is necessary throughout the process of designing, developing, operating, and evaluating digital platforms. Moreover, supervisors should require system developers to introduce appropriate competition

mechanisms to reduce their reliance on a single technology provider, thereby reducing the risk of abuse of digital power due to data concentration with a multi-centered collaborative governance structure.

5.2.3 Perceived risks

When using digital systems in different areas of a city, different groups of citizens have different understandings of how digital systems work due to their own life experiences, educational backgrounds, and other factors, making their perceived risks different from the actual risks.

(1) Perceived fairness risk

Perceived unfairness is a psychological experience that arises when individuals make judgments reflecting their subjective feelings about the fairness of the distribution of resources, services, and rights. Perceived fairness risk is closely related to social risk. When the government uses digital systems to provide public services and implement public policies, if the developers of such digital systems do not pay sufficient attention to socially disadvantaged groups, this may lead citizens to question the fairness of these systems.

To address perceived fairness risk, governments can require system developers to disclose their decision-making process and data usage information to increase the transparency of system operations. System developers should also create a user feedback mechanism to proactively adjust their algorithms based on user feedback. In addition, governments should work with enterprises and civil society to increase investment in education and infrastructure, to reduce the digital divide between different regions and groups, enhance the fairness of digital systems in allocating services and resources, and provide targeted support and assistance to disadvantaged groups, thereby improving citizens' perceptions of fairness.

(2) Perceived security risk

Insecurity is a subjective feeling that arises when perceived threats in the social environment exceed the boundaries of individuals' ability to control them, reflecting their concerns about privacy protection, data security, and the safeguarding of personal rights in the application of digital technologies. Perceived security risk is closely related to technical risk, as citizens fear that their personal information will be misused or leaked, or that surveillance systems will encroach on their personal living space, which in turn leads to a reduced sense of security when using digital systems.

To address perceived security risk, the governments should set clear rules on data collection and use to demonstrate their efforts to ensure data security and reduce the violation of privacy and other individual legal rights by digital platforms. Meanwhile, platform developers should disclose key information about their algorithmic decision-making mechanisms and provide effective feedback channels to actively respond to citizens' questions and enhance their sense of security when using digital systems.

(3) Perceived trust risk

Mistrust is a psychological state in which citizens are suspicious of the behavior of system developers and operators based on superficial information, reflecting their concerns about privacy violations, lack of transparency, technical bias, and lack of security measures in digital systems. These concerns in turn lead to suspicion of the systems' decision-making process, and then to mistrust of the systems' developers and

operators.

To address perceived trust risk, governments and enterprises should cooperate to improve the interpretability and transparency of algorithms in digital systems, and publicly disclose the working principles and rules of digital systems. In addition, governments should enhance the fairness of decision-making in digital systems through institutional means, and provide the public with information on how digital systems work, which will help to improve citizen trust.

5.3 Global initiative for digital urban governance

Digital urban governance is essential to the well-being of citizens and is a common problem facing countries around the world. As UN Secretary-General António Guterres stated in "Our Common Agenda": "The fourth industrial revolution has changed the world. The Internet has provided access to information for billions, thereby fostering collaboration, connection, and sustainable development. It is a global public good that should benefit everyone, everywhere." All countries must act to collaboratively promote global digital urban governance for the coordinated development of human society as a whole. Guided by the concept of a community with a shared future for humanity, we propose the following initiatives based on dialogue, trust building, process commitment, and mutual understanding (Figure 5-4).

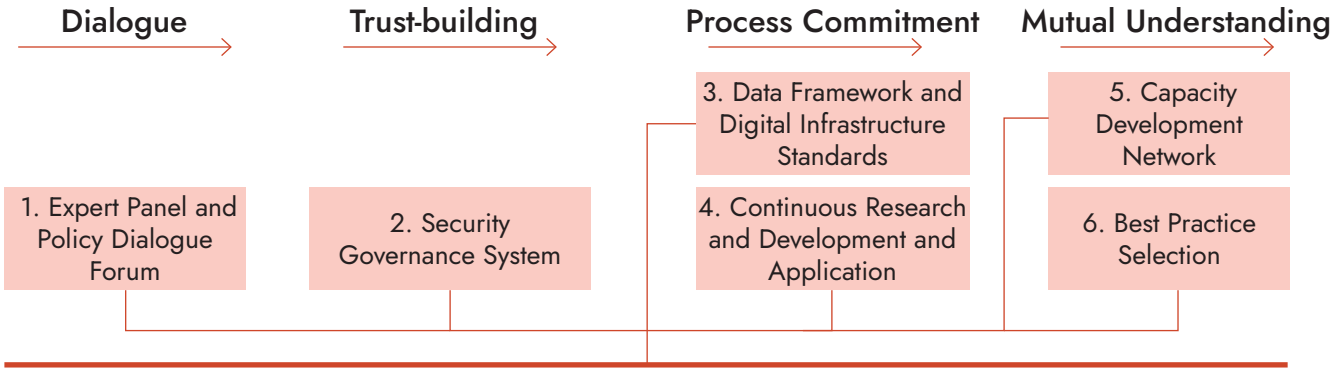


Figure 5-4: Global Initiative for Digital Urban Governance
Source: Created by author

1 Initiative 1: create a global expert panel and policy dialogue forum for digital urban governance.

Bring together experts in public administration, computer science, and related fields from various countries to investigate risks and uncertainties, development pathways, and contributions to the SDGs in digital urban governance. Set up a Global Digital Urban Governance Forum to promote dialogue, exchange, and consensus building among countries around the world.

2 Initiative 2: build a security governance system to address emerging risks.

To enhance the well-being of all human beings and promote the positive development of technology, establish a consensus-based risk management framework that encompasses risk identification, measurement, and response. Develop relevant policies and regulations to ensure security governance to prevent tangible, social, and perceived risks in digital urban governance.

3 Initiative 3: design a consensus-based data framework and digital infrastructure standards.

Establish management standards for the entire data life cycle, including data collection, storage, processing, transmission, and disposal, to facilitate data exchange and sharing across levels, departments, and regions, thereby unlocking the value of data governance. Strengthen global collaboration in building and operating infrastructure such as network equipment, cloud computing, and data centers.

4 Initiative 4: support continuous research and development and application of digital urban technologies.

Establish a global urban digital innovation ecosystem and promote continuous research and development of emerging technologies, to solve urban problems and reduce the cost of technology application. Advance the use of technologies such as AI, blockchain, and quantum computing in urban governance and design effective digital urban governance solutions to better meet the needs of citizens.

5 Initiative 5: build a capacity development network for digital urban governance.

Focus on government officials, Chief Data Officers, social entrepreneurs, and the public and enhance digital literacy training and education to improve stakeholders' abilities to plan and manage urban public affairs.

6 Initiative 6: promote best practice selection for digital urban governance.

Enhance the design of performance evaluation indicators and the assessment of digital urban governance applications, actively conduct best practice selection activities in digital urban governance at national and global levels, and establish a repository of best practice cases with replicable value. This will promote knowledge sharing, exchange of experiences, and international cooperation among cities.

5.4 Future trends in digital urban governance

In the future, it is predicted that emerging technologies will further transform urban governance, globally distributed urban governance will reshape interactions between cities, and the rise of cross-regional data collaboration will become a key pathway for value co-creation.

5.4.1 Transforming urban governance through the application of emerging technologies

Emerging technologies such as blockchain, quantum computing, and AI are increasingly being applied in urban governance, promoting "efficient task management" and "efficient task completion." The transparency, immutability, and decentralization of blockchain technology offer significant advantages in public service areas, including digital currency/payment, land registration, identity management, notarization, supply chain traceability, data management, auditing, taxation, voting, and legal entity management. For example, the Monetary Authority of Singapore has developed a blockchain-based payment network, which is part of the digital currency and blockchain technology project "Ubin." This prototype payment network serves as a model for an international settlement network, enabling faster and cheaper transactions than traditional cross-border payment channels.

Quantum computing technology uses qubits as its fundamental data units. By generating and manipulating qubits, quantum computing can perform calculations much faster than traditional non-quantum computing. In the field of digital urban governance, quantum computing can store large amounts of data and prevent data filtering errors, significantly improving the computational speed of specific types of algorithms. It can address urban issues with greater precision and efficiency, enhancing the capabilities of existing smart city solutions. For example, the Barcelona Supercomputing Center (BSC), in collaboration with IBM, launched "IBM Q Hub Spain," which is now part of IBM's global quantum network.

In November 2022, OpenAI launched ChatGPT, which became the fastest-growing consumer application ever recorded, bringing significant attention to large AI models in human society. These models have potential applications in urban governance. In terms of citizen participation, they can enhance government communication through intelligent Q&A, smart searches, and personalized recommendations. Regarding improving the efficiency of public administration, large AI models can automatically perform routine tasks and simplify bureaucratic procedures through applications such as intelligent task allocation, text generation, and drafting of official documents. For policy formulation and analysis, these models can be used to evaluate policy options and predict outcomes, helping policymakers and analysts make informed decisions. Several cities around the world are currently using ChatGPT to facilitate internal government operations, document drafting, or policy writing. In April 2023, Yokosuka, Japan, announced the use of ChatGPT to help manage routine administrative tasks, allowing staff to focus on work that only humans can perform, in response to the pressure of a declining population. In March 2024, the California government announced a partnership with five companies (OpenAI, Anthropic, Google, Meta, and ServiceNow) to develop and test generative AI tools to improve public services. These tools will be applied in four major departments: the Department of Tax and Fee Administration, the Department of Transportation, the Department of Public Health, and the Department of

Health and Human Services.

With the increasing application of large AI models to urban governance, the future is likely to see the emergence of "City-GPT," enabling dynamic urban governance. In terms of governance architecture, it will include regular governance, transitions from regular to emergency response, emergency governance, and recovery from emergency to regular states. In terms of technical architecture, it will involve "fine-tuning" the general model using data specific to urban governance. In terms of business architecture, urban governance case studies will be conducted in collaboration with multiple stakeholders and will be widely used in administrative approvals, customer service, content generation, and government decision-making.

5.4.2 The rise of globally distributed urban governance

As one of the key trends in the development of digital urban governance, distributed urban governance involves guiding external organizations, and the public to participate in urban governance. It is a new governance model based on open communication, coordination, and alignment between internal and external entities of city governments. A key characteristic of distributed urban governance is openness, which fosters deep and authentic communication, coordination, and connection between city governments and a broad range of third parties, such as residents, contractors, community organizations, local agencies, and nonprofit and for-profit organizations. It emphasizes enhancing the flexibility and responsiveness of urban governance through decentralization. The decentralized approach to distributed urban governance relies on blockchain and other distributed technologies. These technologies enable the distribution of governance authority and data processing across various nodes and participants, resulting in more efficient and transparent management. In distributed urban governance, decentralization of data and decision-making power helps improve the timeliness and accuracy of information. Departments, communities, and citizens can use tools such as smart contracts to access and process information in real time, thus responding quickly to various urban issues. By leveraging decentralized mechanisms, distributed urban governance promotes the direct participation of citizens in the decision-making process, thus enhancing the fairness and transparency of urban governance. With technological advances, distributed urban governance is expected to address the bottlenecks of traditional governance models and improve the overall efficiency of urban operations.

5.4.3 Cross-regional data collaboration for value co-creation

In the digital age, data with governance attributes have become an important resource for urban governance. Cross-regional data collaboration is a new approach to generating social impact by leveraging different data sources and expertise across regions, within and between countries. Traditional urban governance often limits the flow and sharing of data resources within a single region, leading to the creation of "data silos." However, data from different regions not only enable local urban governance but also play a crucial role in promoting urban governance in other areas. As a result, cross-regional data collaboration has become a key development trend in the future of digital urban governance.

From an internal perspective, cross-regional data collaboration within countries is emerging. Local governments are beginning to respond to urgent public demands by

offering cross-regional administrative services in collaboration with regions that have close economic ties or geographic proximity. Cross-regional administrative service collaboration is based on data cooperation between regions. For example, in China's Yangtze River Delta region, the "let data run more so people run less" initiative has established mechanisms for efficient matching of data supply and demand, data dispute resolution, and management of electronic license security and authorization. Shanghai, Jiangsu, Zhejiang, and Anhui have successfully implemented the efficient sharing and mutual recognition of 40 types of frequently used electronic licenses, with over 915 million records of government data shared and exchanged. Additionally, 173 cross-province services, such as healthcare insurance transfer and inter-provincial household registration migration, have been launched.

From an external perspective, cross-regional data collaboration between nations is becoming increasingly prevalent. Countries exchange and share data resources to enhance the value creation of these resources in urban governance, optimize resource allocation, and enable rapid response to issues in areas such as traffic management, environmental monitoring, and public safety. For instance, the European Union's "Data Governance Act" is the first legislative initiative under the European Data Strategy. This act aims to enable the free flow of data across the 27 EU Member States and between different sectors, benefiting citizens, businesses, and public administrations.

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