DESIGN A UNIVERSAL FRAMEWORK FOR CHINA'S SMART CITIES USING INTERNET OF THINGS TECHNOLOGY

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ABSTRACT. *The development of China's urbanization process resulted in both labour and inconvenient urban life. One of the solutions is to build a smart city. Because of the moderately advanced principles of smart cities. The current state of smart city construction in first-tier cities is far too advanced to be replicated in several small towns with construction needs but low economic development. Therefore, to support the development of smart cities in many Chinese cities, a universally applicable smart city framework must be developed. Thanks to China's improved infrastructure construction, even cities with huge economic development differences can find common ground in terms of urban infrastructure. As a result, to meet the universally applicable requirements, this framework must rely on Internet of Things technology, and it is built using the IoT perception layer which is defined in the GB/T 36333-2018 "China Smart City Design Standard." After reviewing several case studies, I believe this framework should include four sections: urban infrastructure, transportation, waste treatment, and urban safety.*

Keywords: smart cities; infrastructure; IoT technology; framework design; universally applicable principle.

1 INTRODUCTION

"Urbanisation" is defined as "the process by which an increasing number of people begin to live and work in towns and cities rather than in rural areas" by the Oxford Dictionary. Since the mid-nineteenth century industrial revolution, Britain has become the first country to be urbanized [7]. Due to overseas invasions and civil wars, China's urbanization is very unequal. In 1950, China's urbanization rate was just 7.3 percent, with China's urbanization process accelerating quickly following economic reform and significantly accelerating the urbanization process. The urban population grows by 10 million people per year [17]. With the advancement of urbanization comes an increase in the population, putting a massive strain on all facets of urban life.

However, all countries are subjected to this type of pressure. Building smart cities have become a popular solution to the management confusion of people and things in towns caused by rapid population growth since the concept of smart cities was suggested by IBM in 2008 [5]. In 2012, China also began to construct smart cities. So far, economically developed cities like Beijing, Shanghai, and Hangzhou have done well in the field of smart city development. However, smart cities are now required in economically underdeveloped regions. And they face many challenges as they work to create smart cities. Because smart cities should be moderately advanced, the results of smart city development in developed areas would not apply to them. As a result, this study aims to design a smart city framework that is equally applicable to Chinese cities.

Thanks to China's focus on infrastructure building, water, electrical, and communication networks have now been covered even in remote areas. The aim is to apply the framework to as many cities as possible. Selecting the infrastructure field to design this framework will help accomplish this objective. The Infrastructure Design sub-directory in the Chinese National Standard GB/T 36333-2018 Smart City Top-Level Design Guide [11], following infrastructure design criteria. There are four different layers of the framework in the infrastructure field. They are, IOT perception layer, including ubiquitous sensing devices in all spaces such as underground, ground, and air; network communication layer, including urban public infrastructure networks, government affairs networks, and other private networks; computing storage layer, including urban public computing and storage service centres, etc.; data and service convergence layer, including urban data resources, application support services, and system interface. There is no doubt that only the perception layer of the Internet of Things framework design can better adapt to more Chinese cities, making the framework universal applicability. As a result, this research aims to consider IoT technology and urban infrastructure in an attempt to develop a smart city framework that is widely applicable to Chinese cities.

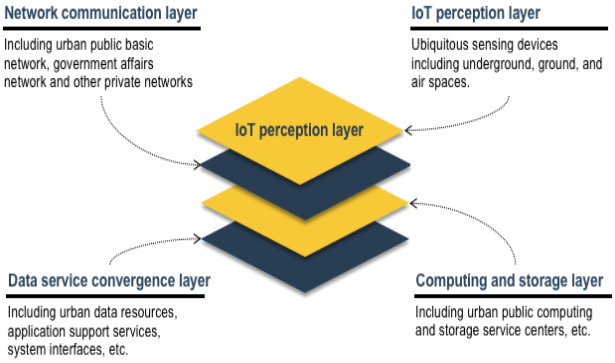

Figure 1 Four different layers of the infrastructure framework

2 LITERATURE REVIEW

IBM first proposed the concept of a smart planet in 2008 [5], and then proposed the concept of a smart city two years later. According to IBM's research, cities have different types of networks, infrastructure, and environments, including people (organizations), businesses/government, transportation, communications, water, and energy. In general, smart cities are discussing how to improve the efficiency of city management through various techniques. It means providing services to residents and improving their quality of life. A smart city's central concept is people-oriented, intending to serve the people in the city, including city managers and ordinary residents.

Following the release of the "ITU Internet Report 2005" by the International Telecommunication Union (ITU) at the World Summit on the Information Society (WSIS) and

formally proposing the concept of the Internet of Things [12], the Internet of Things technology is now used in various industries and citizens' daily lives. It had a significant impact. Smart cities make life easier in cities by requiring a wide range of new technologies to collaborate and complement one another. Big data, deep learning, cloud computing, and the Internet of Things are all critical technologies in the development of smart cities. The data collected via the Internet of Things in the ubiquitous infrastructure of urban life. The internet of everything is infiltrating fields ranging from smart homes to industrial production to urban operations, and a series of infrastructure advancements have aided in the development of the Internet of Things. The Internet of Things collects massive amounts of data. That data will serve as a key component of the data sources. Which can be used to aid in big data analysis.

Various countries around the world have different smart cities based on their specific needs. Therefore, after conducting several case studies, this article will compare the smart cities in the European Union, the United States, Japan, Singapore, and China in terms of conceptual goals, development models, and practical application areas.

Table 1 Concepts and goals of smart city construction in different countries

Cities	Concept Goal	Source by
Amsterdam	Improve the environmental	Dameri [3]
Barcelona	International promotion	Morisson [10]
London	Services for citizens, citizen engagement	Smart London Plan [15]
Stockholm	Create a prosperous ecosystem, and involving citizens in the city	Liu *et al*. [8]
Munich	Efficient energy use	Angelidou [1]
Chicago	Open data policy	Repko *et al*. [13]
San Francisco	Policies drive smart department	Dahlquist and Fell [2]
New York	The world's most digital city	Liu *et al*. [8]
Kashiwa	Compact smart city centred on the station	Yang [18].
Singapore	Intelligent nation	IDA [19]

From the perspective of the concept and goals of smart city construction, the construction of European smart cities tends to improve environmental intelligence and informatization of the living environment. The overall development of the city is based on sustainability. The goal of constructing a smart city in the United States is to improve the domestic economy by leveraging information infrastructure. However, China's smart city development concept focuses on improving residents' quality of life by strengthening urban infrastructure, improving informationized city supervision, adjusting emergency structures, and improving urban infrastructure construction [8].

From the standpoint of the purpose and content of smart cities, there are few targets for economic construction in the selected smart city construction cases. The majority of them are concentrating on smart transportation to improve transportation convenience while lowering carbon emissions. However, on this basis, China must continue to think about developing its economy through the development of smart cities.

Table 2 The development model of smart cities in various countries

Cities	Decision-making mode	Source by
Amsterdam	Bottom-up	Van Winden *et al*. [16]
Barcelona	Government-led	Morisson [10]
London	Cooperation with companies	Smart London Plan [15]
Stockholm	Cooperation with companies	Liu *et al*. [8]
Munich	Cooperation with companies	Angelidou [1]
Chicago	Cooperation with companies	Mehmood *et al.* [9]
San Francisco	Government-led	Kaufman et al. [6]
New York	Cooperation with companies	Liu *et al*. [8]
Kashiwa	Market promotion, government coordination	Yang [18]
Singapore	Cooperation with companies	IDA [19]

From the perspective of the development model, the construction of European smart cities is jointly promoted by residents, the market, and the government. The United States prefers a government-led and business-led model. Because China's smart city development is still in its early stages, it is more inclined to government intervention mode [8].

Table 3 Practical application areas of smart cities in various countries

Cities	Practice Application field	Source by
Amsterdam	Sustainable living, sustainable work, sustainable transport, and sustainable public Spaces.	Dameri [3]
Barcelona	Urban planning, productivity, collaboration, and creativity	Morisson [10]
London	Digital services and applications, electric waste collection, Government services.	Smart London Plan [15]
Stockholm	Digital services and applications, electric waste collection, government services, real-time data collection on the weather.	Angelidou [1].
Munich	Sustainable growth and transportation, and how smart solutions can improve energy management and achieve energy efficiency.	Angelidou [1].
Chicago	A technology-enabled strategy for promoting opportunity, inclusion, engagement, and innovation.	Mehmood *et al.* [9]
San Francisco	Provides multiple recycling and disposal options, renewable energy building, smart travel technology, shared self-driving car projects	Davis [4]; Dahlquist *et al*. [2]; Scheer [14]; Yigitcanlar *et al.* [20]
New York	Open government, engagement, access, and industry are the four main areas.	Liu *et al.* [8]
Kashiwa	Work with the public, private sector, and academia to use the data collected for data-driven regional management.	Yang [18]
Singapore	Financial services, digital media and entertainment, education and learning, health care and biomedical sciences, tourism, hospitality, retail, manufacturing and logistics, land and transportation, government, and society are all covered.	IDA [19]

In terms of practical applications, European smart city projects are primarily used in three areas: public services, public management, and industrial economy. In the United States, smart cities are primarily concerned with the construction of public facilities and the development of information infrastructure. Government-led projects in China are focused on public service facilities such as people's livelihood and e-government. Projects led by non-governmental organizations are focused on e-commerce and transportation.

3 METHODOLOGIES

According to the research objectives, many research methods can be selected. This article will use common research methods such as questionnaire survey, quantitative analysis, and qualitative analysis.

The questionnaire can directly reflect urban residents' needs for smart city construction. This is extremely beneficial in understanding the current state of urban life, analysing the needs of smart city construction, and developing a framework for smart city construction. There will be 20 multiple-choice questions (MCQ) in the questionnaire survey section. Create these questions following my envisioned smart city framework. The questionnaire asked respondents for their thoughts on the current state of transportation and waste disposal in their city, as well as some suggestions for their insights into smart cities.

The larger the sample size for the measurement scale, the more representative the sample is. However, to balance the relationship between survey cost and survey accuracy, we must scientifically formulate the number of samples within the allowable error range. As a result, I intend to survey at least 200 people for this study. Surveys will be conducted both online and on campus. Select residents from various cities to conduct surveys on and compile a comprehensive list of residents' opinions on local cities from China's first to fifth-tier cities.

Since this is a framework design, I believe we should describe what a framework is. In summary, a framework is a set of guidelines. The architecture of the IT field is similar to architectural design drawings. The framework is divided into two parts: upward is the solution for docking requirements, and downward is the docking coding implementation guide. By looking at the framework, a project can get a complete picture of the solution. In general, framework design content should clarify design goals, design principles, multiparty boundaries, key designs, and so on.

The framework design's goals are to create a smart city architecture that is suitable for most Chinese cities and is driven by the Internet of Things technology. Follows China's smart city top design specifications GB/T 36333-2018 [11], smart city architecture is divided into four levels, as shown in Figure 1, because this framework should be based on Internet of Things technology. Therefore, the other three levels, which are the network communication layer, computing, and storage layer, and data service convergence layer, which are not connected with the Internet of Things technology, are not required to participate.

However, this framework does not exist independently. The data collected by the urban infrastructure through the Internet of Things technology provides data support for subsequent data processing. Although little data processing is required at the IoT perception layer, the architecture should include interfaces for the other three layers.

Since the purpose of the research is to design the framework, two analytical methods, qualitative and quantitative, are required after collecting the data from the questionnaire. The data collected by the questionnaire is first counted using the most basic statistical methods, and the proportion and trend are displayed through charts such as pie charts and bar charts. Assumptions about the outcome will be made ahead of time when designing the problem. Because online surveys are more random than campus surveys, the age range will be wider than in campus surveys. Therefore, it is necessary to consider the elderly and adolescents who are less likely to appear on campus when designing some question options. The decisions that those unique groups may make.

The analysis results show that the residents interviewed have smart needs for urban transportation, waste disposal, safety, and urban infrastructure such as streetlights, electronic bus stop board, etc. This corresponds to my smart city framework hypothesis.

4 RESULT AND DISCUSSION

The design of the infrastructure framework will be carried out in the four layers of IoT perception layer, network communication layer, computing, and storage layer, and data service integration layer, according to the top design specification GB/T 36333-2018 of China's smart city [11]. The distinction between them must be carefully distinguished when selecting functions for framework design. This research's IoT sensing layer aims to investigate the perception of all devices underground, on the ground, and in the air. Based on the city's networked devices as well as those that have not yet been connected to the network.

Based on the results of the questionnaire survey, I assume, this framework must include four aspects: urban infrastructure, transportation, safety, and waste disposal. So, in terms of urban infrastructure and transportation, smart street signs, all-in-one lampposts, smart bus stop signs, and customized buses are all good examples of how to use the Internet of Things technology to build smart cities. These are also typical smart city construction applications in various countries. Customized public transportation is a new type of public transportation method that was China to help China resume production and work under the CONVID19 crisis.

When it regards urban safety in China, the Sky-net System must be mentioned. Although some may argue that monitoring one's life infringes on their privacy. But monitoring facilities play a deterrent role before a public security case occurs, and they also guide how to solve the situation after one occurs.

I believe that China's focus point on the development of smart cities should be similar to, but not identical with, that of other countries around the world. Residents' needs in terms of smart transportation, communication equipment support, smart infrastructure construction, and urban safety have always been similar, but energy, such as hydropower, differs from other countries. The central government of China, through its various water and power stations, provides water and electricity to residents in specific areas. Take the power plant as an example.

Although a city typically has multiple power plants to supply electricity, the State Grid Corporation of China calculates and distributes daily power generation, and the state conducts macro-control. One of China's many energy-saving and emission-reduction measures is macro-control of energy distribution. As a result, this research will not consider smart energy management in smart cities in China's smart city architectural planning.

Building smart cities are known to be an excellent solution to the inconvenience of urban life at this stage, and most cities in China are currently undergoing or will soon be undergoing smart city construction. However, due to various disparities in economic development among cities, and because the principle of smart city construction is moderately ahead of the existing level, relatively backward areas lack the ability or need to replicate the achievements of smart cities in economically developed areas. The purpose of this research is to design a framework that will guide as many cities as possible in their efforts to build smart cities. This study chose urban infrastructure as the entry point to achieve this universally applicable principle. Because traffic, water and electricity supply, network coverage, and urban supporting infrastructure services are widely available in China's major cities. For that reason, using this as a starting point for the smart city framework can better meet the universally applicable principles. And choose the IoT perception layer as the entry point for design from the four-layer architecture identified by China's top design specification GB/T 36333-2018 [11]. That's because this framework needs to take into account economic development constraints. Except for the IoT perception layer, all three other layers require high labor and capital costs.

This means that IoT technology guides this framework, and smart city construction is based on infrastructure. As guiding principles, consider the universal application, moderate advancement, and economic development promotion. Smart construction takes place in three areas: transportation, waste disposal, and safety. The preliminary framework for a smart city is depicted in figure 2 below. Following this framework can help cities build smart cities while preserving local culture because this is not a construction plan that requires the city to be rebuilt, but rather a smart improvement on existing urban infrastructure and a small number of new facilities.

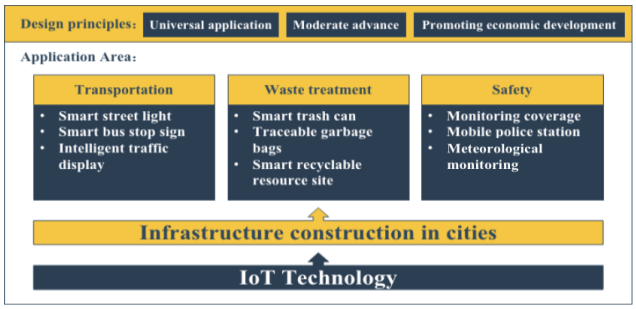

Figure 2 Preliminary smart city framework

5 CONCLUSION

In summary, a smart city framework that is broadly applicable to Chinese cities should be based on urban infrastructure and the Internet of Things at the technical level. Following a review of the literature and a questionnaire survey, I believe that the framework should include transportation, waste disposal, and urban safety based on promoting economic development. It was mentioned in the literature review that China's smart cities should promote economic development, but this goal is not prominent in the current framework. I intend to improve this framework in future research by looking into how smart city construction can support urban economic development.

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