

# Analysis of Application Scenarios of Cloud Computing and Internet of Things Technology in Smart Cities

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**Abstract:** Based on information technology, Internet of Things technology, big data technology, and cloud computing technology, smart city achieves the integration of urban information, thus developing an all-round perception of the city. Moreover, according to the development status of the city, it develops dynamic and refined management, which is of great help to improve the convenience of life of urban residents. This paper analyzes the key technology of smart city construction. It takes intelligent lighting as a case study to analyze cloud computing and Internet of Things technology application scenarios in smart cities.

**Keywords:** Cloud Computing; Internet of Things; Smart City.

## 1. Introduction

The concept of a "smart city" first originated in 2008 with IBM's "smart planet". [1] Specifically, it uses the Internet of Things technology and information technology to achieve interconnection in the fields of public services, people's livelihoods, security, and environmental protection, thus further boosting employment and empowering the economy in the context of the financial crisis. In December 2012, China officially launched the smart city pilot program, and in January 2013, August 2013, and April 2014, it released the first, second, and third batches of smart city pilot lists, respectively. [2]

The smart city refers to the combination of Internet of Things technology, cloud computing, and big data in the planning, designing, and operating of a city to promote smarter and more efficient urban management, education, and healthcare. Furthermore, Smart Cities in Perspective of Innovation 2.0 analyzes the construction system of smart

cities from both technical and economic society perspectives. [3] It believes that the construction of smart cities should not only focus on the application of new information technologies, such as the Internet of Things and big data but also the application of the methodology of Innovation 2.0. If Innovation 1.0 is a relatively closed innovation form oriented to production, producer-centered, and technology as the starting point inherited from the industrial era, while Innovation 2.0 is an open innovation form oriented to service, user-centered and human-centered, which is in line with the information era and knowledge society. In the city's future development, the information and resource sharing of the whole society will become a trend, and smart city construction will become an important platform for future social construction.

## 2. Analysis of Key Technologies for Smart City Construction

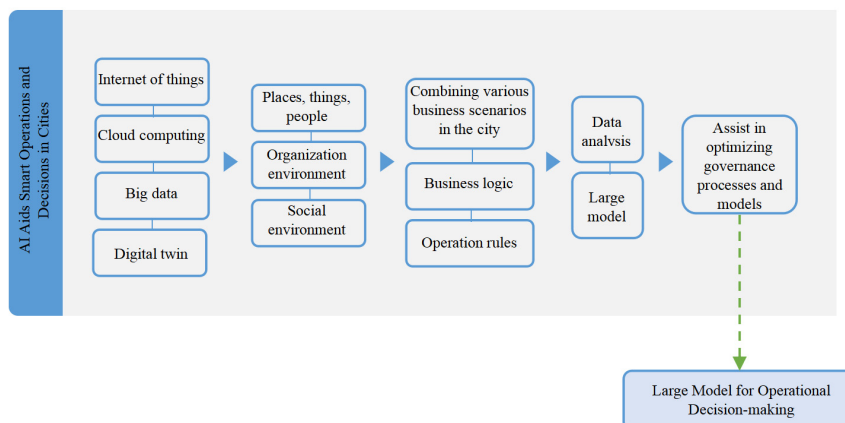


Figure 1. AI Aids Smart Operations and Decisions in Cities

Under the smart city scenario, and based on the whole life cycle, intelligent planning and comprehensive evaluation system. It adopts technologies such as the Internet of Things, cloud computing, big data, digital twin, and artificial intelligence to obtain relevant data such as places, things, people, organizations, environments, societies, economies, business logic, and operation laws. Then it combines them

with all kinds of business scenarios of the city in depth to assist in optimizing the governance processes and modes by means of modern data analysis and innovative large models, reshaping the intelligent operation management system of the smart city. Moreover, based on the Internet of Things, cloud computing, and big data. It can train on massive equipment parameters, state parameters, alarm information, and service

request information and empower the decision-making of intelligent operations in the city (As show in figure 1). Additionally, in multi-directional innovative application scenarios in the city, it achieves the deep integration of new technologies and urban activities, deeply changes the ecology and pattern of the city, and ultimately evolves into a smart, open, and evolving eco-intelligent body.

## 2.1. Internet of Things

The Internet of Things empowers the digital construction of cities and supports the deep ubiquitous perception of smart cities. Furthermore, as the sensory organ of the Internet of Everything, the Internet of Things is an important source of big data and an important part of the construction of smart cities.[4] With the rapid development in recent years, the Internet of Things has rapidly developed from the traditional single communication inter-industry cooperation into the cooperation between communication and various industries. The Internet of Things has completely penetrated all walks of urban life with its powerful characteristics of connecting things, mobility, and collaboration, making people's lives smarter and government decisions more efficient and scientific. However, since the existence of geographical differences and industry differences, many Internet of Things platforms are working separately, the system standard link is not unified, and it is difficult to connect the data between different systems. Nevertheless, under the stimulation of new infrastructure, particularly in the new round of urban renewal, the Internet of Things devices continue to push forward, from traditional to mobile, from wired to wireless, truly realizing the "Internet of Everything". Moreover, in the process of promoting the construction of smart city infrastructure, full-coverage laying is utilized to successfully complete the network of "Internet of everything" for people, machines, and things, improve the operational efficiency and safety performance, successfully complete the combination of the physical world and digital world, actively enhance the ability of all-time, all-domain and all-scene city perception, and lay a solid foundation for the digital management of the city. [5]

## 2.2. Big Data and Cloud Computing

Big data and cloud computing empower the city's digitalization construction, promote data fusion circulation, and construct the data fusion ecology. The city digitalization construction is a step-by-step process. In today's accelerating city digitalization development, the amount of city data maintains an exponential increase. However, a considerable part of the data is still in a fragmented state. The construction of big data centers and cloud computing platforms in the new infrastructure can provide cities with a large amount of resources and smart computing space. [6] On the whole, smart city construction needs to take data center construction as the foundation and digital center construction as the core to ultimately promote smart city development. Moreover, through the construction of a data center, it can properly deal with the problems of departmental information exchange and the inability of data islands to be reorganized and used. It strongly supports the storage and calculation of the city's massive data resources, provides a foundation for the use of data element innovation, and meets the characteristics of multi-data combination and data service visualization.

The development and application of big data technology provide more possibilities for the innovative use of smart cities, thus enabling the infrastructure and city scenes to

maintain a high degree of integration, continuously improving the depth of information technology, and further empowering the city scenes with information technology. Additionally, the use of cloud computing platform construction can meet the needs of city data interworking, storage, and other aspects. Therefore, in the later stage of city digitalization construction, the system itself can be connected through data, and the data can be directly saved in the cloud. The open data can break through the effect of the past "island" to make the data from the synergy effect and further improve the intelligent system ecosystem. Therefore, the maturity of big data, cloud computing, and other technologies provides a technical foundation for data fusion and storage in smart cities.

## 2.3. Artificial Intelligence

Artificial intelligence empowers the digital construction of cities and provides new momentum for smart cities. With the increase of massive data in cities, traditional data algorithms can no longer adapt to the ever-increasing "big city disease", which lacks sufficient wisdom to cope with the growth rate of data. Furthermore, artificial intelligence technology using neural networks and large model training connects cities and independent variables such as economic, social, and natural environments with dependent variables. It makes model descriptions more accurate by setting a large number of parameters to participate in training. The new generation of artificial intelligence makes products such as "city brain" [7] have the reality of real landing, which can adopt place syntax, spatial design network analysis, urban network analysis, future land use simulation, Markov chain, web crawler, spatial analysis, hierarchical analysis, and other models and techniques can be used to dig deeper into the demographic situation, overall development trend, and land use growth prediction of the smart city, and then determine the direction and development of the city. Moreover, through the deep integration of intelligent algorithms based on new technologies with various industries, new capabilities are derived to solve the problems of deep perception, ubiquitous learning, law mining, intelligent deduction, autonomous decision-making, and other issues in the process of urban operation and management, thus promoting the realization of the smart city.

## 3. Case Study: Intelligent Lighting in the Smart City

The street lamp is an indispensable public facility in urban construction, which is directly related to people's daily life and traffic safety, and the control and management of the street lamp is an important indicator to measure the degree of intelligence of a city. With the advent of the Internet of Things era, smart city lighting has become an inevitable trend of the future development of the Internet of Things. Currently, most cities are still using the traditional street lamp management system to implement unified management and timed switching of street lamps in the community. However, there are still many problems with the existing lighting equipment, such as the increasing number of street lamps, which results in higher maintenance costs and social costs; at night, the street lamps are still running because there are not many vehicles and pedestrians, which results in a waste of energy. Nevertheless, applying narrow band Internet of Things (NB-IOT) technology to intelligent urban lighting management. By real-time monitoring and intelligent management of the

operation status of the street lamps, the maintenance and operation costs can be greatly saved. [8]

The smart city lighting control system is an intelligent control system integrating sensing, intelligent control, and telecommunication. A comprehensive control system, including information management and other technologies.

Furthermore, the intelligent lighting control system based on NB-IOT technology is classified according to the application architecture as: terminal layer, network layer, platform layer, and application layer. The whole architecture is shown in Figure 2.

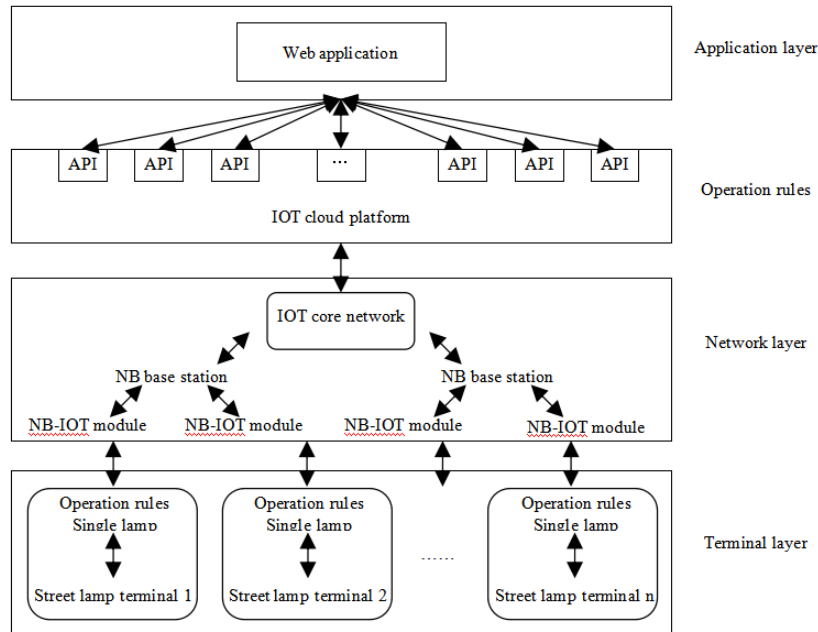


Figure 2. Overall architecture of NB-IOT street lamp control system [9]

### 3.1. Hardware Module Analysis

The NB-IOT wireless communication module is an important module to realize the function of the network layer, and the system's access function, data transmitting, and receiving function all depend on it. The NB-IOT wireless communication module uses the QuectelBC-95 communication module. Furthermore, since the QuectelBC-95 is small in size, it is suitable for large-scale applications and can effectively reduce costs. Additionally, it supports extremely low power consumption, very high sensitivity, and the current consumption in PSM mode is only 5 uA. The NB-IOT wireless communication module adopts easy-to-use LCC components, has a large number of built-in service protocols, supports Coap and UDP, and is suitable for environments ranging from -40°C to +85°C, with good stability. [10] The NB-IOT wireless communication module includes two serial ports, one for communication master serial and one for debugging serial. The module has three functions: sleep, standby, and active. Moreover, the module can be configured to activate when transmitting uplink data and no longer receive data from the base station when it is sleeping, which is a power consumption reduction technique for the QuectelBC-95 module, and the other modes can be configured through software. The communication of the NB-IOT module is based on the mobile network. Therefore, it must be matched with the corresponding operator's network, and the SIM card adopts a special card for the Internet of Things terminals from the China Telecom Corporation.

### 3.2. Software Module Analysis

As an important part of the Internet of Things architecture, the cloud platform has the functions of terminal management, connection management, application support, etc. It is suitable for Internet of Things applications with frequent data

transmission and large amounts of data information. With the support of low-power technology, real-time, low latency data transmission and control using Internet of Things technology is a pivotal part of NB-IOT technology. Currently, there are three major types of cloud computing platform services: infrastructure as a service (IaaS), platform as a service (PaaS), and software as a service (SaaS). Moreover, the system's Internet of Things cloud platform belongs to the PaaS category, with an architectural interface that includes a complete integrated development environment capable of providing device access to the terminal layer and realizing the ability of application development through the application programming interface (API) of the SaaS layer. Currently, the majority of Internet of Things cloud platforms are equipped with the following functions:

1) Terminal management: It supports large-scale device interconnection, and users can register, define functions, and message parsing through terminal devices.

2) Online monitoring: It can monitor the device's status online and perform sending and receiving of commands and detection.

3) Message transmission: It can release the data uploaded by the terminal on the platform through different data interfaces.

4) Event alarm: It is triggered by the user using the event-triggering engine provided by the platform. By using these features, the terminal-to-terminal Internet of Things applications can be easily achieved. Moreover, China Telecom's Internet of Things technology platform is adopted in this research, which can realize all-round interconnection management and self-service from product deployment to service for major operators, thus providing efficient support for Internet of Things business. Additionally, this platform provides users with convenient online development, testing, and API interfaces to realize rapid development functions.

## 4. Conclusion

In conclusion, the Internet of Things technology is closely linked to the construction of smart cities. It has unique application advantages in the practical application of smart city transportation, medicine, logistics, and other fields to implement, which is of great significance. Moreover, based on the advanced Internet of Things and cloud computing technology, it not only improves the living environment of urban residents and brings a more comfortable and advanced living experience but also effectively promotes the modernization level of urban construction and brings new social benefits.

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