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THE CONSTRUCTION OF SMART CITIES AND BIG DATA GOVERNANCE STRATEGIES BASED ON ARTIFICIAL INTELLIGENCE

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Abstract. To tackle the challenge of sluggish resource scheduling in smart city management, the author introduces a study focused on smart city development leveraging artificial intelligence and big data governance strategies. The research uses the Cloud Management Module to monitor the various hardware equipment, and establishes the target functionality of the Cloud Computing Resource Scheduling. Through the application of PSO to this goal function, a optimal scheme is created for the Cloud Resource Scheduling. Experimental results demonstrate that the system achieves optimal resource utilization, nearing 100%, whereas the other two systems have lower utilization rates, both under 90%. This indicates that, compared to similar systems, this approach offers superior overall utilization. The system is capable of efficiently managing smart cities and providing real-time monitoring of urban conditions. When scheduling resources, it achieves shorter task completion times and higher system efficiency, ensuring maximum resource utilization.

Key words: Cloud computing, smart city, Management system, Cultural particle swarm, Resource scheduling

1. Introduction. In recent years, the swift advancement of the Internet of Things (IoT), artificial intelligence, and large-scale model technologies has led to transformative shifts in the development of smart cities. As a fundamental component of smart city infrastructure, the IoT enables seamless connections and integration among people, machines, and objects through the deployment of numerous sensors that gather real-time data on urban operations. However, the increasing number of IoT devices has resulted in an exponential rise in the volume of data being generated [1,2]. How to effectively analyze and utilize this data has become a major challenge in the construction of smart cities. Traditional data processing and analysis methods are no longer able to cope with such large-scale, high-speed, and diverse data. Therefore, utilizing artificial intelligence technology for deep mining and value extraction of IoT data has become an effective way to solve this problem [3]. A smart city represents the future of urban development, combining and surpassing the elements of a digital city, knowledge-based city, ecological city, and creative city into a comprehensive urban system. It is built on an Internet of Things (IoT) infrastructure, where intelligent sensors embedded in urban objects are interconnected through the internet to provide real-time awareness of the physical city. By employing computer technology to process and analyze the gathered information, smart cities integrate the online "digital city" with IoT systems. This enables intelligent responses and decision-making to meet various needs such as governance, public welfare, environmental management, public safety, urban services, and commercial activities [4].

The smart city IoT perception system is an important construction content under the digital national strategy, and it is also a key infrastructure for achieving fine and precise management of smart cities. Through the use of state-of-the-art technologies like the Internet of Things, Cloud Computing, Big Data Analytics, and Artificial Intelligence, cities can achieve real time monitoring and insight into many fields. This provides urban managers with precise and comprehensive data, supporting more informed and rational decision-making. As a result, these technologies drive the modernization and intelligent evolution of urban environments. However, in the process of building smart cities, how to effectively govern big data has become an important challenge. The diversity, complexity, privacy, and security issues of data make big data governance particularly important. Making data safe, reliable and transparent is one of the most urgent problems in developing intelligent cities. Therefore, the establishment of a strong Large Data Management Framework is crucial to support Smart Cities' long term development and sustainable development. The author aims to explore the overall framework of building smart cities based on artificial intelligence, and focus on analyzing the strategies and methods of

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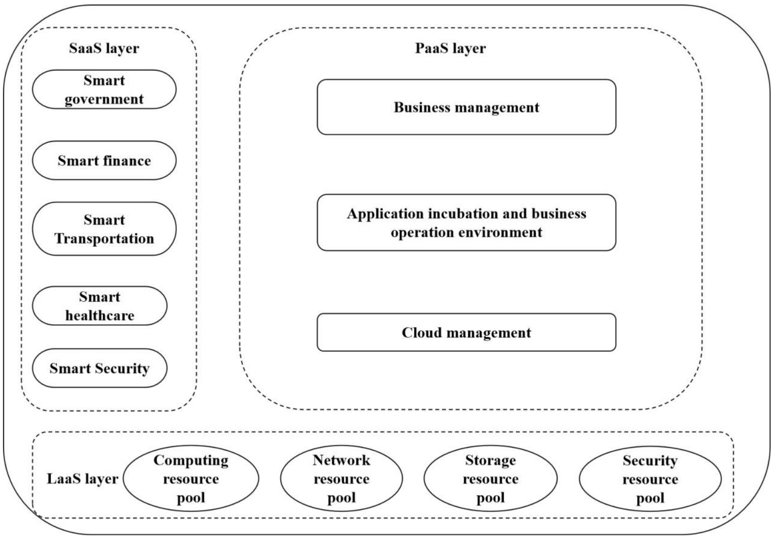


Fig. 3.1: Overall System Structure

big data governance, providing theoretical and practical support for the construction of smart cities [5,6].

2. Literature Review. Smart City was originally conceived in the 1990s, and it was used to describe the process of technological, innovative, and globalized urban development[7]. Liu, X. et al. examined the current state of smart cities, exploring specific needs and broader developmental trends. Their work has been thoroughly analyzed, and they have created a Intelligent Urban Management System with Java Programming Language and Browser/Server (B/S) architecture [8]. Li et al. investigated issues such as insufficient planning in the development of national smart city information service systems. To address these challenges, they proposed building a smart city information service system aligned with the goals of big data. They employed data clustering algorithms to effectively integrate and manage smart city information within a big data environment [9]. Liu, Y. et al. studied the frameworks for smart city development and services, focusing on the applications of cloud computing and the Internet of Things. Their research included extensive testing of data mining algorithms, demonstrating their impact on enhancing computational efficiency and optimization within smart city public management systems [10].

Based on the above issues, the author used cloud computing platforms as the foundation and designed an intelligent city management system to meet the requirements of modern urban development.

3. Method.

3.1. Overall structure of smart city management system based on cloud computing platform. Taking into account the system's overarching objectives and management principles, an evaluation of the smart city system's operational functions was performed. Following this analysis, a detailed framework for managing smart cities through a cloud computing platform was designed. The outcomes of this framework are depicted in Figure 3.1.

The basic architecture of the system consists of an IaaS (Infrastructure as a Service) resource level, with the primary focus on the promotion of the Platform as a Service Platform. This level deals with the administration of the system and is characterized by developing the Cloud Management and Business Management Modules, ensuring the smooth operation of both the system and its associated business processes.

The IaaS layer, serving as a unified resource foundation, is primarily tasked with supporting the PaaS platform layer. The system consists of the Net Resource Pool, the Memory Resource Pool, the Computation Resource Pool, and the Safety Resource Pool. This layer delivers essential hardware resources to both the SaaS and PaaS layers. Additionally, it manages and maintains the health of various resource pools and physical

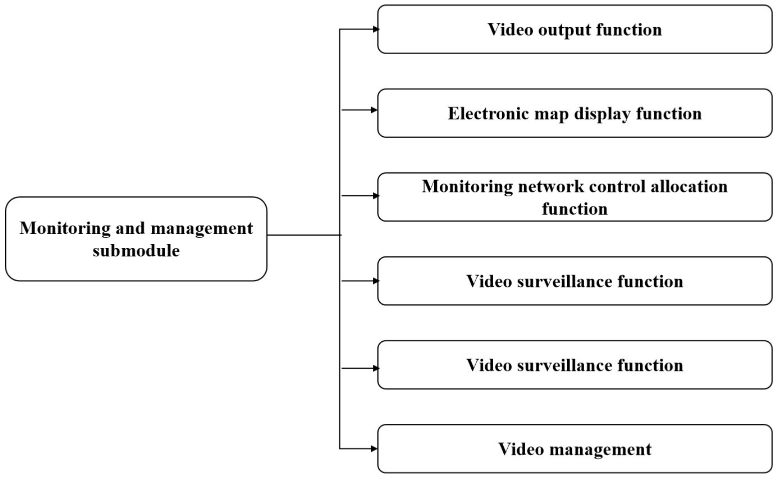


Fig. 3.2: Structure of Monitoring Management submodule

devices, overseeing the allocation and regulation of resources.

The PaaS layer delivers standardized, shared cloud services to various applications. It encompasses the business operation environment and application development infrastructure, and is divided into three main functional components: the cloud service engine, middleware, and data management components. The cloud service engine handles tasks such as service scheduling, resource management, monitoring, routing, and authentication. Middleware manages dynamic resource sharing and provides unified management capabilities. The data management component oversees dynamic resource allocation and centralized database administration. In this layer, the cloud management module oversees the overall cloud operations for the smart city management system, including resource management and operation of various sub-modules. Meanwhile, the business management module focuses on the cloud platform's business operations, ensuring the smooth functioning of service management and other related sub-modules.

The SaaS (Software as a Service) layer is designed to support a range of applications across seven key domains within smart cities. This layer primarily consists of national-level management applications as well as those tailored for provincial and municipal levels, with applications categorized according to industry and geographical region. The way to showcase applications is through cloud platforms.

3.2. Design of Monitoring and Management Module. To efficiently monitor and assess the city's condition, the smart city management system depends significantly on the cloud platform's monitoring and management submodule. The configuration of this submodule is shown in Figure 3.2. It includes six essential functions and utilizes various equipment such as audio and video capture devices, transmission media, control systems, and terminal monitoring units. These components work together within the camera system to fulfill the six primary functions of the monitoring control submodule. By strategically deploying surveillance cameras throughout the city, real-time monitoring capabilities are established [11].

3.3. Cloud computing resource scheduling strategy.

3.3.1. Scheduling principle. In the cloud, there is no direct one-to-one relation between computational resources and tasks. Rather, a task is initially allocated to a resource, which is then accessible by the respective physical device. The Map/Reduce programming model, introduced by Google, is widely utilized in cloud computing platforms. This model can be described using a five-tuple to represent the resource scheduling framework of cloud computing:

$$S = \{T, V, D, M_{TV}, M_{VD}\} \tag{3.1}$$

In the formula, $V = \{v_1, v_2, \cdots, v_m\}$,$D = \{d_1, d_2, \cdots, d_m\}$ and $T = \{t_1, t_2, \cdots, t_m\}$ represents the resource set, physical device set, and task set [12]. Equation 3.2 reflects the total duration needed for device dk to complete the execution of the assigned task:

$$\begin{cases} Sum(d_k) = \sum_{i=1}^{m} c_{ik} Finish(t_i M_{TV}, d_k) \\ c_{ik} = \begin{cases} 1 & t_i M_{TV} = d_k \\ 0 & t_i M_{TV} \neq d_k \end{cases} \end{cases} \tag{3.2}$$

In the formula, represents that physical device dk is ultimately mapped and executed by task ti. The total execution time of all tasks $T = \{t_1, t_2, \cdots, t_m\}$ is represented by equation 3.3:

$$total(T) = \sum_{k=1}^{n} Sum(d_k) \tag{3.3}$$

The main goal of Cloud Computing Resource Scheduling is to minimize the value expressed in Formula 3.3. Thus, formula 3.4 is used as an objective function for optimization of resource scheduling in cloud computing.

$$Goal(T) = min \sum_{k=1}^{n} Sum(d_k) \tag{3.4}$$

3.3.2. Cloud computing resource scheduling strategy based on cultural particle swarm algorithm. Traditional particle swarm optimization algorithms utilize rule-based binary encoding, which is not well-suited for cloud computing resource scheduling. The main aim in cloud computing resource scheduling is to minimize task completion times. To achieve this, it is crucial to ensure high particle quality, which is reflected by a high fitness value, in order to derive an optimal scheduling solution. Equation 3.5 specifies the fitness function for evaluating particles [13,14].

$$fit = \frac{1}{min \sum_{k=1}^{n} sum(d_k)} \tag{3.5}$$

The common way for particle swarm optimization algorithms to generate initial particle swarm is random, which can easily lead to particle concentration in a certain local area, resulting in non-uniform feasible solutions. In this study, the initial particle swarm was generated using a uniform approach, ensuring that the particles were evenly distributed at the outset.

Figure 3.3 illustrates the flow of Cloud Computing Resource Scheduling with Cultural PSO. First, we initialise the knowledge space and the initial particle swarm. Then, the iterative count is set, and the knowledge space is updated as the fitness of the particles is evaluated. Once the knowledge space update is complete, the group undergoes self-evolution to verify if the evolution meets the termination criteria. If not, the evolution process is repeated. If the criteria are met, the influence operation is applied to the particle swarm space. The fitness of the particles is recalculated, and both individual and global best values are updated accordingly. Simultaneously, the location and speed of the particle are adjusted to check whether the end condition is satisfied [15]. If this condition is not satisfied, the procedure will proceed for a specified number of iterations. When these conditions are satisfied, the best particle location can be found, and then the ultimate optimum solution can be obtained.

3.4. Construction strategy of smart city management platform based on urban information model. After extensive research and development, the framework of smart cities has evolved into a four-tiered system, organized from the ground up as follows: the Perception layer, the Transmission layer, the Data Processing layer, and the Application layer (see Table 3.1).

Smart city management focuses on serving the public by enhancing and streamlining social resources to deliver high-quality and efficient urban services. The development of a new smart urban management platform should begin with the creation of a unified service system, incorporating medical, educational, dietary, transportation, consumer, and administrative services [16]. Aiming to establish a high-standard service platform, this approach relies on the urban information model as a crucial step in building the smart management

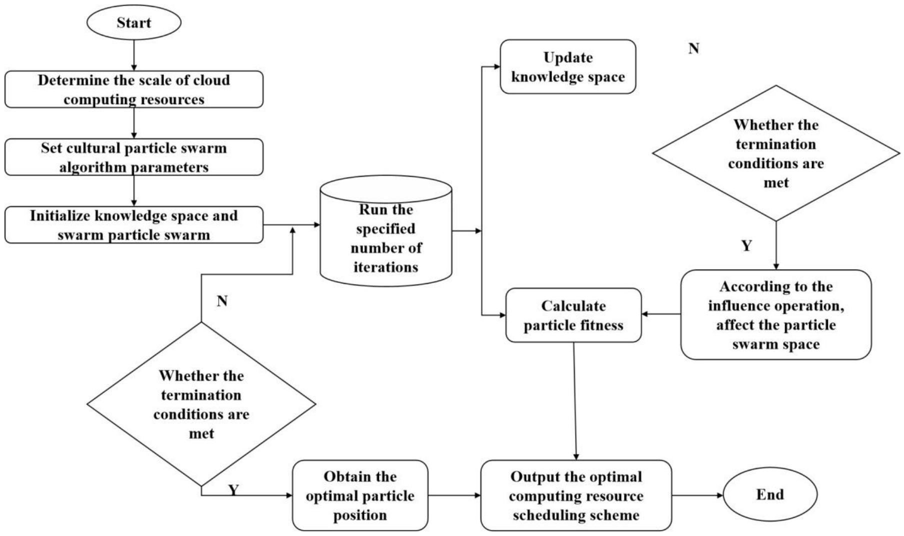
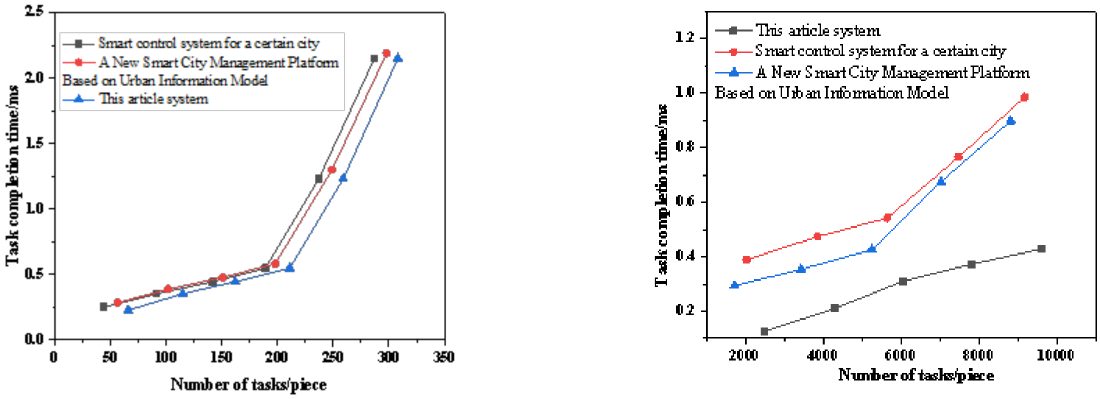


Fig. 3.3: Cloud computing resource scheduling process

Table 3.1: Structural System of Smart Cities

Level	Function	Related research directions
Perception layer	Responsible for collecting various data parameters in the city, such as humidity, temperature, pressure, light, etc	Various sensing devices, such as Zigbee, Bluetooth and Radio Frequency Identification (RFID) sensors, cameras, and Global Positioning System (GPS) terminals
Transport layer	Collect and summarize data obtained from sensors through various communication networks	Network transmission, such as 3G, 4G Long Term Evolution (LTE), 5G, and Low Power Wide Area Network (LP-WAN)
Data Processing Layer	Perform functions such as data processing, organization, analysis, storage, and decision analysis	Data integration, such as the fusion of BIM and GIS data, the fusion of sensing equipment and environmental data, etc
Application layer	The top-level of "smart city" is the functional design layer guided by practical applications	Smart economy, smart citizens, smart government, smart travel, smart life, smart environment, etc

platform. This facilitates the integration of advanced information technology with urban services and infrastructure, promoting coordinated urban development. In urban development and intelligent management, it is essential to establish clear objectives that emphasize enhancing convenience and fostering a high-end smart economy to achieve effective urban management. Utilizing CIM technology as a foundation and focusing on network security, a robust framework for smart city development should be built, leading to the creation of a smart city characterized by its omnipresence, intelligence, and integration. For instance, in developing a smart city management platform, resident ID cards can be utilized to consolidate various functions such as urban public administration, social security, micro-payments, utility services, and identity verification. By leveraging these multifunctional cards, the level of urban intelligence and service efficiency can be significantly enhanced. Additionally, residents can install mobile apps on their smartphones, allowing them to use their ID cards for streamlined services including medical insurance, public transportation, and digital payments. An



(a) When the number of tasks is small

(b) When there are a large number of tasks

Fig. 4.1: Completion time of resource scheduling for different task scenarios

intelligent management platform is crucial for urban development. It drives urban construction by prioritizing intelligence, overcoming previous limitations, and ultimately achieving the goal of enhancing and simplifying life for residents [17].

Building a connected and multi-dimensional urban smart management platform, centered around urban development, aims to enhance and refine city services and administration. The goal of smart urban management should be to advance smart city initiatives by gathering and optimizing extensive data, establishing large-scale computing servers, and supplying robust data support for networked systems. This platform should facilitate coordinated development, allowing residents to access improved online services and thereby significantly boost operational efficiency.

4. Results and Discussion. To evaluate the efficiency of resource scheduling, two different task volumes were assigned to each cloud computing node: fewer than 300 tasks and over 10,000 tasks. This paper compares the Intelligent Control System of an urban area with that of a newly developed Intelligent Urban Management Platform. The comparison is illustrated in Figure 4.1. As demonstrated in Figure 4.1 (a), when the task count is low, there is no noticeable effect on the resource scheduling completion time, with all systems displaying nearly identical task completion times and minimal differences. However, as shown in Figure 4.1 (b), with a larger volume of tasks, the time required for resource scheduling increases across all systems. Despite this increase, the new smart city management platform consistently demonstrates the shortest scheduling time, indicating a clear advantage in resource scheduling efficiency compared to the other systems [18].

Also, the amount of Cloud Computing Resource Nodes affects the efficiency of Resource Scheduling. In this evaluation, 5000 tasks were distributed across 60 cloud computing nodes, and a comparison was made between the three systems. The results of this comparison are presented in Figure 4.2.

In the smart city management system, the resource utilization rate serves as a key metric for assessing resource scheduling efficiency within the cloud computing platform, reflecting the system's resource availability. The primary objective of the cloud computing platform is to optimize resource utilization and ensure efficient resource sharing. The comparison of overall utilization rates among the three systems is illustrated in Figure 4.3. According to Figure 4.3, this system achieves the highest overall utilization rate, nearing 100%, whereas the other two systems fall below 90%. This indicates that, in comparison to similar systems, this system demonstrates superior resource utilization [19,20].

5. Conclusion. The author suggests a study focused on developing smart cities and big data governance strategies using artificial intelligence. The study involves designing a comprehensive system architecture and

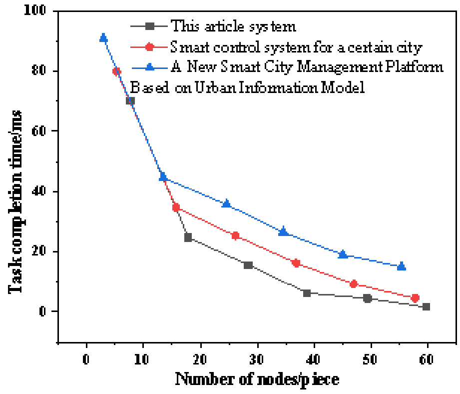


Fig. 4.2: Number of Nodes and Task Completion Time

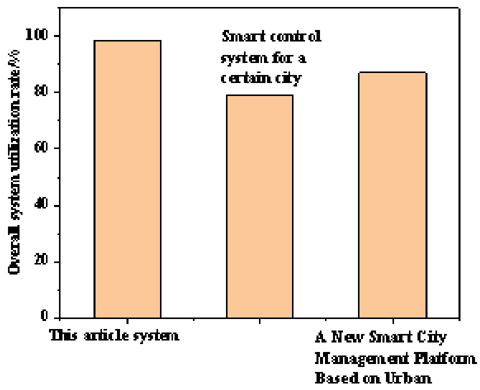


Fig. 4.3: Overall utilization rate of the system

implementing cloud computing resource scheduling through a cultural particle swarm algorithm. This approach enables efficient smart city management and real-time urban monitoring, with notable effectiveness in resource scheduling. Even with a high volume of scheduling tasks, the system maintains rapid performance and demonstrates superior resource scheduling outcomes compared to similar systems.

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