



The Collaborative Development Framework of Smart Urban Agglomeration

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Abstract. Integrating the construction of smart cities with urban agglomeration, realizing the cooperation and complementarity of advantageous urban resources, and establishing the development model of smart urban agglomeration with Chinese characteristics become an important direction of advancing new urbanization. This study combines the urban agglomeration development theory with the smart city development theory to analyze the internal mechanisms of the coordinated development of smart urban agglomeration. By constructing a theoretical model, the paper figures out key elements of urban agglomeration from the perspectives of information accessibility, global adjustability, and system optimality. Based on the model analysis, this paper makes suggestions on top-level designing, data-sharing platform construction, and standards-setting to promote high-quality urban agglomeration development.

Keywords: Smart City · Urban Agglomeration · Collaborative Development

1 Introduction

The smart city is an essential factor to promote new urbanization and develop the digital economy, which has been vigorously promoted and implemented throughout the country. With the continuous development of China's urban form to the urban agglomeration model, the demand of smart cities for regional resource sharing and industrial chain spatial integration is becoming more and more important. In this situation, integrating the construction of smart cities with urban agglomerations, establishing the development model of smart urban agglomerations with Chinese characteristics, and realizing the cooperation and complementarity of advantageous urban resources has become an essential direction of city governments at all levels.

The concept of the urban agglomeration was formally put forward in the "13th Five Year Plan" for national informatization issued by the State Council in 2016. In the following years, domestic scholars combined with the construction practice of smart city clusters in China put forward many views on the concept connotation, construction path, and evaluation system of smart city clusters.

In this area, domestic studies primarily emphasize the driving role of information technology in the smart city consortium and the interconnection of city networks. Chen (2014) [2] analyzes the connotation of smart urban agglomerations from the four aspects of science, technology, application, and construction. He points out that smart urban agglomerations rely on modern transportation facilities and highly developed information networks. Gu & Chen (2012) [4] believe that the construction of the smart city clusters should start from the whole, comprehensively study and grasp the practice of new smart city, especially highlight urban resource sharing to avoid information silos.

The concept of smart urban agglomerations in foreign countries first appeared in Europe. Cities from Belgium, Germany, Denmark, Netherland, Sweden, and the U.K. cooperated closely and achieved remarkable results in e-government and e-services from 2001 to 2007, so they are called “Smart Regions” [7]. In recent years, the research on smart urban agglomerations mainly focuses on technology application, urban planning, and development path. Kobayashi & Ikagura (2015) [5], Quwaider (2016) [6] believe that new technologies such as the Internet of things are very important to promote the regionalization of smart cities, and ICT technology should continue to iterate further development of smart cities and the development of collaborative smart industries. Esteve (2016) [3], Bholey (2017) [1] propose suggestions from the regional governance model and economic growth of smart cities, advocated the development of new models such as sharing economy to solve the problem of unbalanced regional development. Villan (2017) [10], Van den Bergh & Viaene (2016) [9] propose that the development characteristics of different urban agglomerations are different. The construction strategy of smart urban agglomerations should fit the context of urban development, and keep up with the changes of the development situation.

2 The Theoretical Framework of Coordinated Development of Urban Agglomeration and Smart City

In the Guiding Opinions on Cultivating and Developing Modern Metropolitan Areas (National Development and Reform Commission, 2019), it is pointed out that there are still obvious problems in the development process of metropolitan areas, such as a low level of integration, insufficient division of labor and cooperation, low-level homogeneous competition, imperfect cooperative development system and mechanism. On one hand, the resistance and constraints come from subjective factors, such as ideological concepts, institutional mechanisms, and policies. On the other hand, the problems lie in the limitations of objective technology, such as the lack, lag, or bottleneck of the integration of digital platforms and technology with social entities. The construction and development of smart urban agglomeration can effectively improve the ability of urban agglomeration in this regard.

2.1 Demand Analysis of Coordinated Development of Urban Agglomeration and Smart City

2.1.1 Integration of Public Service

The integration of public services is an important factor in realizing regional integration development and promoting the free flow of residents within urban agglomerations. “All-in-one card” and “one code for all payments” in the fields of transportation, medical treatment, social security, and other public services put forward high requirements for the access of remote system data between cities. Taking government service as an example, in the Yangtze River Delta Urban Agglomerations, because of lack of effective data exchange means, registered residence and other basic information can not be shared, the service integration system of urban agglomerations has never been established. It results in a greater difficulty on the cross-domain government service, which hinders the integration process of the urban agglomeration.

2.1.2 Integration of Regional Governance

Promoting the integrated development of regional governance and promoting the coordination and linkage of public safety, epidemic prevention and control, ecological environmental protection, emergency relief, and other fields within urban agglomerations is key for realizing high-quality regional development. Especially under the influence of COVID-19, taking Beijing, Tianjin, and Hebei as an example, because the regional epidemic prevention data are not interconnected, residents in Yanjiao (an area belonging to Hebei Province but bordering Beijing) are strictly restricted from entering Beijing for daily commuting without being in medium and high-risk areas.

2.1.3 Integration of Regional Industrial Development

Promoting the exchange of data elements, promoting logistics information sharing, financial information coordination, and mutual recognition of regulatory information has become an important force for urban agglomerations to form a joint force for economic development and promote the integration of regional industrial chains at a higher level. Take the Yangtze River Delta Urban Agglomerations, where logistics and financial services have been relatively developed, as an example, due to the imperfect coordination mechanism of local management departments in credit information sharing and local financial services, the credit resources accumulated by enterprises locally cannot be extended to other regions. It is inconvenient to carry out relevant businesses in different places, resulting in high operating costs.

The coordination problem of smart urban agglomeration is generally a multi-level control system, as shown in Fig. 1 [8]. Multi-level control is essentially a hierarchical structure (large-scale system structure) formed by hierarchically arranging the subsystems and controllers of the large-scale system. The characteristics of this structure are:

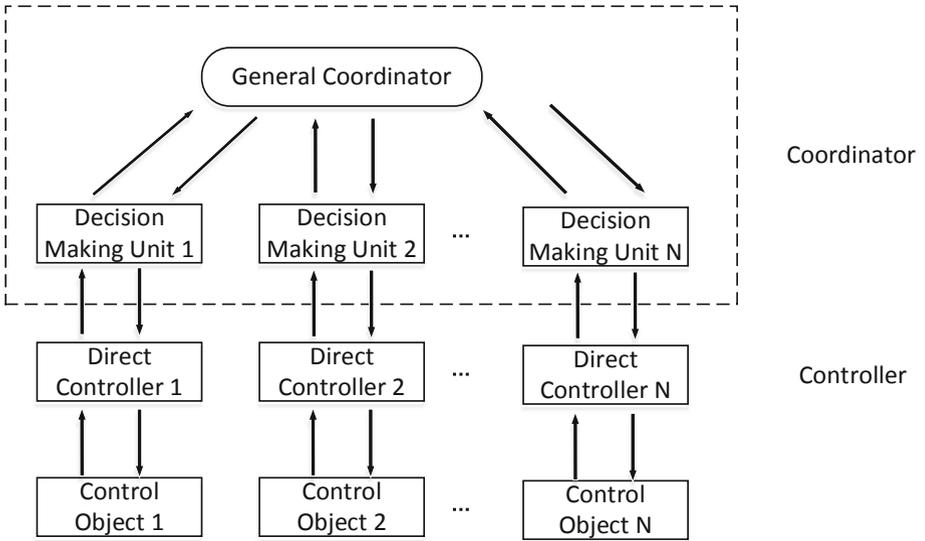


Fig. 1. Multi-level Control System

Firstly, the superior and subordinate are subordinate relations, and the superior has the coordination right to the subordinate, so the superior controller is also called coordinator, and its decision directly affects the action of the subordinate controller. Secondly, the information is transmitted vertically between the upper and lower levels. The downward information (command) has priority. The controllers at the same level work in parallel. There can also be information exchange, but not commands. Thirdly, the functional level of the superior control decision-making is higher than that of the subordinate. The problems solved involve a wider range, have a greater impact, take a long time and play a more important role. The higher the level, the more concerned about the overall and long-term objectives of the system. Fourthly, the higher the level, the more uncertain the problems involved, and the more difficult it is to make accurate quantitative description and decision-making.

Based on the multi-level control model and combined with the development characteristics of smart cities, the coordination model of smart urban agglomeration is shown in Fig. 2.

In Fig. 2, “City A”, “City B”, and “City N” in the urban agglomeration play the role of controlled objects. The smart city system, composed of information infrastructure, data resource database, and smart city application, plays the role of direct controller. The smart city management department (big data Bureau) plays the role of decision-making unit, and the urban agglomeration coordination organization (such as the urban agglomeration integration office) plays the role of coordinator.

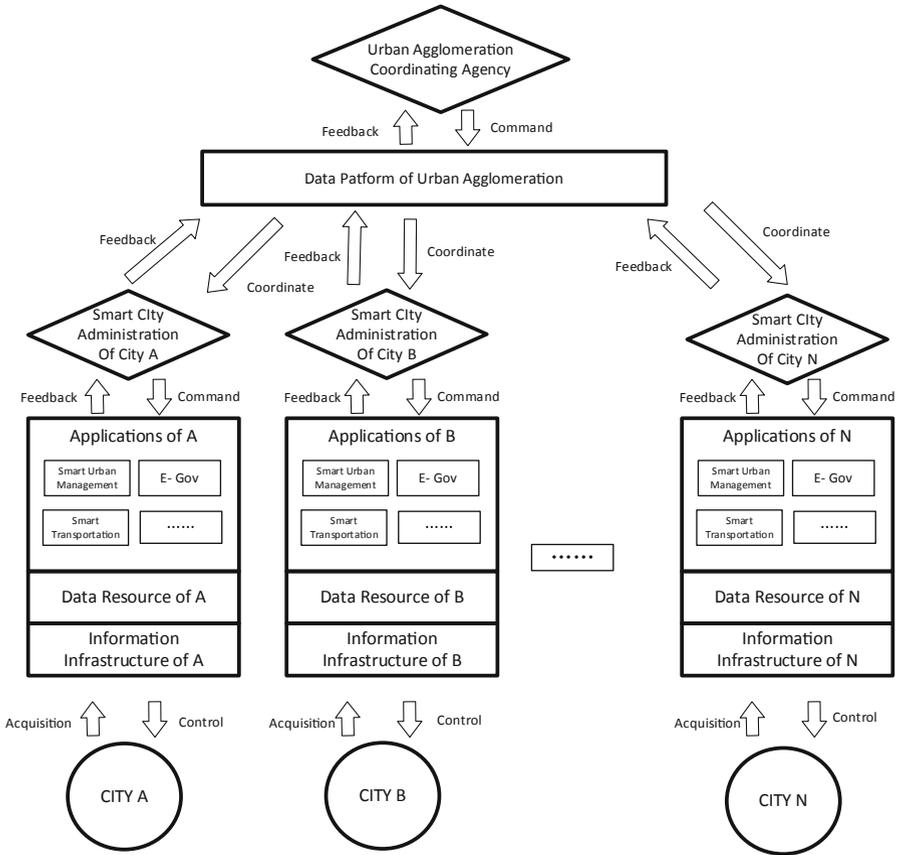


Fig. 2. Coordination model of smart urban agglomeration

3 Model-Based Analysis

After summarizing the coordination of smart city clusters into a multi-level control problem, we can analyze the development of smart city clusters through several key elements of multi-level control. There are many angles and ways to evaluate and optimize the multi-level control system. According to the development characteristics of urban agglomeration, this study focuses on analyzing the key elements of the collaborative development of smart urban agglomeration from the perspectives of information accessibility, global adjustability, and system optimization.

3.1 Information Accessibility

The accessibility of information structure is the basic index of the multi-level control system. Its basic physical meaning is that the information between various system elements is fully connected, minimizing system data redundancy and enabling controllers at all levels to carry out global collaborative control. For the coordinated development

of smart city clusters, the information infrastructure between cities should be opened up first, to make the information communication network between cities unimpeded. Then, the sharing of data resources between cities and the interconnection between urban databases are realized, which lays a good foundation for the coordination and optimization of the system.

3.2 Global Adjustability

The global adjustability of the hierarchical control system can be judged from two aspects. On the one hand, the distributed system should have a certain degree of autonomy, that is, to carry out control without relying on other subsystems. On the other hand, it is necessary to maintain a certain coordination relationship among subsystem variables in structure, that is, to establish the coordination relationship between control functions, retain or strengthen the beneficial relationship between controlled objects, and offset or weaken the destructive relationship between controlled objects. Firstly, for the coordinated development of smart city clusters, it should be structurally guaranteed to set up an organization similar to the global coordinator, collecting relevant data from subsystems (i.e., cities) and carrying out relevant feedback control. Secondly, it is necessary to carry out a coupling analysis on the data of various cities, enhance the variables conducive to the integrated and high-quality development of urban agglomeration, and eliminate the repeated construction and collaborative and shared infrastructure.

3.3 System Optimality

Based on global adjustment, system optimization should be realized. A hierarchical control system has a variety of optimization objectives. In this study, the optimal objective is to “achieve global optimization with the least cost and the relative optimization of each subsystem.” Collaborative optimization method is the most suitable for this study. The initial expected value is first assigned to each subsystem at the system level, and each subsystem obtains the relative optimization under the constraints of the system, and then returns to the large system for optimization and adjusts the initial value, and finally realize the system optimization by iteration.

4 Conclusion

At present, data elements are the most active and efficient production factors. Realizing a free and efficient technology flow, material flow, and capital flow by using data flow is an effective way to break through the boundaries and obstacles, and promotes win-win cooperation in urban agglomeration. In this context, there is an urgent need to promote the collaborative linkage between smart cities in urban agglomerations and promote the integrated and high-quality development of urban agglomerations.

4.1 Top-Level Design

Top-level design is the basic condition to realize the global optimization of complex systems. It is necessary to take the lead in carrying out the special top-level design and implementation scheme of smart urban agglomeration in the Yangtze River Delta, Greater Bay Area, Chengdu-Chongqing Urban Agglomeration, in which the competent departments for the interconnection of data elements of various urban agglomerations are determined, and special work schemes of regional integrated data governance according to the development strategies of different urban agglomerations are formulated. Promote regional cities to sign a memorandum of cooperation on data governance and form a set of regional data governance cooperation mechanisms in urban agglomerations. The central cities of urban agglomeration are encouraged to take the lead in infrastructure construction to realize the sharing of ICT infrastructures among cities.

4.2 The Data-Sharing Platform for Urban Agglomeration

From the model analysis, it can be seen that information exchange is the basis for system coordination and optimization. Therefore, greater efforts should be made to promote the interconnection of ICT infrastructure and data resources among cities in the urban agglomeration. In terms of hardware, the interconnection of fixed networks, IoT private networks, and other network infrastructures should be promoted. The cloud computing infrastructures in the urban agglomeration should be unified managed and scheduled. We should focus on realizing the connectivity and sharing of regional data. Firstly, the data sharing platforms in the urban agglomeration should be upgraded for data exchanges among cities. Secondly, data brains should be explored in central cities or cities with good foundation, enable all cities in urban agglomerations to share data, and to provide various integrated services for government, enterprises, and people.

4.3 Standards and Specifications

Standards and specifications are important part of data access. We should emphasize the guiding role of government departments in charge of urban data standards, give full consideration to the existing standards and specifications, and encourage urban agglomerations to formulate unified standards for data governance following the principles of “physical dispersion, logical concentration, global coverage, overall scheduling, and resource sharing.” On this basis, the government data, industry data, and social data of cities in the region are unified and integrated according to standards to form the basic database and theme resource database of urban agglomeration to support the collaborative applications.

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