Research on Architecture Strategy and Estimation Model of Digitized and Business-oriented Smart Community System

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Abstract: The level of intelligence in the community has become an important indicator to reflect the level of urban development. This article starts with the architecture strategy of the system and builds a dynamic digital business smart community system. The goals of software product management for the three-dimensional digital community are clarified, which improves the effectiveness and reliability of system development. Based on the function points, data management system estimation model, geographic information system estimation model, APP system estimation model, and content management system estimation model are created separately. The interaction interfaces of the information management system, information publishing system, activity publishing system with the geographic information system, APP interaction interface, and content management system are unified into the data management system estimation model. By analyzing the technical and economic theory, the bottleneck problem of promoting the application of digital communities is solved, and the development cost of digital community software systems can be predicted clearly. This also facilitates the calculation of the direct economic and social benefits brought by the promotion and application of results.

1. Introduction

With the continuous breakthroughs and widespread application of new generation information technology, the world is experiencing a new technological revolution and industrial transformation since the third industrial revolution, especially during the epidemic prevention and control period. Digital transformation has become a major trend, and new online platforms for "non-contact" services such as online shopping, online education, and remote medical services have flourished. The government's digital governance system is accelerating, and the community is an area where social groups are highly concentrated, reflecting the different degrees of society. In the process of community management, the integrated application of new information technologies such as the Internet of Things, cloud computing, mobile internet, and artificial intelligence is a new model of social management innovation in the new situation[1]. The construction of smart communities has swept the world. Its purpose is to provide community residents with a safe, comfortable, and convenient living environment, ultimately making residents satisfied and continuously improving their quality of life. The degree of community intelligence is also an important indicator of the level of urban development. The new generation of information technology continuously promotes the integration of the real world and the virtual world in terms of depth and breadth, and is affected by the type, structure, function, and development changes of communities, which has created unprecedented complex dynamic systems, requiring new architectural solutions to address the challenges of smart community governance[2].

2. MATERIALS AND METHODS

2.1. Scope of Smart Community Construction

Digital transformation is "the integration of digital technology into all areas of a business, fundamentally changing how you operate and deliver value to customers"[3]. Smart community is a new form of community governance that fully applies various information technology means, integrates various community service resources, and builds a management and service model based on information and intelligence. The National Information Center's Smart City Development Research Center's "Smart Community Construction and Operation Guide (2021)" summarizes the core businesses of smart communities into four aspects: "government affairs," "business," "services," and "household affairs." The overall framework includes four parts: infrastructure layer, data layer, platform layer, and application layer. The technical implementation is guaranteed by relevant standard systems such as regulations, technology, operations, and security. The content of smart community construction mainly consists of five parts: basic network infrastructure, data center, public information platform, basic database, and Internet of Things facilities.

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2.2. Architectural Strategies

2.2.1. "Top-down" Design Strategy

The core idea of this strategy is to emphasize the construction concept of "top-level design, gradual advancement", which coordinates and plans community-wide affairs, starting from a comprehensive to a local level and from a long-term to a short-term perspective, to achieve a smart community by exploring rational business flows. This strategy is easier to grasp the overall picture, but has greater implementation difficulty and higher cost. Moreover, as the economy and society develop and residents have multifaceted needs, the community service functions are constantly changing, and there is limited room for system improvement[4].

2.2.2. "Bottom-up" Design Strategy

The core idea of this strategy is to follow the construction concept of "decentralized construction, comprehensive governance", starting from specific community affairs, separately solving specific modules, and then gradually expanding multiple parts of the solution. Through system integration and data governance, it finally achieves the smart construction of the community. This strategy can ensure that the final system has strong practicality and can deeply integrate with the business. However, this strategy emphasizes the locality of specific parts, which leads to a lack of overall goals and coordination, making it difficult to ensure the rationality between blocks and the need for dynamic business development[5].

2.3. Community Geographic Information Systems

80% of human society's data is closely related to geographical spatial location, especially for social data such as population and events. By associating social data with spatial locations and utilizing spatial analysis techniques and methods, social data can be transformed into useful information, providing a solid foundation for government decisions on city planning, trend analysis, population policies, and more[6]. Community Geographic Information Systems (CGIS) is a comprehensive geographic information system that aims to provide spatial data, analysis tools, and visualization effects about communities, so that community planners, organizations, policy makers, and the public can better understand and manage community issues. CGIS provides highly intelligent technologies such as data mining, spatial analysis, machine learning, etc., which can help community planners and decision makers better analyze and predict community issues, and improve the scientific and accuracy of decision making.

2.4. Digitization of Community Services

The projects and content of community services have basically covered various fields of material and spiritual life for the majority of residents. The service content has developed from more than 10 items to over 200 items. Community service projects and content typically include community health services, community education services, community public facilities services, community environmental services, community cultural services, community economic services, community volunteer services, and other aspects. The Shenzhen Bay Smart Community utilizes the Internet of Things (IoT) and cloud computing technologies to provide intelligent parking, access control, security, and management of public facilities, as well as an online community service platform that offers convenient services to residents. Singapore's smart communities mainly focus on public housing areas, using digital, IoT, and intelligent technologies to achieve intelligent parking, access control, smart waste sorting, and energy management, while also establishing an online community service platform to provide one-stop services for residents. The Chicago Smart Community integrates city and community data to establish an intelligent city planning and management system, including smart transportation, smart buildings, smart environment, and smart healthcare, aiming to improve residents' quality of life and achieve sustainable urban development. It can be seen that community service projects are not rigid and need to be classified, planned, and implemented based on the characteristics of each community, and continuously improved during operation. [7] Therefore, a dynamic digital business model is more suitable for the construction of smart communities. Therefore, adopting a dynamic digital business model is more suitable for the construction of smart communities.

2.5. Changes in Mobile Internet Users' Behavior Habits

The rise and development of mobile internet have changed people's lifestyles and social habits, and subsequently affected the behavior habits of community users. The changes in community users' behavior habits brought about by mobile internet include changes in information acquisition methods, community service methods, community consumption methods, and community activity methods. Expanding community grid service management from "offline" to "online" has effectively improved the level of community management. Creating mobile apps has made community management services digitized, visualized, intelligent, and refined. Establishing a community management information database and resident information files to provide support and guarantee for residents with precise service management. The rise and development of mobile internet have promoted the informationization, intelligence, and socialization of the community[8].

3. RESEARCH OBJECTIVES

In the architecture of smart cities, there are increasing concerns about the exercise of power in top-down strategies. There is also a growing movement advocating for a "bottom-up" approach that prioritizes citizen needs and redefines smart cities[9]. This approach seeks to

involve citizens in the planning and deployment of smart city projects, giving them more direct control over the process. However, more and more people are realizing the limitations of the binary perspective. First, we agree with recent research that suggests the top-down vs. bottom-up binary overlooks the behavior of actors that neither sit at the top of power relationships nor at the bottom of citizen-driven strategies[10]. Second, we believe that the content and business of smart community development are regionally diverse and dynamically changing, driven by people and services closely related to smart communities. Finally, the rapid development of technology is silently changing the way people live, work, and think in the information age[11].

This paper mainly uses survey, literature research, and model methods to study the architecture strategy, business requirements, project management, and geographic information of smart communities. We construct a basic architecture model of dynamic digital business smart communities, complete the project management standards, and realize the smart community project scale estimation model. We set two main research questions to answer:

Rq1:How can we unify top-down and bottom-up design strategies in a dynamic digital business system architecture to address the lack of overall goals and coordination in business adaptability, scalability, changeability, and specificity?

Rq2:After clarifying the goals of three-dimensional digital community software product management, how can we use technical and economic theory analysis to predict the development costs of three-dimensional digital community software?

4. RESEARCH METHODOLOGY

Typically, there are three objectives for product management: the working environment, functionality and performance of the product, as well as the types of data processed and output results. Only with a clear understanding of these basic requirements can effective project management be carried out, including project estimation, risk analysis, and project planning[12]. During the project estimation phase, the key issues that need to be addressed are the major attributes of the project, including the size of the product to be developed, the effort required for the project, and the cost of the project. In order to develop reasonable project plans and budgets, in-depth analysis and evaluation are needed to adjust plans in a timely manner to respond to risks and changes[13].

4.1. Dynamic Business Functional Architecture

The function point method is suitable for estimating the three-dimensional digital community software project. In order to distinguish different functions, it is necessary to establish the concept of the application system boundary[14]. The functional types include: geographic information systems, apps, content management systems, information systems, information release, and activity release. The relationships between the six types are shown in Figure 1. There are six functions that cross the boundary, including the information management system's interaction interface with the geographic information system, the information management system's interaction interface with the app, the information release system's interaction interface with the app, the activity release system's interaction interface with the app, the information release system's interaction interface with the content management system, and the activity release system's interaction interface with the content management system, which are referred to as interface functions[15].

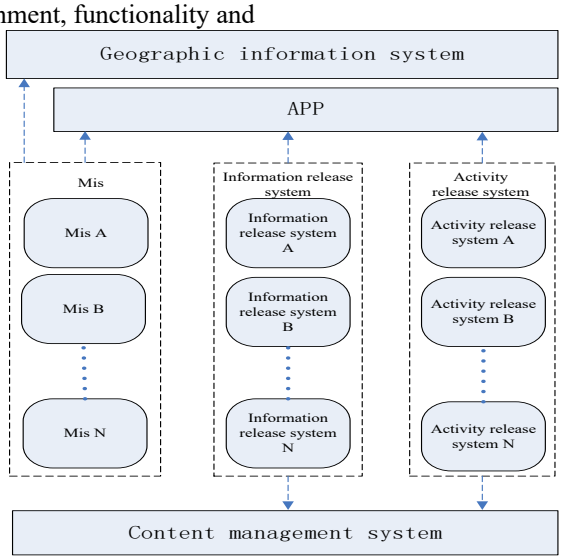

Figure 1: Schematic diagram of functional type boundary of 3D digital community software project

Six types of functions: The scale of geographic information systems mainly depends on the drawing techniques used, as well as the area and architectural complexity. The number of APPs is mainly related to the development tools, information management systems, information publishing systems, and event publishing systems. The number of content management systems is mainly related to the development tools, information publishing systems, and event publishing systems. Management information systems are a set of logically related data or control information that can be used in application systems and data analysis systems, and

represent the data storage requirements that the application system can support. Information publishing systems and event publishing systems are related to the processing and publishing of multimedia data that they can handle.

4.2. Data Management System Estimation Model

The complexity of the interaction interfaces between the information management system, information publishing system, activity publishing system, and geographic information system, as well as the APP interaction interface and content management system interaction interface, can be divided into three levels: simple, medium, and complex. To represent the degree of difference, different impact parameters are assigned. Table 1 lists the influence parameter values of functional complexity.

Table 1 Functional complexity impact parameters

Interface	GIS interactive interface			APP interactive interface			CMS interactive interface		
	Simple	medium	complex	Simple	medium	complex	Simple	medium	complex
MIS	7	10	15	5	7	10	-	-	-
XMTZZ	-	-	-	3	4	6	4	5	7
ARS	-	-	-	3	4	6	4	5	7

As long as the number of complexity function points for the three systems and their interaction interfaces can be obtained from the specification, denoted as C, it is easy to calculate the value of function points.

$$\mathrm{UFP} = \sum_{i=1}^{3}\sum_{j=1}^{3}\sum_{k=1}^{3}\omega_{ijk}C_{ijk} \qquad (1)$$

Where: i represents the function type number: i=1, 2, 3. 1 represents information management system, 2 represents information publishing system, and 3 represents activity publishing system. j represents the level of complexity: j=1, 2, 3. 1 represents simple, 2 represents moderate, and 3 represents complex. k represents the interface type: k=1, 2, 3; 1 represents the interface of the geographic information system, 2 represents the interface of the APP, and 3 represents the interface of the content management system.

ω_{ijk} represents the impact parameter of the i-th functional type, j-th complexity level, and k-th interface type, that is, the parameter value in the i-th row and k-th j-th column of the table above;

C_{ijk} is the number of functional points for the i-th functional type and the k-th j-th complexity level.

4.3. Geographic Information System Estimation Model

After analyzing various module software, the following seven types of influencing factors are comprehensively identified for the geographic information system: geographic area, building complexity, data communication, performance objectives, interface data entry, statistical analysis with complex processing logic, and facility changes.

Among them, geographic area and building complexity are decisive factors, which are represented by M and N. The impact levels of the other five types of influencing factors are divided into six levels, represented by C, as shown in Table 2.

Table 2 Impact Levels of Impact Factors

Impact level	Level 0	Level 1	Level 2	Level 3	Level 4	Level 5
Influence degree	No impact	Minor impact	Mild impact	Moderate impact	Significant impact	Major impact

After considering the impact of the five types of influencing factors, the degree of impact C should be the sum of the five types of impact, which results in the complexity adjustment factor MAF:

$$MAF = (0.45 + 0.01C) \qquad (2)$$

Based on data analysis, if the complexity of the building has 60% influence on the area influence, then the Map Function Points (MFP) of the Geographic Information System are:

$$MFP = 0.6MAF * M * N \qquad (3)$$

4.4. APP System Estimation Model

Ignoring the development tool factor, the number of APPs is mainly related to the information management system, information publishing system, and activity publishing system. Based on the known data volume relationship, the APP Function Points (AFP) are:

$$AFP = 0.047 * UDP \qquad (4)$$

4.5. Content Management System Estimation Model

The content management system mainly refers to the background of the website's information publishing system. Ignoring the development tool factor, the number of content management system function points is mainly related to the information publishing system and activity publishing system. Based on the known data volume relationship, the Content Management System Function Points (WFP) are:

$$WFP=0.029*UDP \qquad (5)$$

Finally, the software estimation function points (SFP) of the three-dimensional digital community software project are:

$$SFP=UFP+MFP+AFP+WFP \qquad (6)$$

The relationship between function points and DLOC can be calculated according to the basic standards of software engineering.

5. RESULTS AND DISCUSSION

The five parts of smart community construction, including basic network facilities, data centers, public information platforms, basic databases and Internet of Things facilities, are the core content of smart community construction. Building a smart community public information infrastructure platform based on the dynamic digital business system architecture. Aiming at the complexity of community business, the dynamic digital business system architecture is adopted. This architecture can make full use of the Internet of Things, cloud computing, big data, mobile internet and other new technologies to quickly realize the online and offline of various community businesses. Smart communities are closely related to community management business and the life, study, entertainment, work and other aspects of community residents, and their business is largely driven by the needs of relevant personnel. Using this architecture, we can maximize the business encapsulation of data on the basis of community data integration, and upgrade it to a new business segment, avoiding the impact of users' conversion between the roles of business personnel and system operators on normal work, and this mode will promote the role of relevant personnel to play a greater initiative. At the same time, this method solves the problems of business adaptation, addition and change caused by the theorization of the "top-down" design strategy, and also avoids the need for the particularity of the "bottom-up" design strategy, which lacks the overall goal and coordination, and is difficult to ensure the rationality between blocks and dynamic business development.

The 3D digital community software project management methods, such as project estimation, risk analysis, and project plan formulation, have been developed from the four basic factors of personnel management, software system product management, process management and project management involved in the smart community. The objectives of 3D digital community software product management have been clarified, and the effectiveness and reliability of system development have been improved. Based on the function points, the data management system estimation model, the geographic information system estimation model, the APP end system estimation model, and the content management system estimation model are created respectively, in which the information management system, the information release system, the activity release system and the geographic information system interaction interface, the APP interaction interface, and the content management system interaction interface are unified into the data management system estimation model. Through technical and economic theory analysis, the bottleneck problem of digital community promotion and application has been solved, and the development cost of digital community software system can be clearly predicted, and the direct economic and social benefits brought by the promotion and application of achievements can be easily calculated.

Community geographic information system and dynamic digital business of community services are important components of smart community construction. The changes of mobile internet users' behavior habits also have an impact on the construction of smart communities. The construction of smart communities can promote the digital transformation of communities, improve the quality of life of community residents, and make contributions to the development and progress of cities. The construction of smart communities can improve the informatization level of communities and make community services more efficient, accurate and intelligent. At the same time, smart community construction also faces some challenges, such as technology upgrading, information security and other issues.

6. SUMMARY AND OUTLOOK

Smart community construction is a new model of community governance in the digital era, and its future development direction is digital, intelligent and sustainable development. With the continuous development and application of new generation information technology, smart communities will undoubtedly become an important means of community management. In the future, smart community construction also needs to pay attention to the needs of residents, give full play to the main role of community residents, build a community governance model with residents' participation, and realize the democratization, informatization and transparency of community governance. At the same time, we need to strengthen the planning and management of smart community construction, fully consider the development characteristics and needs of the community, and improve the quality and efficiency of smart community construction. In the future, the construction of smart communities will also face more challenges and opportunities. It needs continuous innovation and development to better serve community residents and urban development.

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