Developing a Smart Real Property Management System: A Case Study in Hangzhou, China

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Abstract. The real property is one of the critical assets in the city that engages in multiple stakeholders like consumers, agents, government authorities, and construction contractors. Construction of a smart real property management system is of particular importance to manage the life cycle of properties effectively. This study proposes a real property information model with the objects of resident community, underground space, block, pipe and unit to model the real properties in reality. A layered architecture of the smart real property management system, consisting of databases, data middle platform, map services, and service gateway platform, is implemented. A case study in Hangzhou, China is demonstrated with the implemented 'OneMap' smart real property platform and its application to stakeholder scenarios including property security, marketing administration, sales and rental transactions, facility management, accommodation for low-wage residents. The experiences and lessons gained from the practices in digital transformation of real property management in Hangzhou are summarized.

Keywords: Smart Real Property · Real Property Information Model · GIS · System Architecture

1 Introduction

The city, which is a large human settlement and a complex system with interrelated infrastructural, economic and social components, is under a fast pace of growing and development. The projected population increase, as well as the associated social, ecological and climate issues, has shown the threat to modern urban development, urging a sustainable and resilient way of living for all. The real property is one of the critical assets in the city. It attracts huge national and global finical investments, and engages in various stakeholders such as consumers, agents, government authorities, and construction contractors. Smart real property management is of particular importance to break the information barriers among the stakeholders and to strengthen the fundamentals of efficient and effective governance and public services.

D. Qiu et al. (Eds.): ICBBEM 2022, AHIS 5, pp. 1020–1026, 2023.
https://doi.org/10.2991/978-94-6463-030-5_100

The geographic information system (GIS) was one of the fundamental technologies to aid digital real property management in the past decades. Owing to its capability of modelling, managing, and analysing spatial data, the geographical location of properties can link to the data produced in different phases of real property life cycle to support administrative management [6, 8], site selection [10], property valuation [5], market investigation and trading analysis [3]. The prevailing of internet, especially mobile internet in the recent 10 years, enables the real property information and services to be obtained widely by the public [2, 7]. Recent technology innovations, for examples cloud computation, internet of things (IoT), artificial intelligent (AI), drones and virtual reality, have shed the lights of the smart city establishment. In the context of data explosion in the modern society, the real property industry requires a deep digital transformation. Some pilot smart real estate projects of applying and integrating IoT, AR and BIM were reported in [1, 4, 9].

The challenges in the pathway to smart real property management lie in: (i) the real estate life cycle includes the phases of design, construction, trade, management, and maintenance. This requires a scalable data model to manage the data produced in the full life cycle and to tackle the history of the properties; (ii) the information transparency is concerned. This requires an efficient and secure manner to share the relevant data across stakeholders; and (iii) a flexible system architecture of smart real property management system being capable of developing business modules to satisfy administrative management requirements, and applying disruptive technologies to explore the potential to advance real property industry.

The objective of this paper is to propose a property information model being capable of modelling the spatial, temporal and attribute data associated with the property in its full life cycle. Technical details and architecture of the smart real property management system will be presented. The practices of establishing the smart real property system and the potential of applying BIM and IoT technologies will be demonstrated. Finally, the gained experiences and lessons from the digital transformation of real property industry in Hangzhou will be summarized.

2 Real Property Information Model

The city is a complex system including not only static indoor and outdoor objects, but also dynamic people, transport, resource, capital and energy flows. A smart city model includes the components to model the architecture, infrastructures, transport, people and environment etc. The real property information model is the basic concept to organise the information relevant to the property. It manages the physical characteristics of the property like location, space, structure, age, size, as well as the associated business information such as ownership and transactions.

Figure 1 illustrates the relations among the objects in the property information model. There are five primary types of objects, including resident community, underground space, block, pipe and unit. Each object is represented as a table in the database. The unit is the basic object to model the property, managing its physical information (i.e. location, size, and floor plan) and the associated property owners and transactions. The block object models the physical building, which contains units located in different stories,

Fig. 1. The relationship of the objects in the real property information model.

and pipe infrastructures for various supplying purposes (e.g. water, gas, communication). The resident community object includes blocks (or buildings) and shared public facilities under centralized management. It also refers to the object of underground space such as carpark. Each object has a unique identification to link with other objects and external data sources. For examples, the block object could link to BIM to access the 3D models of the building in order to track its construction, surveillance and maintenance status. The public facility objects (e.g. main entrance) often link to the IoT systems to facilitate the access of real time operation information.

3 System Architecture

Technically, as shown in Fig. 2, the smart property management system is established in a layered architecture. The bottom layer is the core business data layer storing the raw data produced in the whole life cycle of real properties. This includes the property information model, sales and rental transactions, and other records relevant to the workflow of administrative management. On top of the core business data layer, databases are created to store the statistics to serve for efficient and effective query purposes. A data middle platform is constructed to facilitate the automatic data clean, pre-process, model build and other specific routines. Aided by data middle platform, the business data and serveries can be re-organised and deployed flexibly.

The GIS powers the capability of interactive visualization, query and analysis of real property data. Considering the complexity of spatial data handling, a series of web services, including map services, BIM services, property information model services, are developed to serve for spatial-aware requests. The developed services are registered in a service gateway platform hence can be called by various applications developed for stakeholders.

The 'OneMap' solution is a centralized real property data portal that integrates the web services provided by the data middle platform and the service gateway platform. A smart real property cockpit is implemented to interactively access and visualize the real

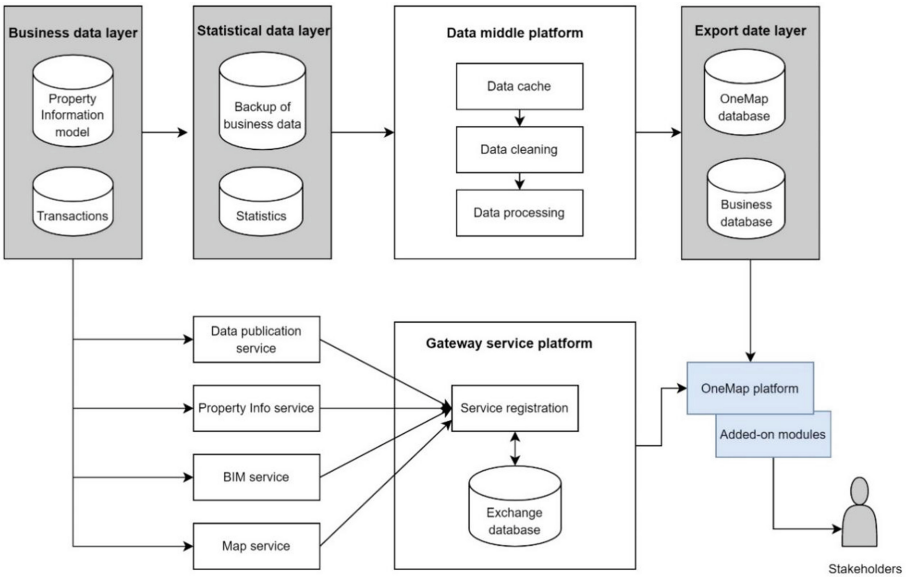

Fig. 2. The architecture of the smart real property system.

property data and on-the-fly statistics for decision makers. In the same way, other modules can be implemented readily and in a scalable manner to satisfy various stakeholder requirements.

4 A Case Study in Hangzhou

Hangzhou is one of the economic centres and prosperous cities in southeast China, having around 12 million permanent residents. The digitalization of real property management in Hangzhou has underwent 20 years, aiming to build a smart software system that can manage the full real property life cycle that engages in various stakeholders. In adaption to the technology advancement, the system architecture has evolved from traditional client-server architecture, to web-server architecture, and service-oriented architecture at present.

Considering the documented property information in the paper in old days, construction of a digital data warehouse is the corner stone of an operational smart real property management system. The raw data is collected from heterogenic sources, and then cleaned, manually checked, and tagged. Following the concept of the proposed real property information model, the spatial and business data of the real properties are digitized. The relationship among the objects and their linkage to transactions and other management recordings are established.

The implemented 'OneMap' smart real property management platform includes five stakeholder scenarios, which are property security, marketing administration, sales and rental transactions, facility management, accommodation for low-wage residents. As illustrated in Fig. 3, the main panel shows the map of the city, with different layers

Fig. 3. Illustration of implemented 'OneMap' smart real property management system.

rendering specific themes (e.g. background, resident community, and buildings etc.). The spatial analysis could be performed to create thematic maps like the heat map of the building age centered in Fig. 3. The right panel shows the statistical figures, tables and charts corresponding to stakeholder scenarios to provide real time market information for supporting decision making. Linking to BIM, the bottom left of the figure demonstrates the details (e.g. structure, floorplan, pipes etc.) of a building and provides the potential to access real time surveillance of facilities via IoT systems.

5 Conclusions

This study reported a case study of developing a smart real property system with its application in a prosperous city Hangzhou, southeast China. Firstly, we proposed the property information model, using the objects of resident community, underground space, block, pipe and unit to model the real properties in reality. Secondly, we illustrated the layered architecture of the smart real property system, consisting of databases for data storage, and the data middle platform and the service gateway platform to provide business and map services. Finally, based on the developed software infrastructure, we implemented the 'OneMap' real property management dashboard with added-on software modules for various stakeholder scenarios. The gained experiences and lessons were summarized as following:

(i) A comprehensive data warehouse for real properties is undoubtedly critical to the success of establishing the smart real property system. The proposed property information model standardizing the data protocol to clean and convert the raw data either from the paper documents or the legacy software. Extensively manual efforts are required to verify the correctness and consistency of the property data and continues efforts are still expected to regularly update the data warehouse to keep it live. Thus, formalization of the data processing workflow and training the skilled engineers will be the next focus;

(ii) The implemented layered architecture of the smart real property system achieves the advantage of scalability. The service-oriented architecture enables the agile development of applications, for an example the 'OneMap' dashboard. To some extent, such an architecture also ensure the data security to disable the illegal access to the original databases. However, the requirement for data sharing across organizations is increasing. This requires the system architecture to be advanced to cope with multi-level data protection to obtain the tradeoff between the data security and data transparency;

(iii) The 'OneMap' real property management dashboard provides a means to readily manage the properties across the whole life cycle and assist decision making. In adaption to the contemporary technology advancement, the disruptive techniques are applied. For examples, the machine learning is used to match the address with the spatial location for database establishment and fuzzy query; the BIM and IoT systems are linked with the 'OneMap' dashboard to facilitate grasp of real time surveillance. Yet, the exploration of such technologies in real property management is still in an early stage. The potential of applying these technologies in mining real property data assets to obtain added social and economic benefits will be an enthusiasm research topic in the future.

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