Research on Smart Campus Architecture Based on the Six Domain model of The Internet of Things

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Abstract. Universities across China have made great progress in the construction of smart campus with the rapid deployment of Internet of Things (IoT). But at the same time, it also exposed some problems, such as the lack of theoretical guidance, the lack of smart campus function design, the lack of overall planning and design. Based on the six domain model of IoT, this paper designs an architecture with the overall construction of smart campus as the core. The smart campus is divided into six functional domains. The information and function description of each domain are given. It provides reference for the structure design of smart campus system and intelligent solutions for the management of the school.

1. Introduction

In recent years, with the rapid development of the new generation of modern information technology, such as IoT, big data, cloud computing, and artificial intelligence. The campus construction and application of the traditional concept has been difficult to meet the needs of the new era of education teaching, many colleges and universities at home and abroad have smart campus exploration, construction, and obtained a series of achievements⁵. Smart campus is based on the new generation of information technology. By strengthening the close connection between the campus and teachers, students and campus environment, it promotes the innovation of teaching and scientific research mode and the improvement of campus management, so as to create a smart campus environment, so as to better serve the teachers and students in the school.

Smart campus mainly has three core characteristics: Firstly, it provides a comprehensive perceptual intelligent environment to create a better learning, research and living environment for teachers and students; Secondly, integrate the scattered data of the campus management system to realize the application collaboration of data information; Thirdly, to realize the efficient communication and docking between the school and the outside world in the intelligent service campus environment⁶. The smart campus architecture proposed in this paper is based on the national standard GB/T 33747-2016, and adapts to the global abstraction of the architecture characteristics of the smart campus construction, so as to provide intelligent solutions for the structural design of the smart campus system.
2. Six domain model of IoT
The Six domain model of IoT is a highly abstract modeling representation of various IoT application systems. This model can provide an effective, reliable and extensible framework design reference for the architecture design of application systems of IoT in various industries. According to the functional classification of the application of IoT, The Six domain model of IoT includes six business function domains: user domain, target object domain, perception control domain, service provision domain, operation and maintenance control domain and resource exchange domain[3]. As shown in figure 1

3. Architecture design of smart campus
Combined with the architecture characteristics of smart campus, this paper integrates emerging technologies such as IoT, mobile Internet, cloud computing, big data and artificial intelligence. The functional modules and entities in the architecture of the campus environment are gradually refined, as well as the interface and correlation between entities. Then, the structure design of each domain in the smart campus system is carried out.

3.1. Target object domain
The target object domain is the collection of object entities that IoT users expect to obtain relevant information or perform relevant manipulation. The architecture stipulates that the perceptive objects of campus IoT include students, teachers, vehicles, buildings, monitoring equipment, experimental equipment and so on. The target object domain is the source and basis of the whole IoT system's perception information[3].

3.2. Perceptual control domain
In the smart campus architecture, the perceptual control domain obtains the attribute information of the object in the target object domain, which is the core of the smart campus to realize the interconnection of all things. This domain mainly realizes a comprehensive perception of the campus environment through the campus card, monitoring equipment, sensors, smart phones, access control, vehicle access control and other devices[4]. In this way, the property information of perceived objects can be obtained in real time, including state perception information, technical parameter information, position marking information, measurement information, audio and video information, etc. The data information is preprocessed through the gateway for the sensing signal to realize the perception of the activity and operation status of the objects in the campus. The sensing data and control data are collected as the basic support of the smart campus.
3.3. Service provider domain
The service delivery domain is the functional realization domain of basic services and business services in IoT architecture. This domain processes the generated perception data and provides the interface of perception and control objects in the physical environment of the campus[3].

3.3.1. Basic service system
The basic service system includes a unified identity authentication platform, a public data integration platform and a comprehensive information management platform. Mainly for the business service system to provide support.

3.3.1.1. Unified identity authentication platform
The unified identity authentication platform uses RFID electronic tag technology to store the basic information of users to authenticate and manage the campus personnel. Combined with Internet, AI technology, it realizes the facial record of entering and leaving campus and the marking and warning of non-campus personnel. Identification can also be used for student and faculty attendance records, sign-in to meetings, etc. Unified authorization is set for different systems, authority control is done well, and user experience is optimized[5].

3.3.1.2. Public data integration platform
The public data integration platform is the premise of smart campus information exchange and sharing. The platform uses big data technology, cloud computing and edge computing technology to build a global shared data integration database. The massive data generated by the smart campus should be mined and analyzed to standardize and improve the internal business process of the smart campus[5]. In general, Hadoop framework and Spark data processor are used to process and distribute massive data, and software architectures such as Hive data warehouse and HBase distributed database are used to store data information to ensure the data security of the system.

3.3.1.3. Comprehensive information management platform
Integrated information management platform for smart campus to provide efficient and convenient information management. The platform classifies and stores the information obtained from various channels to avoid the repeated collection of redundant information and realize the sharing and effective utilization of data resources between systems. In addition, the comprehensive information management platform is used for campus data analysis and decision support, providing visual and multi-dimensional business data statistical analysis report and trend prediction, making campus management decision more efficient and reasonable[2].

3.3.2. Business service system
Business service system is a system that provides IoT business services for a certain type of specific user need[3]. As the expression form of smart campus, it mainly provides all kinds of personalized information services for teachers and students[4]. Business service system mainly consists of teaching, scientific research, logistics, management four parts. Based on the three platforms of the basic service system, the data are processed, analyzed and processed and applied to the system construction of the smart campus.

3.3.2.1. Intelligent teaching
Intelligent teaching uses the Internet platform to share and disseminate knowledge. Digital teaching courses are constructed by using live video, VR technology and emerging multimedia to provide more convenient channels for students' self-study and knowledge review. Analyze the learning data of students to provide strong support for the standardization and improvement of the teaching model. The organic integration of IoT and the existing teaching platform will bring new teaching experience and
efficiency. Through novel teaching methods and immersive classroom experience to achieve a new model of intelligent teaching.

3.3.2.2. **Intelligent research**

The intelligent research system tracks and manages the whole life cycle of the scientific research project, forms the knowledge management database, and provides support for the scientific research project review and project decision-making. The intelligent scientific research laboratory interconnects professors, graduate students, experimental equipment and other scientific research elements to realize the transmission of experimental data on the line, intelligent analysis of data, and advance of experimental results.

3.3.2.3. **Intelligent logistics**

Intelligent logistics aims to build a highly efficient, energy-saving, intelligent and convenient interconnection environment for all things, and realize the intelligent management of campus logistics. The logistics systems are monitored and controlled by sensors located at various locations. Improve the level of office automation and campus information control ability.

| System Name                  | System function                                                                 |
|------------------------------|---------------------------------------------------------------------------------|
| Campus Card System           | Provide identity identification, information inquiry, book borrowing, consumer checkout and other services. Real-time query account balance, bill consumption, scholarship and other information |
| Intelligent building management system | Realize unified and centralized management of building electric power, lighting, network, water supply, ventilation, fire control and elevator |
| Intelligent security system   | The campus buildings, roads, entrance and exit and other key parts of 24 hours of monitoring and electronic patrol, to ensure campus safety |
| Energy management system     | Monitoring of energy use through an energy management system. Data mining is used for analysis to help managers formulate energy planning and improvement strategies\(^6\) |
| Campus office management system | Realize information release, meeting notice, network announcement, attendance management, file management and other functions |
| Comprehensive school affairs management system | Provide basic services, educational administration management, personnel management, financial management, asset management, statistical analysis of the use of various resources |

3.4. **Resource exchange domain**

Resource exchange domain, the other five domains established in accordance with the business logic vertical smart campus architecture, at the same time establishing lateral exchange with external systems, support of external data in the database access interface, realize the data exchange and maintain with the outside world, so as to better deal with vertical closed system and external system of collaborative problem\(^3\). For example, the transfer of file information of students' admission or graduation, information sharing with the talent market, docking with various examination registration systems, etc.

3.5. **Operation and maintenance control domain**

The main function of the operation and maintenance control domain is to ensure the operation and maintenance of the smart campus system and the compliance with laws and regulations. Comprehensive supervision of smart campus is carried out from the technical level. In combination with the demand of smart campus for information fusion, monitoring, management and optimization of various sensing devices and gateways are carried out in the operation process. In addition, the system construction shall be guaranteed to comply with the laws and regulations, follow the industry management requirements touched by the connected objects, and formulate rules to ensure the stable operation of the system\(^3\).
3.6. User domain
User domain provides human-computer interaction interface, presents the system management interface at all levels, implements different users of the corresponding management system easy to use service domain, scientific research, the wisdom, the wisdom of classroom the reception, and other functions, to simplify various complicated processes, providing visual operation interface, promoting the humanization, scientization and intelligentization of the smart campus.

![Smart Campus System Architecture Diagram](image)

Figure 2. Schematic diagram of smart campus system architecture.

From what has been discussed above, we design about the structure of smart campus each domain and common technology have a more clear understanding, combined with the wisdom of the existing campus design cases and IoT application system design industry characteristics, the smart campus system integration design and Six domain model, formation of smart campus standard in the field of IoT development and system application of smart campus architecture (see figure 2), guiding the formation of smart campus related standards.

4. Summarizes
This paper puts forward the smart campus architecture with the Six domain model of IoT as the core, defines the main functional entities in the smart campus and the main functional modules in each domain, and describes the basic service system and business service system in the service providing domain. Smart campus system will be intelligent environment perception data and information between teachers information, students information, teaching information, security information, exchange of information between systems, such as data fusion, realizes the information for the center with sensors and the information fusion for the center with the user object transformation, promote the optimization of smart campus construction, improve the campus management model, provide effect estimation and decision
support for school management, provide a reference basis for the standard in the field of smart campus development.

References

[1] Muhamad, W., Kurniawan, N.B., Yazid, S. (2017) Smart campus features, technologies, and applications: A systematic literature review. In: International Conference on Information Technology Systems and Innovation (ICITSI). Bandung. pp. 384-391.

[2] Fernández-Caramés, T. M., & Fraga-Lamas, P. (2019) Towards next generation teaching, learning, and context-aware applications for higher education: A review on blockchain, IoT, fog and edge computing enabled smart campuses and universities. Applied Sciences, 9: 4479.

[3] Jie, S., Shuyi, C., Mingjuan, W. (2016). Internet of Things Reference Architecture Standards and Applications. China Academic Journal Electronic Publishing House, 4: 12-16.

[4] HUANG, R., ZHANG, J., HU, Y., & YANG, J. (2012) Smart campus: The developing trends of digital campus. Open education research, 4.

[5] Yang, A. M., Li, S. S., Ren, C. H., Liu, H. X., Han, Y., & Liu, L. (2018) Situational awareness system in the smart campus. Ieee Access, 6: 63976-63986.

[6] Yang, C. T., Chen, S. T., Liu, J. C., Liu, R. H., Chang, C. L. (2020) On construction of an energy monitoring service using big data technology for the smart campus. Cluster Computing, 23: 265-288.