Electronic Journal of Structural Engineering

Original Article

Cite this: DOI:10.56748/ejse.234022

Received Date: 19 December 2022
Accepted Date: 03 March 2023

1443-9255
https://ejsei.com/ejse

System of Integrated Management Platform for Smart Park： Design and Project Case

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Abstract

With the continuous development and transformation of 5G, big data, the Internet of Things and other technologies, data sharing and information processing means are becoming more efficient, making smart parks a reality. There are some problems such as unclear design dimensions, poor interactivity of subsystems and high expansion costs in the development of smart park. In the face of these problems, an application-oriented comprehensive management platform system of intelligent park is designed. It is built on a digital twin software-defined campus which is scalability and flexibility with wisdom in the cloud and application at the end as the core service concept. The overall system architecture and management platform module composition are introduced in which the software defined network (SDN) technology is used to separate the control plane and da-ta plane and the four dimensions of people, things, affairs and space are digitalization in the smart Park. One application carries a variety of park services such as production, official business handling, property administration and so on to realize the effective application of the underlying network facilities. The project of high-tech information intelligent park of the Chinese Sixth Design and Research Institute of Machinery Industry Company Limited has been implemented. As an engineering case the platform system can provide personalized design for the park and carry out multi-professional and multi-terminal integrated management, application and display so as to improve the intelligent management level and the service experience to create greater economic and social value.

Keywords

Smart Park; Internet of Things; Integration Management; Digital Twin; Software Defined Network

1. INTRODUCTION

The development of smart parks has experienced the process from large-scale industrial parks, high-tech parks, high-tech and capital-intensive parks to smart parks. With the development of the Internet of Things (IOT), artificial intelligence, 5G technology and the arrival of the industry 4.0 era, the research and establishment of smart cities and smart parks are increasing and bringing great convenience and benefits to human society (Chen, 2022; Bokolo, 2021; Kahkashan, 2022). Smart Park is the guide and demonstration of smart city that integrates the new generation of information and communication technology and has the ability of rapid information collection, high-speed information transmission, highly centralized computing, intelligent transaction processing and omnipresent service provision. Timely perception, transmission and processing of information as well as interaction within the park can improve the industrial agglomeration ability of the park and the economic competitiveness of enterprises and drive the development of related industrial chains in the smart city (He and Liu et al, 2021; Guo and Wang et al. 2015; Emir and Ejub et al, 2020; Amir and Mohammad et al, 2022).

Park economy has gradually become an important part of regional economy that has been developing continuously. The smart park faces the following difficulties in the process of construction (Chen, 2015; Nicos and Christina et al, 2022): (1) The dimensions of the design system are not clear; (2) The linkage between the internal subsystems is poor, and the degree of intelligence is not high; (3) High expansion costs and high management costs. In order to solve the above problems and establish a safe, sophisticated and efficient intelligent park, it is necessary to design a comprehensive management system platform assembling integrated office, life services, energy consumption supervision, emergency command and management decision-making (Ari and Pekka, 2014). This platform can realize one application to carry a variety of park services promoting the development of intelligent parks, and improving the park's operation, service and management capabilities (Liu, 2017; Zhang and Wang et al, 2021).

2. SMART PARK CONSTRUCTION OBJECTIVE

The traditional physical devices such as firewalls and switches are used to deploy a complete IT (internet technology) system platform in smart park, and virtual private network (VPN) are used to realize the effective link and communication between branches. However, laying the IT system platform requires a large amount of investment, professionals and time, resulting in excessive costs and affecting the capital turnover. With the development of advanced information technology and virtual reality technology, the software defined network (SDN) can be used to realize information reconstruction (Peng, 2022), which can solve the problems in the construction process of traditional smart park. SDN technology can effectively separate the control plane from the data plane, and centrally control the network state by using advanced information technology to manage the network hierarchically according to different network operating states and realize effective application of the underlying network facilities (Van and Truong et al, 2015). At the same time, SDN technology can carry out global deployment from the whole point of view to effectively improve the use efficiency of resources and quickly obtain the global information of network resources. By using SDN technology, network functions, virtualization technology and big data technology, the IT system of the park is completely virtualized, as well as the layout management of the park is simplified, and the enterprise environmental management is strengthened so as to truly realize the development goal of the smart park.

The needs of different groups should be met in the construction and planning process of smart park (Wang and Huang, 2015). From the operator's point of view, the efficient intelligent management, green and energy-saving facilities are needed. From the perspective of enterprises, its long-term development needs all kinds of enterprise service resources. From the perspective of employees, a good office environment and perfect life services are the primary needs. Centering on the development requirements of enterprises and the spiritual needs of talents, the resources of the government, enterprises and other parties must be coordinated to realize the intelligence of management, work and life which build a smart park in a trinity. We want to build the park into a software-defined park based on the digital twinning to provide the operators and users with services for wisdom in the cloud and application at the end, so as to maintain the balance between sustainable development and high-quality services of the park as shown in Figure 1.

A software-defined park means that the park can be defined and changed according to operation and maintenance requirements to ensure that the park can continuously adapt to the changes of the era. Wisdom in the cloud and service at the end means that data analysis and computing run on the cloud leaving difficulties to the platform. The applications will be connected to various terminals to provide more convenient and efficient services for employees' work and life.

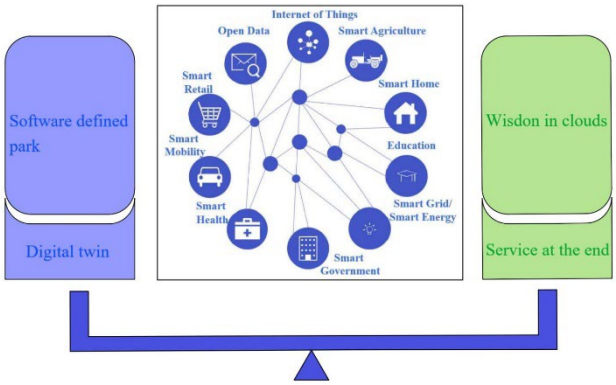

Fig 1. Smart Park construction balance relationship

3. DIMENSIONS OF SMART PARK

The dimensions of smart city are smart economy, smart transportation, smart environment, smart people, smart life and smart management according to relevant literature (Gifnger and Gudrun, 2010; Mohanty and Choppali et al, 2016). These aspects are independent and intersecting which are the main content of smart city construction. The literature (Wang and Sheng et al, 2020) specifically studies the construction of smart e-commerce logistics park in Beijing from the perspective of smart management, in which synergy among the three subjects of city management, park management and enterprise management is considered. Smart Park is an important form of smart city. It not only reflects the main system mode and development characteristics of smart city, but also has the uniqueness that is different from the development mode of smart city. Smart parks have gradually become an important way to attract investment and reserve talents. The smart park uses various intelligent and information applications to help the park to realize the transformation of industrial structure and management mode, improve the market competitiveness of enterprises in the park, and promote industrial aggregation with the park in favor of creating economic and brand benefits for the park and its enterprises. The digitization of dimensions is the foundation of building a smart park. According to the dimensions of smart city and the characteristics of smart park, four dimensions of the park are given, namely people, things, affairs and space. The expansion and connection of the relevant chain can be further realized for these four dimensions. The core of the construction of smart park is the digitization of the park. Digitalized people, digitalized things, digitalized affairs and digitalized space are the four dimensions to realize the digitalized park as shown in Figure 2.

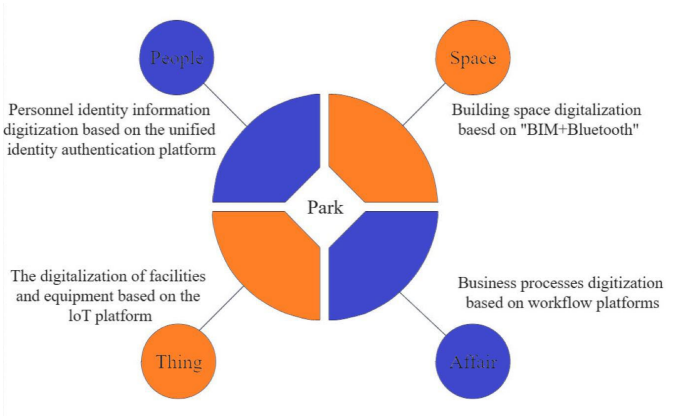

Fig 2. Four dimensions of digital park

4. SMART PARK SYSTEM FRAMEWORK

4.1 Overall Architecture

The main goal in smart park is to realize interconnection among the single systems through the perception system. The multi-dimensional intelligent analysis with the help of cloud computing and the effective integration of IT and other IT technologies can make the park's infrastructure operation more intelligent and greener and make the operation management of the park more standardized and efficient. These can help the park to provide customers with more high-quality and convenient value-added services in order to enhance the park's differentiated competitive advantages.

The network architecture includes cognitive layer, network layer and application layer based on smart city (Jin and Mikail er al, 2019). Literature (Zohreh and Viviana et al, 2020) shows that enterprise architecture layers used for services in smart cities include technology layer, information layer and service layer. Literature (Shwet and Pramod 2022) provides the architecture of IOT including the cognitive layer, network layer, service layer and association layer based on smart city. Literature (Wang and Li, 2020) put forwards an application-oriented cloud platform architecture that includes infrastructure layer, platform service layer and software service layer. The platform architecture in literature (Lin, 2021) is divided into perception communication layer, cloud infrastructure layer, data service layer, application support layer and software service layer. Literature (Ki and Young, 2022) provides the overall architecture of smart factory including physical layer, network layer, analysis layer and application layer.

This intelligent park information architecture of enterprise-oriented consists of the following four layers as shown in Figure 3 which are designed from the equipment layer (including air conditioner, lighting, elevator, etc.), the control layer (including EMS for energy management service, EAM for enterprise asset management, etc.) to the platform of integrated management service (PIMS) and finally to the intelligent operation center (IOC). The hierarchy of the information system architecture of the park is clearly divided. The overall architecture is shown in Figure 4 which includes 1 foundation, 1 platform, N applications and 1 brain.

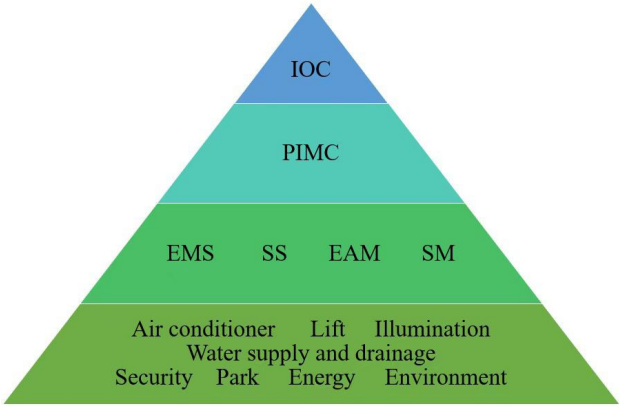

Fig 3. Enterprise Park information architecture system

4.2 Composition of operation management platform

The composition of the operation management platform is shown in Figure 5. The operation man-agement platform can help enterprises realize effi-cient collaborative office, assist the whole process management, and improve the profitability of enter-prises. According to the needs of enterprises, plat-form modules can be expanded and integrated.

4.3 The main modules of platform

IOT platform

The IOT platform is a cross-industry and cross-field platform that provides equipment access, sys-tem access, data collection, data analysis and other support for smart park and digital twin. The platform has built-in mainstream protocols such as Modbus, BACNET, KNX, OPCUA/DA and MQTT which can meet the requirements of various data acquisition scenarios. With the help of rule engine and AI algo-rithm, the platform has the ability of data cleaning and data governance analysis which can provide strong platform support for application development and operation as shown in Figure 6.

Unified identity authentication platform

The unified identity authentication platform is a secure, flexible, stable and extensible enterprise-level unified identity and access control platform. Based on the unified identity account, the platform pro-vides the unified identity account, unified identity authentication, centralized authorization, application management, security audit and other capabilities to support platform, product, and project software de-velopment, and to realize the mutual sharing of basic data (organizations, accounts, etc.) of all applications in the park, unified authentication and login for all terminal applications (website/mobile APP/ desktop client).

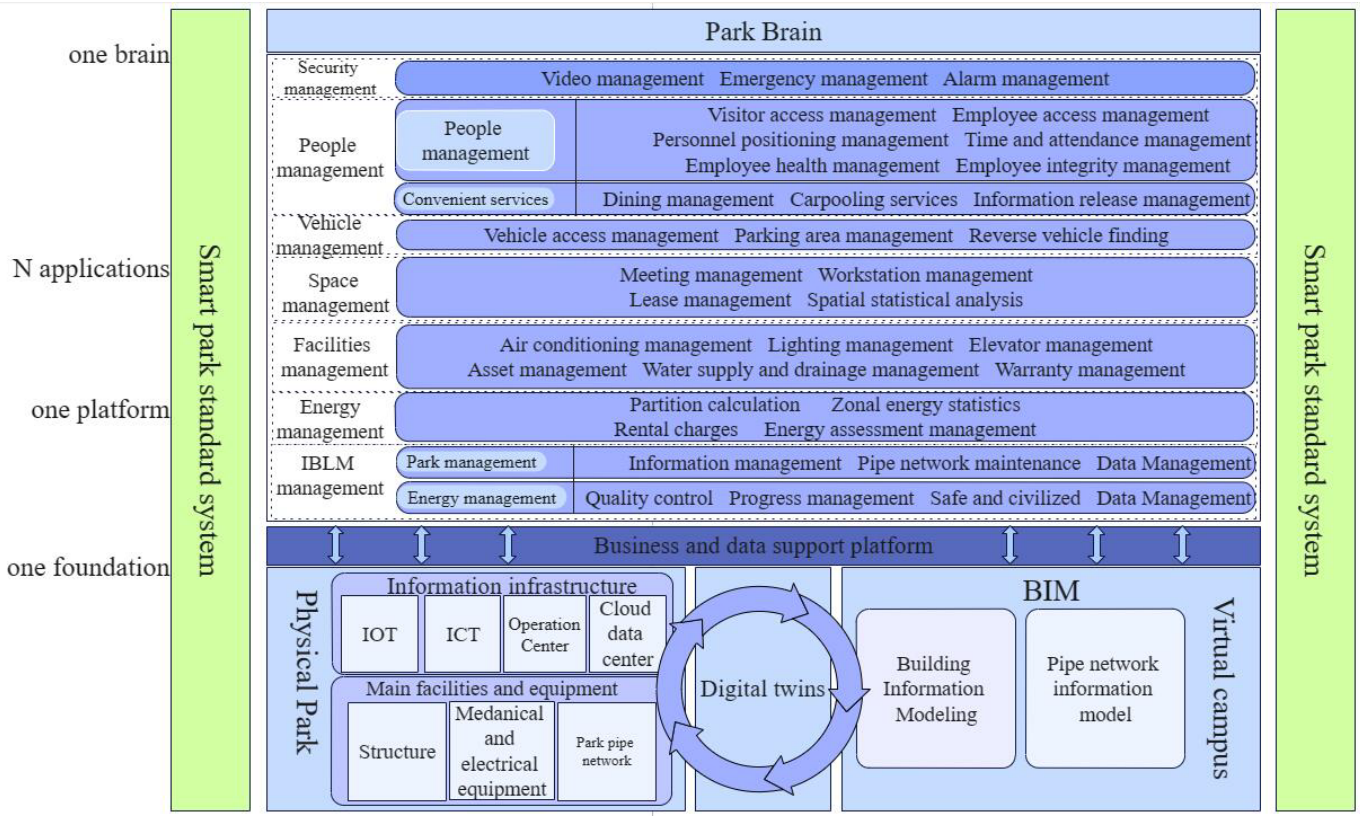

Fig 4. Overall Architecture

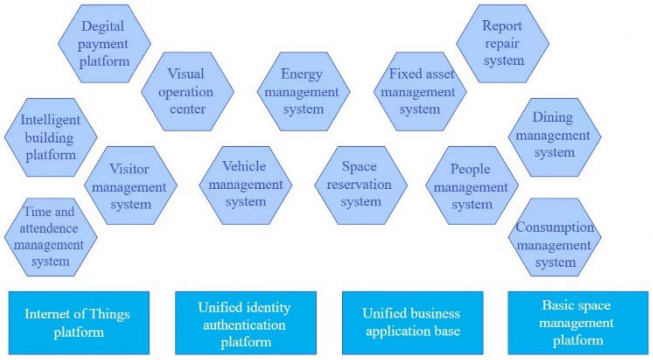

Fig 5. Operation management platform

Fundamentals of unified application

Unified business application base is an enabling platform for efficient collaborative office. It integrates the two essential basic capabilities that are unified collaborative communication and application development for enterprise information construction, thus it can help enterprises to work efficiently and grow rapidly. All kinds of services are distributed and scheduled to users through data bus to complete data collection and summary, thus breaking the information islands of each application system and building the overall big data of the enterprise.

Basic space management platform

In order to meet the spatial location management needs of the park for assets, meeting rooms, exhibition halls, offices, functional rooms and so on, a six-level spatial system of park - building - floor area - room - station to code all the physical spatial locations is used in the smart park .Assets, meeting rooms, exhibition halls, offices and functional rooms can be directly associated with specific spatial locations. Meanwhile, park managers can also grasp the use of each room in the park and their departments based on the spatial system.

Digital delivery platform

These functions such as BIM geometric model management, positioning query, model lightweight, attribute data management, archive data management, IOT integrated management, application scenario release management and the secondary development API (Application Programming Interface) can be provided by the digital delivery platform established on BIM completion model which integrates project design, construction completion information and key parameter information of facilities and equipment based on model lightweight engine and park object coding technology focused on digital asset map service. The organization and management of the model can be supported by the platform according to the relationship of system, partition, space and topology to establish the data collection, sorting and reuse mechanism based on the information model. It can provide model data and development interface data center for park and enterprise operation and maintenance so as to form important data assets for enterprises.

Intelligent building platform

The intelligent building integrated management and control platform is mainly used for the integrated management and control of intelligent building systems to provide system monitoring, alarm management, equipment operation data analysis, calendar configuration, mode configuration, operation log management and other functions. The platform fully embodies the characteristics of intelligent complex and adopts the advanced technology to realize the sharing and management of information resources among the intelligent subsystems in the building complex. The related system can realize mutual operation, fast corresponding and linkage control in order to achieve the goal of automatic monitoring and remote management.

Other modules of the platform

The visual operation center is the BIM comprehensive monitoring system after processing and beautification of the BIM models. The equipment is located and monitored through the system and the fault alarms generated in the management process are collected and pushed to the relevant maintenance personnel in time to confirm the timely maintenance of the equipment and ensure the normal operation of the equipment. Maintenance personnel can improve maintenance efficiency through work order management and task distribution.

According to the user's requirements, the energy management system collects all kinds of data measurement and sensors and completes the main data monitoring, technical analysis, daily report, monthly report, annual statistics and report output functions based on which the operation plan is executed. The collected data is summarized, analyzed and sorted out for energy management which includes energy actual analysis and management, energy quality management, energy cost management, energy balance management, energy forecasting and analysis, etc. to form energy management statements.

The fixed Asset Management system provides functions such as asset information management, asset repair reporting, asset transfer, asset loss reporting, asset scrapping, asset return, and asset information error correction to meet the daily management requirements of the administration department for the park assets. The administrator can effectively perform routine maintenance on assets. Before asset information management the asset type is needed to be configured and assigned to the corresponding information type. The functions of asset

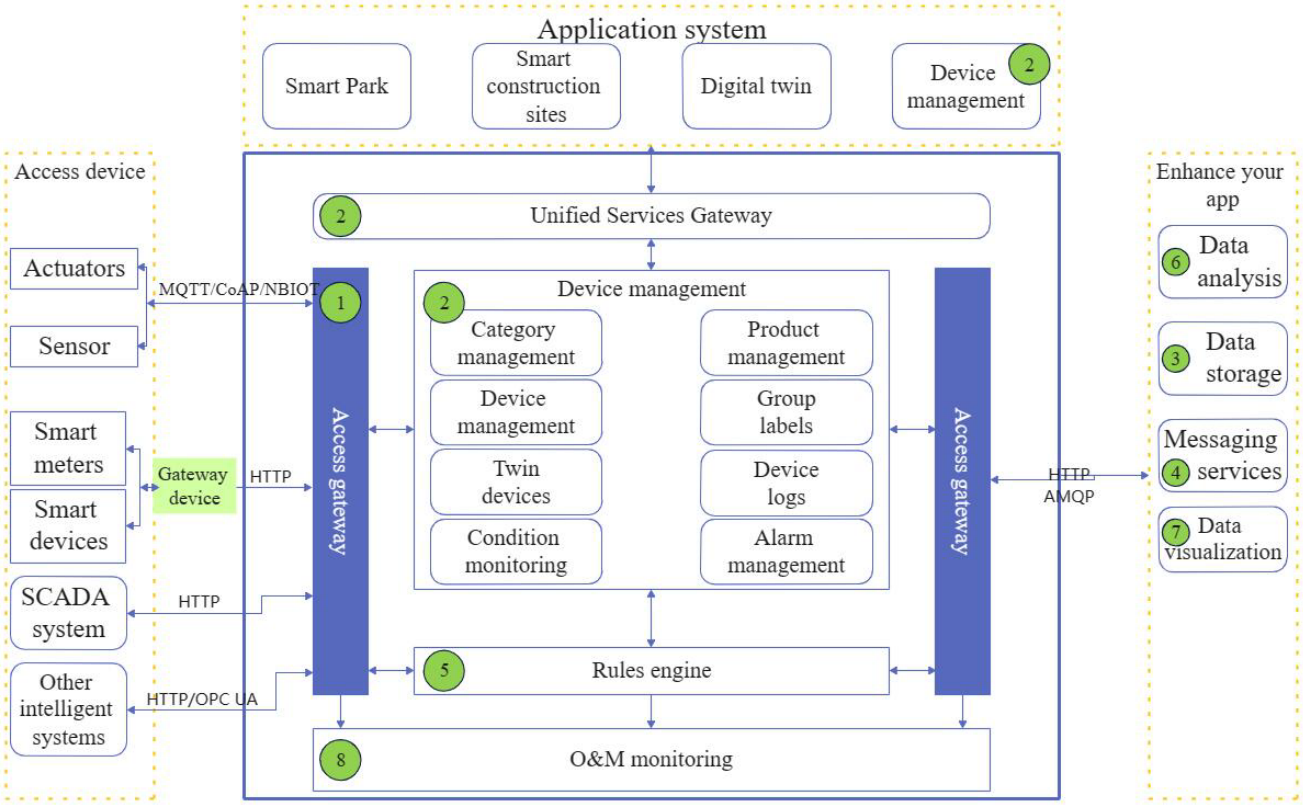

Fig 6. IOT platform

repair, asset transfer, asset loss, asset scrapping, asset return and asset information error correction record the details of asset information status.

The report repair system is a system that can initiate problem record and report anytime and anywhere. Employees use mobile applications to record problems in the form of photos, videos, and text descriptions, locate the problem through Bluetooth, and send the information to maintenance personnel. The administrator can query problem report records and at the same time the event dictionary, the type of on-tap events, and the frequently asked questions can be managed.

Attendance management system is used for staff attendance assessment, including team management, shift management, scheduling management, leave management, card replacement management, daily attendance statistics, monthly attendance summary, etc. The mobile application of attendance management is not only compatible with the face punch card and vehicle punch card of access control system, but also supports various mobile punch cards such as Bluetooth punch card, WIFI punch card, GPS punch card and other mobile punch cards. It also supports the query of personal attendance data, which not only meets the management needs of the company, but also provides more convenience for employees.

The visitor management system collects statistics on visitors' appointments, which facilitates the administrator to query the records of visitors so as to strengthen the security management of visitors. At the same time, it can simplify the visitor registration and verification process to avoid the tedious reception, contact confirmation, access control release process. Visitor management system provides visitor invitation registration, visitor appointment approval and other functions.

Different types of vehicles such as internal employee vehicles, external visiting vehicles, temporary vehicles can be registered, approved and authorized in the vehicle management system to complete the unified management of different types of vehicles. Administrators can view all registered vehicles and owner's information which can be added, deleted, changed, checked. Authorization can be extended for registered vehicles through authorization management. Employees can inquire the number and location of remaining parking spaces through the mobile application and locate their vehicles for easy search.

The conference room and other rooms are endowed with different space locations through the coding of the space location. The space usage is master's in real time through the space management system. Space reservation system can provide functions including space administrator scheduling, space maintenance, space service supplies configuration which can set the cost of service supplies and details and other information. Users can query the unused space through the mobile application and register the space reservation. The administrator receives and reviews the reservation application. The space can be used after the approval.

The number of people in and out of the park and their status are counted in real time in the form of Kanba for different types of people (employees, property, visitors, etc.) in dynamic personnel management system.

Dining management system is a multi-directional management system including menu management, window management, menu calendar, evaluation management, system configuration. The operation of adding, deleting and modifying dishes, dining window and window administrator configuration, daily menu display can be performed for dining personnel to view the menu. The evaluation function collects improvement suggestions for the restaurant, and the administrator can also make evaluation and reply through the background. Employees can query the current staff flow information of the restaurant and the information of today's dishes and can evaluate and give a like to the dishes.

The consumption management system is integrated with the consumption system to meet the needs of mobile terminal online recharge, wallet balance, subsidy and consumption record inquiry. The administrator can view the charging record, circled record and consumption record from the background, and the user-defined query can be conducted according to the time range.

One-code/face-pass can provide digital service for entrance guard management, catering consumption, visitor management and other scenarios through identity identification of enterprise employees, third party personnel and external visitors to realize intelligent management of the park.

5. PROJECT CASE

A system of the high-tech information park operation and maintenance management platform is designed for the Chinese Sixth Design and Research Institute of Machinery Industry Company Limited. Figure 7 is the scene of the intelligent operation center of the high-tech information park.Data are collected and distributed uniformly meanwhile multi-specialty, multi-terminal can be integrated to realize comprehensive application and display by the intelligent park platform established on the emerging IT technologies of BIM, IOT and networking.

The smart park project platform is developed and constructed in accordance with the principles of platformization, unification and servitization. Platformization refers to the integration data of people, things, affairs, space on the same platform. The basic platform framework of "BIM+IOT+ network " has been built first to consolidate the foundation of digital operation and management of the park. Unification refers to the realization of application of platform framework and micro-service. Employees only need to install an APP to use a variety of park applications such as production, office, property etc. The platform supports application expansion of requirements. Servitization means that the intelligent system of the park provides services for both managers and ordinary employees, so that employees can have a better sense of experience and participation in the construction of the smart park.

Fig 7. Smart operation center scenario

6. CONCLUSIONS

Since the concept of smart park was put forward, the development of smart park has been limited by the high cost and technical bottleneck. In recent years, with the development of communication technology, the construction of smart parks has opened a new development path and entered a stage of rapid development. According to the development goal of the smart park, the core concept of four dimentions of digital people, digital things, digital affairs and digital space is put forward. This paper gives the enterprise park information architecture system and the overall structure, that describes the operation management platform components. Finally, a smart park case is given. There is no universal software network architecture for smart parks in different fields (Nebojša and Alok, 2021; Liu and Wang et al, 2022; Yan, 2021), and the proposed design system can be adjusted according to users' requirements with flexibility and expansibility. SDN technology is used to separate the control function from the network equipment, and the function and type of the network equipment are all defined by the software which can obtain a faster response. At the same time, better interaction between architectural elements improves the convenience and functionality of the system and avoids information silos. The intelligent operation center (IOC) is the brain of park management, which is visible, controllable and manageable and supports a large number of business applications.

Despite the rapid development of smart parks, they still face many challenges, such as scientific planning, security issues, experience issues, cost issues, etc. (Ge and Chen et al, 2022; Guo and Wang et al, 2022; Zhu and Xu et al, 2022). In the process of continuous upgrading and development of the smart park, the future operation requirements of the park are needed to be discovered through industry analysis and practice. The functional modules of the design system are gradually optimized, improved and expanded in the direction of integration, networking and green development.

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