Smart facility management: technically supported services based on emerging information and communication technology

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***Abstract:** Facility management (FM) is a discipline that utilizes technologies to integrate management of space, process and people. Nowadays, information and communication technologies (ICTs), such as big data, the Internet of Things and artificial intelligence, are driving the transformation of facility management into technically supported facility management. Despite many perceived benefits, the FM industry has been slow in discussing and adopting the ICT concept. This paper aims to fill this gap by constructing a smart facility management (SFM) framework. Following a comprehensive literature review on emerging ICTs and FM services, we put forward the definition and values of Smart FM, assess the technology readiness of emerging ICTs and systematically identify a number of technically supported FM services. The research is helpful to build a technically supported service system for next generation of facility management featuring information interoperability, resource sharing, and capacity coordination.*

***Keywords:** Facility management, Information and communication technologies, Smart, Service scenario*

1. Introduction

A new generation of information technology swept the world, information and communication technologies are more important under the epidemic. On May 22, 2020, the State Council government work report 2020 issued by the Chinese government proposed to focus on supporting the "new infrastructure" which mainly includes the infrastructure construction of emerging technologies such as artificial intelligence, data center, Internet of things, 5th Generation Mobile Communication Technology and other emerging technology, to strengthen the application of emerging technologies. At the same time, the construction of information technology infrastructure is conducive to driving the transformation of traditional facility management into intelligent facility management, and building a facility management system of information exchange, resource sharing, capacity collaboration and open cooperation.

According to the International Facility Management Association, FM is a profession that encompasses multiple disciplines to ensure the functionality of the built environment by integrating people, places, processes and technology. According to the definition of International Facility Management Association, technology has become an important component of facility management and plays a key role in realizing the value of facility management. At the same time, information and communication technologies have changed people's way of life and production, and created great economic value. Strengthening the research on the emerging information technology in facility management will help to grasp the future development direction of facility management.

Firstly, this paper will explain the value of the application of emerging information technology in facility management and put forward the concept of intelligent facility management, then analyze the current research hotspots of information technology in facility management through the software Citespace, and finally propose the concept of technically supported services.

2. Smart Facility Management

Based on emerging technologies, such as internet of things, cloud computing and artificial intelligence, smart facility management(Smart FM) is an organizational function that is comprehensive perception, extensive interconnection, intelligent decision making and excellent execution to provide comfortable, convenient and safe personalized services, enhance the value of core business and promote

production and life and ecological sustainable development by integrating people, space and processes in the built environment of public buildings, industrial parks and commercial offices .

Intelligent facility management can provide better services than traditional facility management. The following four points are the core values of intelligent facility management, the value and role of smart facility management are shown in Figure 1.

1) In most organizations, facility managers will perform two economic responsibilities, one is asset management, the other is providing user services[1]. Jensen[2]found that building owners value space planning when building a business model of facility management value chain. Smart FM uses emerging information technology to create efficient space for different user needs, improve user satisfaction, and provide personalized services for users.

2) Voordt and Jensen[3]pointed out that facility management is a process set to support the effectiveness of major activities within the organization. Compared with the traditional facility management, smart facility management is easier to find the deficiencies in the management process, and then improve the management process, ensure the quality of the organization operation, so that smart FM can create value for the organization, and realize the refined operation.

3) Hinks and Puybaraud [4] illustrate the harm of fire to business continuity through a large number of cases, and emphasize that facility management plays an important role in business continuity. Smart facility management can perceive the crisis in advance and intelligently propose solutions according to the situation. A definition of facilities management is that facilities management is the process by which an organization achieves and sustains a quality environment and operational services to meet strategic needs at best cost[1]. Smart facility management uses technology to improve work efficiency, maintain business continuity, provide strategic support for the organization, and ensure the core business of the organization.

4) In the whole management process, smart facility management has changed the working environment of employees and promoted their physical and mental health. By extending the thinking of facilities management to a broader scope of cities, Albino and Dangelico [5] believe that smart cities are composed of city's own systems, such as transportation, energy, health care, education, food, water and urban security, which need the facility management. The successful application of emerging technologies in facility management can accelerate the construction of smart city, reduce environmental pollution, accelerate social progress and realize sustainable development.
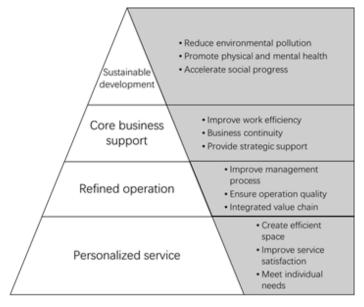

Figure 1: The value of smart facility management

3. Technically Supported Services in Smart Facility Management

Technically supported services regards technology as a tool to support service. Technical services use the advantages of technology to optimize the service process and create value for the organization. This chapter summarizes the technically supported services scenarios and related technologies in smart

facility management.

3.1 Hotspots of Smart Facility Management Services Applying with Emerge ICTs

In this chapter, the authors export the articles about the "(key functions of facility management)" and "information technologies" in the core collection of web of science from 2016 to 2020, and then use CiteSpace to analyze the cluster label to get Table 1.

From table 1, we can see that resilience, family business, business continuity plan, sustainability and IOS22301 are research hotspots of business continuity management. Because of the emergence of new coronary disease in 2020, the labels of "cowid-19" and "crisis" have appeared, and the research on new coronary disease and crisis management has increased.

The research hotspots of environment, health and safety training (EHS training) focus on safety, perception, risk and big data. The labels of big data ranks ahead indicating that big data can be applied in EHS, such as health monitoring.

There are many research hotspots on energy management, among which microgrid is closely related to facility management and is an important research direction of energy management.

In recent years, the research focuses on reliable, renewable energy and predictive maintenance. Predictive maintenance is the use of detection, condition monitoring and diagnosis technology to predict the state of the equipment, arrange the maintenance pertinently and eliminate the fault in advance, so as to avoid and reduce the loss of downtime. To complete predictive maintenance, we need certain data acquisition ability, information transmission and storage ability, and data analysis ability, which are inseparable from the support of information technology. From the co-occurrence results, predictive maintenance, fault diagnosis and prognostic are related to predictive maintenance, which indicates that predictive maintenance is an important research direction in operation and maintenance.

Table 1: Cluster keywords

Theme	Cluster label							
	0	1	2	3	4	5	6	7
Busniess continuity	Resilience	Family business	Business continuity plan	Sustainability	ISO 22301	COVID-19	Crisis	Disaster preparedness
EHS training	Perception	Safety	Risk	Big data	Management	Patient safety	Quality in health care	Disinfection
Energy management	Microgrid	Energy management strategy	Energy efficiency	Smart grid	Energy management	Optimization	Energy consumption	Renewable energy
Operation and maintenance	Maintenance	Reliability	Renewable energy	Predictive maintenance	Management	Fault diagnosis	Preventive maintenance	Life cycle management
Real estate management	Management	Real estate investment	Regulation of the legal status of properties	Corporate governance	Real estate	Property management	Change management	Cultural heritage
Security service	Food security	Cloud computing	Network security	Authentication	IoT	Security	Trust	Internet of things
Space planning and management	Marine spatial planning	Urban green space	Optimization	Climate change	Land use	Urban planning	Green space	Sustainability
Human computer interaction	HCI(Human Computer Interaction)	Emotion recognition	Deep learning	Eye tracking	Gesture tracking	Usability	Virtual reality	Human–Computer Interaction

The research hotspots of real estate management include real estate investment, regulation of the legal status of properties, corporate governance. The label of corporate governance shows the importance of real estate management in enterprises.

In recent years, the research hotspots of security service are food safety, cloud computing, network security and Internet of things. The label of cloud computing and Internet of things shows that many scholars study the application of cloud computing technology and Internet of things technology in security services, and optimize security services with the help of emerging information technology. At the same time, the emergency network security suggests people pay more attention to the protection of

personal privacy.

The research on space planning and management mainly focuses on urban space planning and management, such as urban green space planning, land use and so on, while the research on space planning and management in facility management is less.

Human behavior learning and recognition are the main research direction of human-computer interaction, such as emotion recognition, eye tracking, gesture recognition and eeg. The label of usability shows that the feasibility of human-computer interaction technology in practical application needs to be studied.

3.2 Technical supported service maturity of smart facility management

Choosing the right technology is the key to realize the technically support services, and the technology readiness provides a certain reference for the facility management manager. Technology readiness is a kind of useful degree that technology development can achieve in the process of project development. It is a measure of the degree that technology meets the project objectives and an important content of project risk management. Released by Gartner, a global authoritative consulting company, Hype Cycle analyzes and forecasts the technology readiness of emerging technologies and the time required to reach maturity. Hype Cycle refers to the time curve of exposure of new technology and new concept in media, describing the process of a technology from birth to maturity. It is a prediction model to evaluate the technology development cycle and a common tool to study technology maturity.

Table 2: Technical service scenarios

Classification	Relevant technologies	Sevice scenarios	Classification	Relevant technologies	Sevice scenarios
Internet of things	Near field communication	Equipment maintenance	Cognitive computing	Cognitive expert advisors	Cognitive analysis
					Cognitive exploration
	Digital twins	Access control		General machine intelligence system	Discovery consultant
			Pattern recognition	Speech recognition	Voice to text
	Machine communication				Voice interface
		Environmental monitoring		Face recognition	Identification
	Nano sensor		Automatic driving	Sensor	Unmanned trucks in the park
				High precision map	
	5G	Conference room management		V2X inter vehicle communication	Driverless bus
				Automatic driving AI	
Cloud computing	Distributed data storage	Cloud brain	Human-computer interaction	Human augment	Equipment operation and maintenance
	Massive data management technology	Cloud office		Brain-computer interface	
					Employee health

Category	Technology	Application	Category	Technology	Application
	Mobile cloud computing	Cloud communication		Wearable devices	
	Hybrid cloud computing	Cloud printing		Gesture control	
Data analysis	Intelligent data mining	Personalized maintenance		Virtual personal assistant	EHS training
	Edge calculation	Video surveillance index		Mobile health monitoring	Virtual service desk
	Big data analysis	Remote intelligent maintenance		Quantified self	
Robot	Robot vision	Robot cleaning	Rapid manufacturing	3D scanning	Virtual building model
	Unmanned Aerial Vehicle	Robot inspection		3D printing	Fast printing buildings
	Humanoid robot	Security patrol		4D printing	Print self work construction
Reality experience	Virtual reality	Emergency Preview	Building Information Model	Industry Foundation Classes	Equipment maintenance
	Augmented reality	Training practice		3D visualization	Space management
	Holographic display	Park visit		Network database	Building performance improvement

Gestational period   Introduction period   Growth period   mature period

On the basis of Garter Hype Cycle for emerging technologies from 2018 to 2020, combined with other emerging technology reports, the author divides the technology readiness into four stages: incubation period, introduction period, growth period and maturity period, and summarizes the possible application scenarios of the technology, as shown ina Table 2.

In the table, different colors are used to represent different maturity of technologies. A certain type of technology contains a number of specific technologies and can be applied to different service scenarios. The use of emerging technologies can solve many problems in facility management, provide users with

comfortable and efficient services to increase the satisfaction of users. Finally, facilitate the development of the core business of the organization. The technically supported service scenarios in the table have certain reference value for facility management practitioners.

4. Conclusions

Technology has become one of the important elements of facility management. The author analyzes the co-occurring keywords of the main functions of facility management, and finds that many emerging information and communication technology technologies have become research hotspots, which indicates that people are trying to apply emerging information and communication technology technologies into facilities management. The addition of emerging information and communication technology will promote the transformation of facility management into intelligent facility management, change the traditional way of service provision.

The author summarizes and sorts out the technically support service scenarios of a large number of emerging technologies, We found that supporting services and operation and maintenance management that rely on a large number of labor to provide services can be replaced by emerging technologies, which change the delivery mode of services, and turn from labor-intensive to technology-oriented; energy management, space management, real estate management using data awareness technology ,such as Internet of things, cloud computing and data analysis, complete the transformation from target driven to data driven; business continuity management, EHS management, project management, etc. are more related to the application of data decision-making and auxiliary execution technology, which can improve the compliance through these technologies from the empirical judgment type to the standard analysis type.

Facility management is the main organizer and provider of services in an organization. It is an inevitable trend to provide high-quality services with appropriate technologies. However, successful smart facility management cannot be achieved without management system, perfect rules and regulations, standardized report system, scientific management methods and reliable and complete data.

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