Title:	**Application of "Big Data" for Intelligent Fire Safety Emergency Operations and Management**
Authors:	Fang Li, Vice President, Jensen Hughes Martin Reiss, President, Jensen Hughes
Subjects:	Fire & Safety IT/Computer Science/Software
Keywords:	BIM Fire Safety Life Safety
Publication Date:	2016
Original Publication:	Cities to Megacities: Shaping Dense Vertical Urbanism
Paper Type:	1. Book chapter/Part chapter 2. Journal paper 3. **Conference proceeding** 4. Unpublished conference paper 5. Magazine article 6. Unpublished

Application of "Big Data" for Intelligent Fire Safety Emergency Operations and Management | 大数据在智能化消防安全运营和管理中的应用

Fang Li | 李方
Vice President | 副总裁

Jensen Hughes International
杰森衡志国际公司

Shanghai, China | 上海，中国

Fang Li is the Executive Vice President of Jensen Hughes's China Operations. She was the first to advocate Performance Based Design (PBD) in China and was awarded the Chinese Silver by Ministry of Science and Technology for her "Technical Guideline of Performance Based Design. Li is a member of CTBUH, WOBO, NFPA, SFPE, CFPA, SALAMENDAR, and other committees of experts of nationwide. She earned her Masters of Science degree from Worcester Polytechnic Institute (WPI) in fire protection engineering and has been elected as a Fellow of the Society of Fire Protection Engineers (SFPE).

李方女士是Jensen Hughes公司中国营运执行副总裁。李方女士在中国率先提出了消防性能化设计并参与编写了中国消防性能化设计技术导则，并获得国家科技部的银质奖章。李方女士是世界高层建筑与都市人居学会会员、国际建筑官员委员会(WOBO)成员，NFPA 化工指南规范参编成员、美国消防工程师协会终身荣誉会员、中国消防协会会员、美国火神荣誉协会会员，以及全国多地专家资料库成员。 李方女士持有伍斯特理工学院（WPI）的消防工程科学硕士学位，是美国消防工程师协会终身荣誉会员。

Martin Reiss
President | 总裁

Jensen Hughes International
杰森衡志国际公司

Framingham, United States
弗雷明汉，美国

Martin Reiss is President of Jensen Hughes International. He has been a global advocate for the advancement of the science of safety. He has served on the NFPA Board of Directors and was elected as its Chair. He has also served on the boards of several other international organizations, including the World Organization of Building Officials (WOB0) and the Society of Fire Protection Engineers (SFPE), where he was elected as a Fellow. Reiss received his Bachelor of Science and Mater of Science degrees from the Massachusetts Institute of Technology (MIT).

马丁瑞斯先生是Jensen Hughes 国际公司的总裁。他是全球倡导消防生命安全科学进步的先驱。他是NFPA董事会成员并担任主席一职。另供职于其他国际组织董事会，包括国际建筑官员委员会（WOBO）和美国消防工程师协会（SFPE）。他还是美国消防工程师协会终身荣誉会员。Reiss先生持有麻省理工学院（MIT）的科学学士学位以及科学硕士学位。

Abstract | 摘要

High-rise buildings are incredibly complicated structures. Many contain mixed-use programs and/or are located in multi-building complexes. They include large spaces; intricate fire detection, alarm and control functions; and difficult firefighting response and communication logistics. This can result in large amounts and types of data being transmitted and processed during an emergency event. Use of the building network is also an integral part of the technology-driven data exchange to efficiently provide ongoing management and operations of the building systems. In this paper, thoughts on how smart "Big Data" can be used via the Internet-of-Things (IoT) to facilitate the application of intelligent building information for fire safety operations and management will be discussed.

Keywords: Building Information Management (BIM), Emergency Management, Fire Safety, Internet-of-Things (IoT), Life Safety, Smart Buildings

高层建筑结构极其复杂，许多为多功能综合体建筑。这些建筑内部空间大、火灾探测报警和控制功能复杂、消防响应和通信困难，火灾时需要传输和处理数量庞大、种类繁多的数据。由技术驱动的数据交换可以实现建筑系统有效持续管理和运行，建筑网络的应用是其中不可分割的一部分。 本文将讨论智慧大数据如何通过物联网得以应用，以促进智能化建筑信息在消防安全运营和管理的应用。

关键词：建筑信息管理、应急管理、消防安全、物联网、生命安全、智慧建筑

Introduction

In his book Big Data, Bernard Marr presents the concept of using data to make better business decisions and improve performance through data analytics and metrics. For modern building operations and management, building performance data is collected, analyzed, and acted upon for a broad range of building functions. At the city level, data is also collected, analyzed, an acted upon for such functions as traffic and video surveillance. The same concept of using multiple integrated large data sources intelligently can be applied to improve the emergency response and operations of any building, especially a high-rise. The integration of intelligent application of building and city data allows for a more efficient utilization of resources to address emergency situations and to improve the safety of building occupants and firefighting personnel.

In fire safety and emergency management operations, data is the driver that can help improve response times, facilitate the evacuation of occupants, and provide timely communication with first responders. In most emergency situations, the availability of more data can result in quicker response times, less of an impact on building operations, and improved occupant safety. The use of data

引言

在《大数据》中，伯纳德·马尔提出了一种概念，即应用数据做出更准确的商业决策，通过数据分析和度量提高性能。在现代建筑的运营管理中，建筑性能数据将被收集和分析，以实现广泛的建筑功能。在城市这一层面上，数据经收集和分析用于交通和视频监控。灵活智能地运用多种整合大型数据源的概念也可以用于提高建筑，尤其是提高高层建筑应急响应和运行的水平。整合建筑和城市数据智能应用，能够在应急响应、提高建筑内部人员和消防人员安全水平等方面高效地利用现有资源。

在消防安全和应急管理运营方面，数据是减少响应时间、促进人员疏散、及时与消防救援人员沟通的驱动力。在多数应急状态下，可用的数据越多，应急响应就越快，对于建筑运营的影响就越小，也越有利于提高人员安全水平。数据应用于应急状态下，主要基于哪些数据是可用的，以及数据如何帮助提高人员的响应能力来实现。理解和整合多元数据将有利于对火灾以及其他紧急情况进行有效管理。

什么是建筑环境中的"大数据"？

在建筑环境中，建筑管理大数据包括建筑内部和城市环境中，正常及应急状态下储

Figure 1. "Big Data" (Source: copyright)
图1. 大数据（来源：copyright）

in these situations is based on what types of information is available and how it might aid response capabilities. Understanding and incorporating information from multiple sources will help in the effective management of fire and other emergency situations.

What is "Big Data" in the Built Environment?

In the built environment, "big data" for building management encompasses a large amount of information of different types being stored, transmitted, and processed in individual buildings and urban environments during both normal and emergency situations. In modern buildings, numerous building networks are integrated into a building automation system (BAS) that allows buildings to monitor systems in a streamlined manner. There is a common network where data is shared from smart devices operating on the same platform. In most of these modern facilities, a BAS has the ability to control building conditions and systems to improve occupant conditions and generate cost savings. The integration of other systems may be interfaced to a BAS through hard-wired device connections. This integration allows building managers to have a more comprehensive capability to manage building systems and operations (Figure 1).

The concept of how to process and use building data is changing: devices are becoming smarter, now with the ability to sense and transmit additional events; software is being written to process, analyze, and display this information from devices; and most important, the transmission media is changing from wired devices to wireless devices that operate over cloud-based control as part of the Internet of Things (IoT). This innovation is causing a dramatic effect on the ability to manage large amounts of data and to obtain real-time information for making better decisions in emergency situations.

Figure 2. Multiple stakeholders (Source: copyright)
图2. 多元利益主体（来源：copyright）

The IoT collects the data from objects and processes needed to be monitored, linked, and interfaced in real-time. The aim is to connect object with object, object with human, and object with the internet, for easy identification, management and control. It is a mix of hardware, software, data, and service, and it is becoming the platform for future "smart buildings."

Stakeholders and User Groups

The traditional stakeholders in the safe design and operation of a building include architects, engineers, occupants, owners, insurers, operating management, and government authorities with jurisdiction. With these smart systems, a key new stakeholder is the IT network manager. With all of the stakeholders involved, early team communications are important in order to help assure all interests are being addressed. The data from different building systems, in many cases, impacts the operation of other systems (Figure 2).

The ability to have all parties agree on how the security of building networks can be cyber protected is paramount in creating the desired result. Interfacing the building systems with the network is the challenge. The equipment designers and vendors are concerned with someone hacking into the installed systems to prevent them from operating properly or activating at the wrong time, while the IT manager is concerned with other systems interfacing with a network that can be hacked and granted access to private personnel and company confidential information.

The actual communication and use of big data is key in fire operations and emergency management. Data provided by various systems installed in the building requires a sound approach to how it can be gathered and how it can be utilized before, during, and after a fire or other emergency situation.

存、传输以及处理的各种庞大数据。在现代建筑中，许多网络被整合形成了建筑自动化系统（BAS），它能够以精简的方式监控建筑各系统。该系统存在一个公共网络，在此网络中，同一平台上运行的智能设备能够进行数据共享。在这些现代化的设施中，BAS能够对建筑环境和系统进行控制，改善人员所处的环境条件并节省成本。而其他系统的整合可能需要与BAS接口进行硬线连接。这一整合使管理者能够对建筑系统和运营进行更全面更综合地管理（图1）。

关于如何处理和应用建筑数据的理念一直在改变。由于可以感应和传输更多的事件，设备也越来越智能。用于处理、分析和显示设备信息的软件程序也正在被开发。最重要的是，传输中介已经由有线设备变成了无线设备，一种基于云控制而运转的物联网的一部分。这一变革对管理大型数据以及获取实时信息应对应急状态的能力方面产生了戏剧性的影响。

物联网实时采集需要监控、连接和交互的物体和过程，目的是实现物与物、物与人，以及物与网络之间的连接，方便识别、管理和控制。物联网是硬件、软件、数据和维保服务的综合，正逐步成为未来“智慧建筑”平台。

利益相关者以及用户群

建筑安全设计和运维的传统利益相关者包括建筑师、工程师、内部使用人员、业主、保险商、运营管理者以及政府职权部门。随着上述智能系统的出现，IT网络管理者也成为了一个关键角色。所有利益体在早期进行团队交流，有助于确认各自所关心的问题是否已得到解决。在许多情况下，不同建筑系统的数据也会对其他系统的运行造成影响（图2）。

想要实现预期的效果，首先要使各方对建筑通信进行网络保护达成一致，而面临的挑战是建筑系统与通信网络如何对接。设备设计方与供应商关心是否有人会入侵安装后的系统，试图阻止他们的合理操作，或者阻止他们错误激活设备。IT 经理则关心是否有人会为获取个人隐私或公司敏感信息的访问权限入侵与通信网络相连接的其他系统。

大数据的真实通讯和使用是消防运营和应急管理的关键。需要采取切实可行的方式，表明建筑各系统的数据如何被采集、如何在火灾以及其他应急事件发生前、进行中以及发生后应用。安保、建筑管理及政府职权部门等用户群需要各自判断哪些数据是自己可用的，这些信息又是如何显示呈现的。用户群需应能有效理解数据，在特定情况中快速应用。

User groups, including security, building management, and authorities with jurisdiction need to identify what data will be available to them and how the information will be presented. User groups need to have the ability to effectively understand the data and be able to utilize it quickly and easily during any situation.

Emergency Operations and Management

Effective emergency management planning includes pre-determined response strategies that are designed specifically for the building and its operations. The planning process must address management, communications, response, and recovery protocols to identify, communicate, and contain an emergency quickly to limit the potential impact on the building and its occupants. Emergency management plans are designed with pre-determined protocols that coordinate response efforts to expected emergency situations the building and/or occupants may face. Effective emergency management plans are developed to allow for fluidity of response based on the specific nature of the emergency and potential impacts on the building and occupants. This includes team member responsibilities, evacuation determination, and coordination with the first responders. They could be for such events as fire, hazardous materials, weather, power loss, or terrorist threat. Planning for these type of events is necessary at the beginning of the program.

The value of building data is the ability it provides to collect, process and organize information for real-time communication and visualization to the viewer in a situation where the building environment may be changing very rapidly, making a quick understanding and response to the emergency critical. It enables the data to be understood and allows for informed decisions to be made on any actions that might need to be taken. Building information and system data is one of many critical components to emergency response operations and can assist the building management team in identifying what is occurring, where the emergency is located, and other key information that can aid response efforts. In the planning process, building management should review what information can be gathered from systems and other data sources and who will receive the information. Once the information is received, the data needs to be understood by the user and then direct them to a specific communication and response protocol (Figure 3).

The foundation for achieving the desired results is an interactive process between recognizing the desired data for processing by the system software and the availability of sensor technology to provide it. New technologies and software platforms, including mobile apps and web-based response platforms, are being developed to provide building management with the ability to have situational awareness in their building while also creating a platform for them to effectively communicate information and response directions to responders, tenants, residents, and visitors in their building or on their property. New technology, including mobile apps and web-based response platforms, is being

Figure 3. Collect, process, analyze, and visualize for solutions (Source: copyright)
图3. 解决方案收集、处理、分析和可视化（来源：copyright）

应急操作与管理

有效的应急管理计划应包括专为建筑及其运维预先设定的响应策略。该计划过程必须阐明管理、通讯、响应以及恢复预案，以便能够快速发现、告知并控制应急事件，限制事件可能对建筑及其内部人员造成的影响。应急管理计划可以采用预定方案的形式，组织协调应急工作以应对建筑或内部人员可能面临的紧急应急情况。有效的应急管理计划，能够根据应急事件的特定性质或事件可能对建筑及其内部人员造成的影响作出区别应对。计划包括团队成员的责任、疏散决策以及与消防救援人员的配合。计划所针对的应急事件可以是火灾、危险物品、气象灾害、供电中断以及恐怖威胁。在项目开始，必须就针对这些事件制定应急管理计划。

建筑数据的价值在于能够被采集、处理和组织，实时传递并直观呈现给观察者。在建筑内部环境迅速变化的情况下，快速了解应急事件并及时作出响应至关重要，能够使数据被充分理解，对于应该采取的所有行动作出精确的决策。建筑内信息和系统数据是应急响应处置中众多影响因素的关键之一，它帮助建筑管理团队识别发生了什么、应急状况发生的位置以及其他有助于应急工作的关键信息。在制定计划的过程中，建筑管理人员应该检查从系统或其他数据源中可以获得什么信息，谁将收到这些信息。 信息一旦被接收，数据需要被使用者理解，并且指导其执行特定的通信和响应预案（图3)。

实现预期效果的基础，是辨识需要系统软件处理的数据与传感器技术书记提供能力之间的相互作用。包括移动应用和网络响应平台在内的新技术和软件平台正在被开发，他们能够使建筑管理者及时了解建筑内部情况，同时也建立了与消防救援人员、租户、居住者以及来访者之间有效沟通和指挥的平台。新技术均用于采集控制中心发出的信息并实时发送，以便根据指挥中心人员接收和处理的数据，协调整合通讯、告知和指示。这项由系统和操作驱动的技术为建筑管理提供了新工具，使其能够更好地组织消防和应急行动。

目前已有很多建筑数据应用于消防安全系统以及其他应急系统的案例，这些数据来源于建筑中火灾报警系统、建筑自动化系统、门禁控制系统、视频监控系统及其他应急系统技术，例如在建筑中安装传感器监测地震活动。上述系统的大量元始数据需要有经验的人员析、理解其代表的建筑情况和系统状态。从消防及其他传感器采集的数据应包括火灾或应急事件的位置、事件的严重性、该区域存在的危险以及可能对建筑运营和内部人员带来的影响。采集的数据可以供建筑运营管理方指定协调相关的疏散指令，或经处理用来预测火灾发展和增长趋势，预计疏散路径的可行性（图4）。

Figure 4. Managing people movement (Source: copyright)
图4. 管理控制人员的活动（来源：copyright）

Figure 5. Real-time Information (Source: copyright)
图5. 实时信息（来源：copyright）

designed to take the information received by command centers and distribute it in real-time to coordinate communication, notification, and direction, based on the significance of the data being received and processed by users in a centralized command location. These technologies, driven by data from systems and operations, are providing building management with another tool to allow them to better coordinate fire and emergency operations.

There are many applications for building data in fire safety and other emergency systems. Data could be collected from numerous systems installed in a building, including fire alarm, building automation, access control, video surveillance, and other emergency system technologies, such as sensors installed to monitor buildings for seismic activity. The amount of raw data collected from these systems requires an operator with experience to analyze it and understand its meaning for the specific building and the status of its systems. The data collected from the fire safety and other sensors could include the fire or emergency location, severity of the blaze, other hazards in the area, and its potential impact on the building operations and occupants. The data collected could be used by building management to coordinate evacuation instructions and/or be processed to predict fire development and growth in order to anticipate the viability of future exit routes (Figure 4).

The use of building data to coordinate emergency response efforts with the occupants of a building is one of the key components of emergency response planning. For example, accurate information needs to be provided to building occupants in a format that allows them to easily understand the information and what their responsibilities are, based on the type of emergency. Data provided to building occupants could include evacuation directions, response actions, or other information they may need to remain safe during a fire or other emergency situation.

Advances in electronic equipment technology include video fire detection technology to the point where cameras installed for security purposes can also see a fire event at the building command center and use the visuals to make informed decisions on how to respond. The video can also be sent to fire service responders in real-time during their travel to the building. The ability to determine the room of the fire and to see the nature of the fire together can help both the building and responders more efficiently and successfully address the situation.

Due to the rapid changes in personal technologies, occupants in buildings are able to receive data related to an emergency in various forms including mobile phones, digital displays, workstations, televisions, tablets, and over voice communication systems. This change in how occupants can receive data provides building management with better ways to disseminate key information to occupants based on their location, the potential impact on their safety, and the overall response strategy for the building (Figure 5).

Buildings are currently embracing new technologies including dynamic wayfinding, smart signage, and others tools that allows them to provide information to occupants on their location, exit paths, and other key data, based on specific locations in the building. These new technologies provide building management with the ability to transfer critical building and response information to occupants in a manner that is easily understood by them, notifying them of where they are located, where to go based on that location, and what to do during a fire or other emergency.

应用建筑数据组织协调建筑内部人员应急响应工作，是应急响应计划制定的关键因素之一。例如，需要以特定格式给建筑内部人员提供准确的信息，方便人员理解信息内容，了解该应急状态下他们的责任。数据应包括疏散方向，响应行动或火灾或其他应急状态下保持安全的信息。

电子设备前沿技术包括目前的可视化火灾探测技术，出于安防目的设置的摄像机也可以使建筑指挥中心发现火灾事件，并且做出准确的应对决定。视频也可以发送给受命前往的消防救援人员。这项技术能够定位火灾发生的房间并观察火灾性质，可以更好更迅速的帮助建筑内人员和救援人员。

伴随个人信息技术的飞速发展，建筑内人员可以采用各种手段接收突发事件的相关数据，包括移动电话、数字显示屏、工作站、电视、平板电脑以及语音通信系统。由于接收数据方式的改变，使得建筑管理能够根据人员所处位置、安全可能受到的影响以及整栋建筑的应急策略，以更好的方式向其传播关键信息（图5）。

当前，建筑十分提倡动态路径寻找、智能疏散指示等新技术，以及能够给建筑内部人员提供位置信息、出口路径以及其他关键数据的其他工具。这些新技术能够使建筑管理人员可以通过简单易懂的形式，将关键建筑信息和响应信息发送给人员，使其了解自己处于什么位置，发生火灾或其他应急事件时可以去往何处、可以做些什么。

对非公共智能建筑门禁控制系统中所有进入人员的姓名、位置以及离开记录进行整合是非常有帮助的。这样就可以通过手机GPS系统、安全章或安全卡技术提供数据，控制和帮助确认人员已全部远离危险。系统能够识别出已经依照指示采取行动的人员所在的位置。追踪个体行动会产生大量需要处理的数据。也可以查找发现由于当前应急环境以及可能发生的变化而需要营救的人员方位。

Integration of a smart building access control system in non-public spaces that records the name and location of all people entering and then records their egress can be useful. It can provide the data via GPS on mobile phones and/or security badges/cards technology that can be used in controlling and helping to assure that all occupants have been removed from the hazardous situation. It can identify the location of those that have followed the desired movement based on the instructions provided. Tracking individual people movement will generate significant amounts of data to be processed. It can also identify the location of occupants needing rescue due to both the current and anticipated statuses of an emergency.

In fire and non-fire emergency situations, the key initial steps include the identify of the emergency situation, an assessment of its severity, and a determination of the initial response steps to be taken. Once the first responders arrive, information gathered during the initial stages of the emergency and current building conditions is critical in the transfer of command to first responders. Data related to the building structure, systems and operations can now be coordinated with first responders prior to their arrival at the building. This pre-incident planning process allows first responders to obtain key information prior to their arrival to the building and helps them the understand the building layout, access points, staging areas, system and structural information and key operational points of contacts for the building. The data being provided to first responders aids in their ability to coordinate effective response protocols, identify potential issues or concerns based on the building structure or operations, and identify the center location and system monitoring locations, as well as any backup required.

In managing building operations, condition monitoring of devices can allow for preventive failures. By analyzing changing conditions on devices before failure, a pattern of predicting when a failure could occur. This can be a significant benefit of collecting, analyzing, and using large amounts of data over a period of time to define the failure pattern.

Figure 6. Condition monitoring (Source: copyright)
图6. 状态监测（来源：copyright）

A value provided by having a BIM model for the building can be applied to ongoing maintenance and periodic testing of the building fire safety systems so they are assured to operate properly in emergency situations. The information can be used to provide alerts and real time risk warning when the sensors indicate an out-of-normal reading or event. Management of the required test and maintenance programs also can be processed from smart sensor data. This will provide a record of sensor performance over a period of time and anticipate preventative maintenance or replacement (Figure 6).

Through the use of building data for fire and other emergency responses, the pivotal aspect that needs to be addressed in training and drills is to educate and test building management, security and related parties' abilities to understand provided data, the meaning of the data, and how to use the information before, during, and after a fire or other emergency situation. The training and drills should be conducted with the systems, staff, and first responders of a building to allow them to understand how the data is being presented and identify critical data points that require specific response strategies.

Global High-Rise Fire Safety Management Situation Analysis

High-rise buildings around the world have a single critical factor in common: they are incredibly complex structures. Architects look for ways to design and create unique spaces for building occupants. This approach includes increases in height, occupant experiences, and overall design esthetics. High-rise buildings include larger spaces; complicated fire detection, alarm and control functions; and challenging firefighting response and communications logistics. This can result in large amounts and types of building data being transmitted and processed in an emergency. Smart systems are an important vehicle in displaying the information needed for the occupants and first responders to make informed and effective decisions.

Due to the fact that high-rise buildings may be designed as mixed-use facilities and include various occupancy types and occupants, these buildings create unique challenges related to fire safety and emergency response. The type of emergency response for each of these occupancies is

在火灾及非火灾应急状态下，需要最先采取的关键步骤包括对紧急情况的发现、对紧急情况严重性的评估以及应采取的首要措施。当消防救援人员到达现场时，向其下达命令的关键在于事件初始阶段整理的信息以及建筑目前状况。消防救援人员在到达建筑前，便可对其结构、系统和运行等数据进行整合分析。预案能够使消防人员事先获得建筑的关键信息，了解建筑布局、消防车道入口、登高场地、建筑系统和结构以及靠近建筑的关键操作点位。提供给消防人员的数据可以帮助他们有效配合应急响应计划的执行，也可以协助他们发现建筑的结构和运营中的潜在问题或关注点，找出中心位置和系统监控位置以及所有备份信息。

在管理建筑运营的过程中，通过分析设备在故障前的情况变化及预测故障发生模式，设备的状态监测可以预防故障。在一段时间内收集、分析和使用大量数据对于定义故障模式很有帮助。

建筑BIM模型可用于设备持续维护和周期测试，确保在应急状态下能正常投入使用。当传感器接收非正常信号或非正常事件时，会发出警报和实时风险提示。测试管理和维护计划，可以通过对智能传感数据进行处理而实现，这一过程中，传感器性能和预期的预防性的维护和更换将被记录一段时间（图6）。

关于在火灾和其他应急事件响应中如何使用建筑数据，需要在培训和演习中解决的关键问题是培养和测试建筑管理、安保和相关部门理解数据的能力，理解数据的意义以及在火灾以及其他突发事件发生前、发生后如何使用数据。培训和演习需要结合建筑系统、员工以及消防部门进行，使参与者理解数据如何呈现，辨识需要采取特殊响应策略的关键数据点位。

世界各国高层建筑消防安全管理现状分析

高层建筑的关键共同点是拥有复杂的结构。建筑师试图为建筑内的人员设计提供特别的空间，如增加建筑高度，增强人员体验以及建筑整体美感。高层建筑拥有更大的空间，具有复杂的火灾探测报警和控制功能，具有挑战性的消防响应和通信系统。这些特点使得高层建筑在应急状态下需要传输和处理的数据数量庞大、种类繁多。而智能系统成为了为建筑内部人员和消防救援人员提供所需信息、作出准确有效决策的重要媒介。

由于高层建筑往往具有多种用途，具备各种功能和使用人群，这给其消防安全和应急响应工作带来了前所未有的挑战。不同建筑功能的应急响应策略也有不同，人员疏散策略也会随人员类型和事件类型的不同而有所不同。包括全楼整体疏散、部分

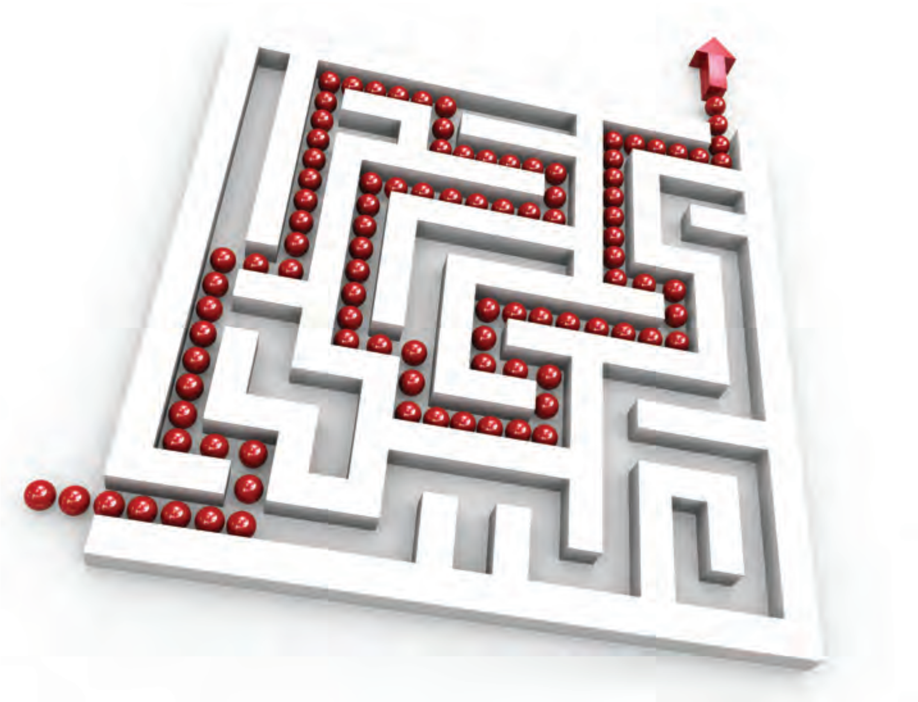

Figure 7. Wayfinding (Source: copyright)
图7. 路径寻找（来源：copyright）

different. The evacuation of occupants would vary depending on the mix of occupants and the type of event. Strategies could include full building evacuation, selective occupancy or floor-level evacuation, refuge floors, defend-in-place tactics, or combinations of these (Figure 7).

Unique challenges to a building-safe operation require building management to use provided data and pre-defined protocols to effectively coordinate responses based on the nature, location, and severity of the situation. Without proper data, building management would face a daunting challenge on how to coordinate response strategies for multiple occupancy types, ranging from residential to commercial to the general public.

High-rise buildings are also prone to being affected by external situations, including weather, acts of terrorism, or other situations that affect multiple high-rise buildings in the same complex and at the same time. Big data related to these types of situations may be received from outside sources as well as internal building systems. In these situations, the data received from external sources needs to be incorporated into overall fire safety and emergency response protocols to aid in response to the scenario.

High-rise buildings are pushing the limits on design and system capabilities. As buildings become more complex, so does the amount of data that can be provided. Due to this added complexity, data sources need to be clearly identified, coordinated, and integrated into building operational, fire safety, and emergency response protocols.

Challenges

There are a variety of challenges to achieving the level of data integration and use of data in creative and efficient ways. Not the least of the challenges is the size and quality of the data that is collected and used. Is there a BIM model and does it include all additions or alterations to the building? Are changes in room functions or occupancy reflected accurately in the current database? How does the database interface with the occupant and fire responders systems? Obvioiusy, the lack of a current database is an important factor and, depending on the importance of this, the value of the responses may be in question.

Another challenge is the current building regulations in most jurisdictions that prescribe exactly how exit signage should be designed, making dynamic wayfinding more difficult to be realized as an alternate or current regulations regulations limiting the way emergency messages are communicated.

In many locations, the ability of both building management and the public fire service to integrate and manage more complex building data may be limited by available technology and the understanding of the new technology. Other limittions might include issues such as the reliability of the information coming in from personal devices, such as cell phones.

功能区疏散，部分楼层疏散，避难层疏散，就地防护以及以上策略的组合（图7）。

建筑安全运行面临的特殊挑战要求建筑管理者使用可提供的数据和预案，根据当前现状、位置和严重性作出有效应对。在针对由住宅到商业，再到一般公共建筑的建筑功能改变制定不同的应急响应策略方面，如果缺少合适的数据，建筑管理这将面临艰巨的挑战。

高层建筑也会受到外界环境的影响，包括天气、恐怖活动，以及其他同时影响综合体中多座高层建筑的情况。这些状况相关的大数据可以从外界获得，也可以从建筑内部系统中获得。从外界获得的数据需要成为消防安全和应急响应策略的一部分，以便针对该场景作出应对行动。

高层建筑正在超越设计和系统功能的局限。由于建筑越来越复杂，需要提供的数据也越来越复杂。伴随建筑复杂性的增加，数据源需要被弄清楚，被协调组织和整合到建筑的运营以及消防应急响应方案中。

挑战

关于实现数据整合以及数据的创新高效使用仍面临各种挑战，绝不仅仅是收集和使用数据的数量和质量，其他挑战还包括：是否有建筑BIM 模型，它能否涵盖建筑所有附属部分和变更？目前数据库能够准确反映房间功能或者使用的变化？数据库接口如何与人员和消防系统相接？显而易见，当前的数据库的缺少是重要因素，基于此，响应的价值也许会受到质疑。

另一个挑战源于当下大多区域的建筑规范，规范中准确地阐述了安全出口标志设计的要求，使动态路径寻找更难作为替代方案，亦或者现行规范限制了应急通信方式。

在很多地方，建筑管理者和公共消防对于复杂建筑数据进行整合和管理的能力受到可用技术以及对新技术的理解能力的限制，其他限制因素包括个人电子设备，如手机发出信息的可靠性问题。

结论

建筑数据信息使管理者能够及时获得建筑内实时清晰画面，为建筑管理者发现与火灾、紧急情况或系统中断有关的问题提供了有效方法。发现建筑内部潜在问题的能力的加强，能够使信息快速推送给建筑内有不同需求和分工的群体。与建筑系统和紧急情况相关的数据可以传递给建筑管理

Conclusion

Building data and information is providing building management with the ability to have a clearer picture of what is happening in their building at any moment in time. This information also provides building management with effective ways to identify issues related to a fire, emergency, or system interruption. This enhanced capability in identifing potential issues inside a building provides for the ability to quickly push information to specific groups of individuals based on their needs and roles in the building: data related to the building systems and emergency situations could be directed towards the building management and operational staff responsible for the coordination of response efforts and engineering; data related to emergency management could be refined and directed to occupants to provide them information on the situation and their response; and data related to the building structure and system status could be routed to first responders to aid in their preparations for responding to the building and the event.

Regardless of the amount of information available, the key driver for big data in fire and emergency events is the proper identification, review, and transmition of information in a format that is easy to understand and provides clear direction on what the various recipients should do with the data (Figure 1).

As buildings look to incorporate big data into fire safety and emergency operations, building management needs to create a clear strategy on what data is available, where the information is being received, who is receiving the information, and what should be done with it. Strategies need to be developed to identify potential data sources and incorporate the data into response protocols and fire safety and emergency plans that will aid in the creation of a safe building for all occupants.

Big data for intelligent life safety and emergency management will be a critical part of the future for complex buildings, particularly high-rise structures. Integration of the building systems will provide for improved fire safety solutions, and the Internet of Things will be the catalyst to making this happen.

者和负责应急工作和工程的员工。应急管理相关数据应该准确提供给内部人员，指明当前情况和应对信息。建筑结构和系统状态信息可以传送给消防部门，协助他们为建筑和应急事件进行准备工作。

忽略可用信息的数量，合理地发现信息、以简单易懂的方式检查和传递信息，为接收者处理数据提供清晰的指示，推动了大数据在火灾和应急事件中应用（图1）。

由于建筑期望将大数据结合到消防安全和应急管理工作中，建筑管理者需要建立一个明确清晰的策略，指出哪些数据是可用的，这些信息从哪里可以获得，谁来取得这些信息并应该如何处理这些信息。策略需要发现潜在的数据源，将数据结合到响应方案、消防安全和应急计划，为建立安全的建筑环境提供帮助。

智能生命安全和应急管理的大数据将成为未来建筑综合体，尤其是高层建筑的一个关键部分。建筑系统的集成整合能够改善消防安全解决方案，而物联网将推动其早日实现。

References:

Marr, B. (2015). **Big Data.** Wiley.