Title:	**The Making of a Vertical Intelligent Community Through Information Systems**
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Subjects:	Building Case Study IT/Computer Science/Software
Keywords:	BIM Building Management Community
Publication Date:	2014
Original Publication:	Shanghai Tower: In Detail
Paper Type:	1. Book chapter/Part chapter 2. Journal paper 3. **Conference proceeding** 4. Unpublished conference paper 5. Magazine article 6. Unpublished

The Making of a Vertical Intelligent Community Through Information Systems

通过信息化系统打造垂直的智慧社区

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Shanghai Tower is devoted to creating a vertical intelligent community. From the detailed demands of the stakeholders, the owner's team clarified the direction of intelligent applications, demonstrated the rational top-level design architecture, selected mature, stable and forward-looking technical measures, and organized a rigorous design and construction process. The team also constructed a Cloud Computing Center for Shanghai Tower that hosts massive data and information services by providing communication support with high reliability. The team also introduced BIM technology for applying energy-intelligent running, building intelligent operation management and intelligent customer services throughout the whole lifecycle of the building.

上海中心大厦致力打造一个垂直的智慧社区，业主团队从详细的社区应用需求出发，明确智慧应用方向，论证合理的顶层设计架构，选择成熟稳定具有前瞻性的技术措施，组织严谨严密的设计施工过程，通过提供高可靠度的通信配套保障，建设上海中心云计算中心承载海量数据及信息服务，引入BIM技术在建筑全生命期的应用，着力实现的能源的智慧运行、大厦的智慧运营管理及客户的智慧服务。

Introduction

Shanghai Tower is a multifunctional building that acts as a vertically distributed city. The vertical height of the building is divided into ten functional zones. Each section also contains a combination of multi-functional spaces.

This is a vertical community, a combination of neighborhood-like zones. The people within can find the best balance of art and science, technology and beauty, emotion and rationality, safety and convenience.

From an angle of intelligence, the Shanghai Tower is a living vertical community. It is driven by energy through intelligent systems via the control center. It also is a community system that provides safe, convenient, energy-efficient, environmentally friendly, and human-oriented service.

From an informational perspective, both inside and around the periphery of the Shanghai Tower, vertical communities are producing a large amount of data. This allows building operators to accumulate a great deal of summary information such as data-sensing, data collection, data transmission, data integration, data analysis, driving the integrated control, joint command, and decision support. This data can later be used to optimize the operations of future buildings.

From the perspective of the contractor and administrator, a numbers of challenges and problems have arisen. Both the contractor and administrator dealt with everything from the allocation of assets and affairs to the combination of delivery technologies.

Therefore, organized by the builder, the cooperative team formed by the project management, consisting of consultants, designers, and a construction team was put together to create a vertical intelligent community based on the need to cope with challenges.

Analysis of Details Determines the Pivotal Point of the Intelligent Community

1. Analysis clarifies the functional demands and the technical requirements of the intelligent systems in different regions, through a comprehensive analysis of the regional functions of the architecture.

引言

上海中心是一个形态柔和、垂直、螺旋的多功能大厦，就像一个垂直分布的城市，大楼缓缓向天空延伸的形体中，从低到高分隔成十个相邻的功能区段，各个功能区段中又包含多功能的组合空间，为使用者提供多样的生活空间。

这是一个垂直的社区，一个由垂直相邻的邻里区域组合而成的社区。生活在内的市民能够寻找到最佳的平衡: 艺术与科技、技术和美感、感性与理性、安全与便捷……

从智能化视点来看，上海中心大厦这个垂直的社区，他是一个有生命的建筑，他是一个以能源为驱动力、以智能化系统为控制中枢、以设施设备为执行机构的整体，提供安全、便捷、节能、环保、人性化服务的社区系统。

从信息化的视点来看，上海中心大厦这个垂直的社区，从他酝酿建造的那一刻起，内部及周边就周而复始产生着大量数据，并能够汇总形成各种信息——数据感知、数据采集、数据传输、数据集成、数据分析等驱动着综合控制、联动指挥、决策支持、优化运营的实现。

从建造者及管理者角度来看，上海中心大厦这个垂直的社区，面临大量的挑战和难题——面对人员、资产、事件的服务保

2. Further considering the human factor, analysis clarifies the functional demands and technical requirements of the intelligent system by distinguishing different roles through the simulation of users, managers and policymakers throughout the operational period.
3. By considering investments made during the construction period and benefits throughout the operational period, a balanced relationship between the two was established, fully ensuring the owners of investment returns and reflecting the concept of sustainability.
4. From a technological development perspective, technological innovation in specific application areas and achieving the application of those results was only possible by integrating new technology with traditional technology.
5. From the vantage point of data and information usage, achieving technological breakthroughs in terms of integrated control, joint command, decision support, and energy optimization in the operation period was made possible by the integration of both intelligent systems and information systems.

Top-Level Design Based on Forward-Looking Intelligence and Information Technology Determines the Technical Architecture of the Intelligent Community

The construction period of Shanghai Tower comes at a time of surging new information technology and new applications. The new technologies, such as cloud computing, big data and BIM applications, are continuously infused into the traditional applications and the demands of Shanghai Tower during the both the construction and operation periods. Through a comprehensive plan, the new technologies and new ideas not only provide technical tools for the operation of Shanghai

Figure 5.1. The Shanghai Tower, upon completion, will act as a vertical community (Source: Gensler)
图5.1. 即将竣工的上海中心大厦将扮演垂直社区的角色 (来源: Gensler)

障、整合建筑功能提供社区运营服务、各种运管系统的技术集成、安全可靠的环境保障、便捷人性化的功能保障、绿色环保节能的运营保障、高效的日常及应急保障等。

因此在建设方组织下，由项目管理、咨询顾问、设计方、施工方组成工作团队，本着从需求出发，合力打造一个垂直的智慧社区，一起应对挑战并创造奇迹!

细致的需求分析决定智慧社区的着力点

1. 从建筑功能出发，通过全面分析建筑各区域功能，明确不同区域内对智能化系统功能需求和技术要求。
2. 从建筑功能出发，通过全面分析建筑各区域功能，明确不同区域内对智能化系统功能需求和技术要求。
3. 从投资效益的因素出发，兼顾考虑建设期投资和运营期效益，平衡两者关系，充分保障业主投资效益，体现可持续理念。
4. 从技术发展的因素出发，考虑新技术与传统技术整合的可能性，在专项技术应用上进行科技创新并实现成果应用。
5. 从数据及信息使用的角度出发，考虑智能化系统与信息化系统整合，在运营期中的综合控制、联动指挥、决策支持、能源优化方面的实现科技突破。

前瞻性的智能化、信息化顶层设计决定智慧社区的技术架构

上海中心的建设周期内正值IT新技术及新应用风起云涌的时刻。物联网、云计算、大数据、BIM应用等新技术新理念不断灌注到上海中心大厦建设期和运营期的传统应用和实际需求中来，通过一个完整的策划，不但能够获得新技术新理念带来现实红利，为上海中心的运营提供技术工具，更能够为上海中心今后的发展奠定智慧基础。

根据需求分析，制定标准、成熟、可靠的智能化系统顶层设计。在实现各项运营管理功能正常运转的基础上，关键在于:

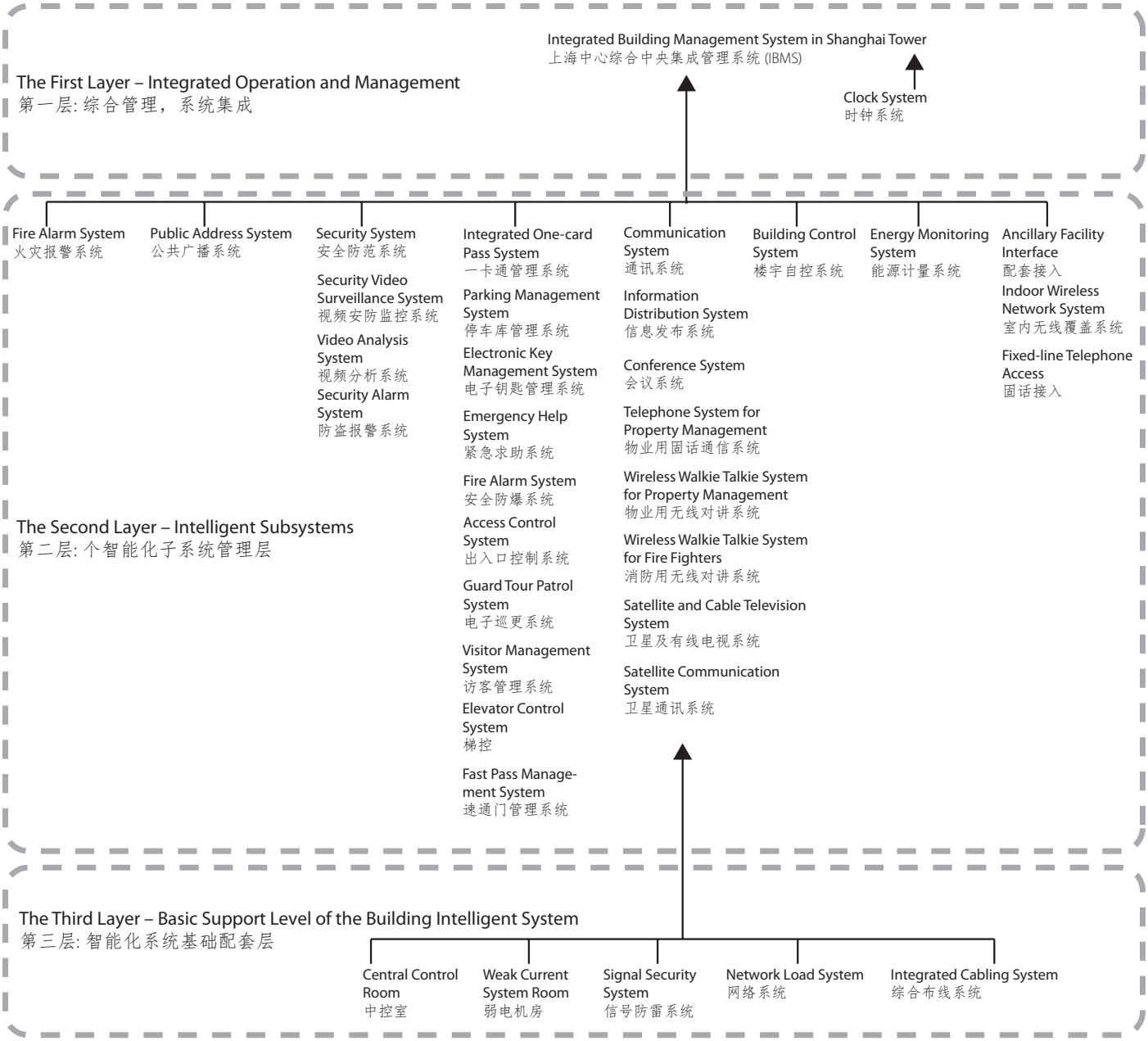

Figure 5.2. The 31 intelligent subsystems of the Shanghai Tower
图5.2. 上海中心的31个智能子系统

Tower, but also lay the foundation of intelligence for the future development of Shanghai Tower.

Development of reliable standards appropriate for the top-level design of intelligent systems was directed by demand analysis. Each standard was developed on the basis of achieving properly functioning operational management standards. The emphasis is as follows:

- The completion of the integrity and expansibility of the system architecture
- The safeguarding of real-time access to all types of operational data
- Focus on data security and conformance

The Shanghai Tower consists of 31 intelligent subsystems in the traditional sense, and is divided into three logical levels, including:

1. The bottom layer provides basic support level for the building intelligent systems, including the physical location of the core equipment placement, basic cabling and network load of each subsystem, signal security, electricity security and other subsystems.
2. The middle layer houses the intelligent subsystems that are independently running for professional monitoring and operation. Monitoring occurs on the fire alarm system, public security system, public address system, building control systems for the operation of building facilities and for the safety operations of the building. Energy

- 完成系统构架的完整性和可扩展性;
- 保障各类运营数据的实时获取和调用;
- 注重各项数据安全及统一。

上海中心大厦仅传统意义上的智能化子系统就包括31个，供划分了三个逻辑层次，包括:

1. 上海中心大厦仅传统意义上的智能化子系统就包括31个，供划分了三个逻辑层次，包括:
2. 中间层是各独立运行，承担专业监控和运转的智能化子系统，包括负责大厦安全运营方面的火灾报警系统、公共安全防范系统、公共广播系统; 以及负责大厦设施设备运转的楼宇控制系统、能源

Visual Presentation Layer 可视化展示层	Integrated Display Platform 综合展示平台		
Comprehensive Analysis Layer 综合分析层	Process Monitoring 流程监测	KPI Index Monitoring KPI指标监测	
Monitor 监测	Process status 流程状态 Process performance 流程绩效 Process compliance 流程合规	The external environment 外部环境 Operating conditions 运营情况	Comprehensive performance 综合绩效 Core resources 核心资源
	Comprehensive Analysis 综合分析	Thematic Analysis 专题分析	Trend Analysis 趋势分析
Analysis 分析	External environment analysis 外部环境分析 Analysis of long-term operation 长期运营情况分析 Coordination analysis 协调情况分析	Comprehensive Performance 综合绩效 Development Capacity 发展能力 Risk control 风险控制 Competitive ability 竞争能力	Trend prediction 趋势预测分析 Data monitoring 数据挖掘
Application Software Layer 应用软件层	Finance, project, business, public relations, investment, risk, official website, office automation 财务、工程、商务、公关、投资、风险、官网、OA……		
Middleware Layer 中间件层	ERP, e-commerce, finance, information release, IBMS, business intellegence, BIM, GIS, big data middleware, BPM ERP、电子商务、财务、信息发布、IBMS、商务智能、BIM、GIS、大数据中间件、BPM		
Infrastructure Layer 基础设施层	Database, operating system, network (intranet, internet, VPN) 数据库、操作系统、网络 (内网、互联网、VPN)		
Data Acquisition Layer 数据采集层	Weak current systems, intelligence systems, CPMS systems, electrical and mechanical equipment, sensors, RF/ID 弱电系统、智能系统、CPMS系统、机电设备、传感器、RF/ID		

Table 5.1. Unsupported circular foundation pit of 121 meters' diameter (Source: Shanghai Construction Group)
表5.1. 主楼121米直径无支撑圆形基坑 (出自: 上海建工集团)

monitoring systems, an integrated one-card pass management system, and integrated communications systems manage all types of communications coverage within the building.

3. The top layer contains the IBMS systems for all integrated collection, storage, processing, analysis, and display of all subsystems. It also unifies coordination of the clock system for each subsystem.

A clear hierarchy positions the standard data transmissions and clears the system interface to clarify the relationships between the aforementioned levels. This arrangement is not only for safety insurance, but expandability insurance as well. Late in the design process, unique intelligent subsystems of Shanghai Tower have been respectively super-imposed at all levels. For instance, the expansion of the BIM-based operations management system is at the top layer, the expansion of the building security monitoring system is in the middle layer, and the intelligent curtain-control systems and floodlighting control systems are on the bottom.

Development of the top-level design for the forward-looking information system was established according to demand analyses. For the integration of the Shanghai Tower operations, the following guidelines were created by the management in consideration of the period and various types of information application systems. The guidelines are as follows:

- Rational combination of functions of various information systems achieves optimization and information sharing during the operation period
- Real-time dynamic data from the intelligent systems should be compatible and interoperable with the various types of running information systems
- Continuous improvement of the operation and management measures should be sought

监测系统; 负责客户服务及管理的综合一卡通系统; 以及负责大厦内各类通信配套覆盖的综合通讯服务系统等;

3. 最高层是负责对所有子系统综合采集、存储、处理、分析及展示的IBMS系统和统一的协调各子系统的时钟系统。

明确的层次架构定位、标准的数据传递、清晰的系统界面，既理清了各层次关系，确保了安全性同时也保证了各层次的可扩展性。在设计后期，分别在各个层次叠加了部分上海中心特有的智能化子系统，比如在最高层次中扩展了基于BIM的运营管理系统，在中间层扩展了大楼性态安全监测系统，智能窗帘控制系统、泛光照明控制系统等。

根据需求分析，制定前瞻性的信息化系统顶层设计。在整合上海中心大厦运营期以及管理团队今后发展过程中的各类信息化应用系统基础上，关键在于:

- 大厦运营期各种信息系统的功能合理组合、流程优化、信息共享;
- 大厦运营期各种信息系统的功能合理组合、流程优化、信息共享;
- 完善优化各项运营管理措施;
- 完善优化各项运营管理措施;

信息化系统顶层设计符合开放性、可扩展性的要求，软件系统技术结构可采用多层体系结构。

- 数据采集层¬——是负责各类数据采集的基础层，采用物联网技术采集包括上海中心大厦的弱电系统、机电设备系统、智能化系统、信息发布系统、安防系统、多能源管理系统的数据采集;
- 基础设施层——是维持应用系统的运行数据库和网络操作系统层;
- 中间软件层——是从应用层和底层系统软件分离出来的一个层次，它解决各应用系统的公共支撑逻辑，为异构操作系统、异种网络、异构数据库等提供统一的处理平台;
- 应用软件层——实现大楼管理的物业、酒店、商务，以及集团管理的办公自动化、工程管理、综合管理、计划财务管理、资产管理、公共关系管理、人力资源

- Design the system in consideration of possible group management and multi-property management

The top design level of the information system meets the requirements of openness and expandability, while the technical architecture of software systems can be multi-tiered.

- Data acquisition layer: The base layer for all various data is collected digitally. It collects data from the electrical and mechanical equipment systems, intelligence systems, information systems, security systems, and energy management systems of the Shanghai Tower.
- Infrastructure layer: Maintains the operation database of application systems and network operating systems.
- Intermediate software layer: Separate from the application layer and the underlying system software, it figures out the public support logic for the various application systems and provides a unified processing platform for heterogeneous operating systems, networks, databases, etc.
- Application software layer: Achieves office automation, project, general, planning and financial, asset, public relations and human resources management for the building property management.
- Comprehensive analysis layer: This is the decision analysis layer for achieving the strategic objectives of the group. It establishes a data warehouse, or data-mart for extraction, analysis, transformation, and loading (ETL), after which the desired results can be achieved.
- The visual presentation layer uses all kinds of visual display methods, such as a variety of 3D digital presentations via BIM-based panoramic displays. The hand-held mobile format allows data analysis and the technical methods for screen images to encompass the demands of the managers. Allowing managers to see the actual operation vividly represented in real time affords better responsiveness.

Rational Technology Selection and Scale Determines the Technical Genesis of the Intelligent Community

1. IP-based intelligent transmission systems architecture makes it easier for Shanghai Tower's intelligent applications in terms of openness and compatibility to basic transmission. More than 90% of the various intelligent subsystems, including one-card passes, video surveillance, broadcasting, fire protection, energy metering, smart curtains, and intelligent lighting consume are based on a 10-Gigabit backbone and 1-Gigabit level IP network architecture, and can be smoothly upgraded.
2. System integration technology effectively integrates intelligent systems and information systems, facilitates functional integrations and overlays community intelligent applications. Integration of functions, data, protocols, etc. for each aspect of the intelligent subsystems occurs at all system levels. This collects the independently coordinated system and makes full use of the front-end of each device for data acquisition and control functions. This reduces investment, to increase the economical benefits of data integration and provides comprehensive mass data storage, application, and analysis while integrating capabilities during the operational period with via application layers and information systems integration.
3. Intensive design measures effectively save space which can be reserved for future expansions. It is convenient for upgrading hardware and software environments during the process of operation in the community intelligent application. Intensive

管理等等;

- 综合分析层——为实现集团的战略目标的决策分析层，它通过数据仓库/数据集市的建立，抽取、转换、装载数据，然后进行数据清理、挖掘、分析，形成所需的结果;
- 可视化展示层——利用各种Web展示方式、三维动态方式、基于BIM的全景展示方式、移动互联展示方式、视屏图像的智能分析及其关联技术方式等各种可视化展示的手段体现管理者的真正需求，让数据发挥增值效果，让管理人员在实际操作中看到简单、干净、形象化、实时活化的表现形式，使得管理人员可以通过形象生动的表示方法来处理实际问题。

合理技术选择及规模决定智慧社区的技术基因;

1. 基于IP传输的智能化系统架构，便于上海中心大厦智慧应用在基础传输方面的开放性和兼容性——在主干万兆，水平千兆的IP网络架构 (并能平滑升级) 基础上，构建各智能化子系统，包括一卡通、BA、视频监控、广播、消防、能源计量、智能窗帘、智能照明等，覆盖90%以上系统。
2. 系统集成技术有效整合智能化系统以及信息化系统，便于社区智慧应用的功能整合和叠加——在设备层次、传输层次、系统层次对各智能化子系统进行功能、数据、协议等方面的集成，打破原有系统各自为营的现状，充分利用各设备前端采集数据和控制功能的复用性，降低投资，提高数据整合带来的效益，并在应用层与各信息化系统整合，提供运营期的综合海量数据存储、应用、分析及整合能力。
3. 集约化设计有效节省空间预留今后扩展，便于社区智慧应用在运营过程中的软硬件环境升级——在传输线路层次和网络设备层次充分的集约化设计，利用好每一项的垂直光纤资源和网络带宽资

design in the transmission-line level and network equipment levels should make good use of all fiber and network bandwidth. The device management room should fully consider the rational distribution of cabinet space and wall-mounted equipment layout for the operation and equipment. In accordance with the command-hall layout, adequate management space and sufficient core equipment expansion areas should be put on reserve in the core machine room.

4. Highly centralized control of building energy facilitates continuous optimization and energy-saving operations in the Shanghai Tower. The integrated energy management system governs the various mechanical systems (cooling-heating-power (CHP) energy, ice storage energy, conventional electric refrigeration energy and geothermal heat pump energy) of the Shanghai Tower. Pointed energy measurements are taken via the energy consumption monitoring systems (i.e. lighting, HVAC, elevators, plumbing, etc.) in the building. Combined with relevant data information collected from other informational subsystems, including indoor and outdoor environments, people, traffic and events, the analysis for integrated energy optimization and utilization is carried throughout, and continuous adjustments and optimizations will be carried on throughout operations.
5. Services reflection
6. Management reflection

The Control of the Design and the Implementation of Key Points Ensures the Technical Realization of the Intelligent Community

1. Strict construction design is optimized by the BIM model.
2. Develop detailed technical specifications, clearing the control factors such as function demands, technical requirements and parameter indexes of each subsystem.
3. According to the demands of the intelligent applications in the process, continuous improvements and constant adjustment and optimization of system software functions, data acquisition, data transmission and system functions are imperative.

源; 在设备管理间充分考虑机柜空间合理布局及挂墙设备布置，预留操作空间及设备空间。在核心机房按照指挥大厅布局，预留充分管理工位，预留充分的核心设备扩展区域。

4. 建筑物能源高度集中管控，便于上海中心大厦能源使用方面的持续优化和节能运行——在上海中心大厦的多种产能侧 (三联供能源、冰蓄冷能源、常规电制冷能源、地源热泵能源) 上建设综合能源管理系统; 在大厦内大量耗能侧 (照明、暖通、电梯、给排水等大型设备) 对使用能耗进行精细测量，建立能耗监测系统; 并结合其他智能化子系统以及信息系统采集的相关数据信息，包括室内外环境、人流、车流、事件信息 (大型会议、高规格接待) 等，进行综合的能源优化利用分析，以期在运营期进行不断的调整和优化。
5. 体现服务。
6. 体现管理。

设计及实施关键点的把控确保智慧社区的技术实现;

1. 严格的施工图设计，并通过BIM模型进行优化设计; ——
2. 制定详细的技术规格书，明确各子系统功能需求、技术要求、参数指标等控制性因素——
3. 过程中根据智慧应用的需求不断完善，对系统软件功能、数据采集、数据传递、系统功能等内容做不断调整优化——