

Case Study

Intel® Core™ processor
Intel® Xeon® Scalable processor
Intel® Distribution of OpenVINO™ Toolkit



ThunderSoft Develops a Smart Building Solution Based on Intel Architecture to Empower Building Management with Edge Intelligence

“ThunderSoft has always been committed to cooperating with a wide range of partners such as Intel to further the development of the smart city industry ecosystem in areas such as smart buildings and smart parks through IoT development frameworks, edge intelligence, and other solutions. This strategy has already produced fruitful results. In the future, we will also develop and launch more targeted solutions suited to the needs and characteristics of various industries to facilitate the implementation of smart cities.”

– Zhang Shuo
Product Director, ThunderSoft

Overview

In order to realize refined and visualized data management while ensuring the optimal allocation of key resources such as office space, power, and parking spaces to reduce the total cost of ownership (TCO) and improve the working and living experience, commercial buildings are moving towards smart transformation. Smart commercial buildings differ from conventional ones in that they use artificial intelligence (AI), big data, computer vision, cloud computing, Internet of Things (IoT), and other technologies to collect, analyze, and mine massive amounts of data to meet the demands of smart parking, workstation management, smart conference room management, security management, and other sub-applications.

ThunderSoft Software Technology Co., Ltd. (ThunderSoft) is the world's leading provider of smart operating system products and technologies. Adhering to the concept of software-defined smart building, ThunderSoft creates a universal intelligent bus (IB) for each building that on the basis of realizing access to various building management systems (BMS). The IB can achieve the access and communication of IoT smart terminals in an innovative and software-defined manner, thereby realizing the implementation of the Internet of Everything (IoE).

The ThunderSoft smart building solution supports connection and communication with smart building IoT devices such as sensors, devices and building automation systems through an edge computing platform based on Intel® architecture, along with near real-time data convergence, analysis, and uploads the data to the cloud to meet the needs of smart management.

Background and Challenges

Background: The Rapidly Developing Smart Building Market

As a key part of the pan-smart city ecosystem and an important direction for the future development of buildings as a whole, smart buildings can realize the organic integration of devices, applications, infrastructure, services, and other elements through digital technology to meet the demands of safety, convenience, efficiency, and energy efficiency. Smart buildings can help save time, improve the intelligence of decisions, and optimize operational efficiency by enhancing the control, automation, and analytics of building systems.

According to the latest report from MarketsandMarkets, the smart building market is projected to grow from USD 72.6 billion in 2021 to USD 121.6 billion in 2026, representing a compound annual growth rate (CAGR) of 10.9%¹. The report notes that this growth will primarily come from an emphasis on energy-efficient and environmentally friendly buildings, development

¹ <https://www.marketsandmarkets.com/PressReleases/smart-building.asp>

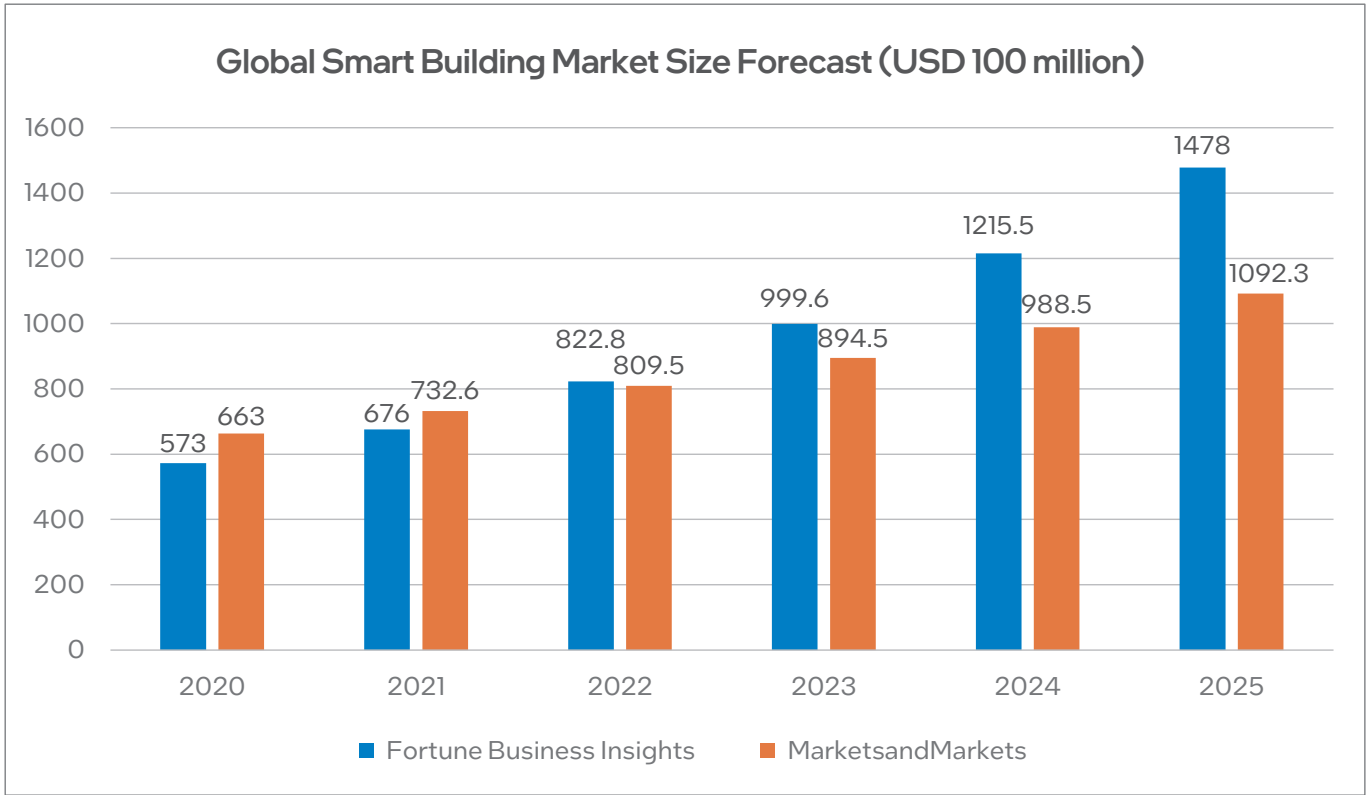


Figure 1. Global smart building market size forecast (2020-2025)³

of wireless protocols, deployment of wireless sensors, increased investment in infrastructure from developing countries, and other factors. The report also projected that the total output of the Chinese smart building market will increase from CNY 723.8 billion in 2021 to around CNY 1016.1 billion in 2025².

Of the sub-industries, building energy management is projected to have the fastest rate of growth as reducing energy consumption is a common concern amongst high-rise buildings, schools, and commercial complexes. Security is one of the most significant demands of smart buildings and is currently the largest market

segment. The size of the smart building security market is projected to experience continued growth over the next few years. Commercial buildings are projected to take up a larger share of the smart building market in 2025.

China is home to the world’s largest smart building market. The smart transformation of buildings in China is expected to create a wealth of business opportunities as smart buildings become the mainstream model of construction and operation for the foreseeable future, primarily driven by factors such as policy, technology, and the economy.

² Data from the In-Depth Analysis and Investment Strategy Research Report on the Chinese Building Intelligent Transformation Market.

³ Data from Fortune Business Insights and MarketsandMarkets.

Policy

Over the past few years, the government has promulgated a large number of policies related to smart buildings. For example, the Smart Building Design Standards clarified the corresponding specifications; the *New Generation of Artificial Intelligence Development Plan* required the strengthened integration of AI technology and home building systems to develop smart buildings; the *Three-Year Action Plan for Promoting the Development of a New Generation Artificial Intelligence Industry (2018-2020)* required support for the application of technologies such as intelligent sensors, IoT, and machine learning in home building systems to improve intelligence, practicality, and security; the *Opinions of the Ministry of Housing and Urban-Rural Development and Other Departments on Empowering Property Service Enterprises to Accelerate the Development of Online and Offline Living Services* required the development of a smart building management service platform with property management,

government services, public services, and life services applications to realize the construction of a life service ecosystem in residential communities and provide residents with smart property services; and the *Notice on the Publication of the 14th Five-Year Plan of the Construction Industry* required the acceleration of the coordinated development of smart construction and the industrialization of new buildings.

The “dual carbon” (peak carbon by 2030 and carbon neutrality by 2060) goals outlined by China in September 2020 have injected greater impetus into the development of smart buildings. The construction industry accounts for a large proportion of overall carbon emissions, of which the building operation stage accounts for 80%-90% of total emissions during a building’s lifecycle and 43% of the industry’s total emissions output⁴. The construction of smart buildings will improve the monitoring and projection of energy consumption, thereby helping ensure the realization of the dual carbon goals.

Market

With the continuous improvement of living standards, users have developed higher demands for the comfort, convenience, and safety of work and living environments. Through smart building construction, developers and property service providers can

enhance the visibility of building environments and resources, and intelligently allocate resources through digital and smart tools, thereby delivering a better user experience.

Technology

Innovation in digital technologies serves as the direct driving force behind the increased demand for smart buildings. The development of AI, big data, 5G, IoT, virtual reality (VR) / augmented reality (AR), edge computing, blockchain, and other technologies is playing an increasingly important role in the construction of smart buildings. For example, the cloud-edge-end synergy system allows applications with high latency, stability, and security requirements to be deployed at the edge,

applications with high computing power and unified multi-location/remote management requirements to be deployed into the cloud for processing, and the cloud-edge-end to be connected through a high-speed, secure private network. This architecture realizes more efficient, flexible, and cost-optimized digital infrastructure; and unlocks new IT service capabilities to better support innovative applications such as AI in smart building systems.

⁴ Data from the Fuyou Xinsheng • 2022 China Building Automation Industry White Paper published by Kong Intelligence and EqualOcean.

Key Technical Challenges

Despite the rapid growth and strong prospects of the smart building market, the key technical challenges faced during the construction process restrict the application of smart building solutions.

● Lack of a Unified Hardware and Software Platform

The industry chain of the building digital/intelligent transformation industry is long and involves devices, basic software, application software, cloud services, solution integration, system integration, and other elements. At present, the construction of smart buildings still follows the conventional organization model of integrators and solution providers. The lack of unified hardware and software platform results in the incompatibility of hardware and software systems among solution providers, leading to redundancies in hardware resources; reduced smart building flexibility and scalability; difficulties in obtaining unified, comprehensive, and real-time data views; and challenges to the unified management of smart building devices and applications.

● Lack of Scenario-Centric Application Configurations

As customer demands for the application experience continue to rise, smart buildings are no longer assembled from multiple independent and unrelated subsystems. The primary demand of the market has shifted towards the integration of multiple subsystems centered around application scenarios. For instance, users can connect their smart parking system with their smart visitor system centered around the car visitor application scenario. On entry, the user can input the vehicle and visitor information through a unified interactive interface. When the car is driven into the parking lot, the nearest parking location can be recommended in accordance with the access information. This information can then be obtained again once the vehicle leaves.

● Lack of Privacy Protection

Current smart building systems are mostly based on end-cloud architecture, which makes it difficult to realize the unified protection of IoT devices and applications. Due to the large data transmission requirements between the local end and cloud, smart building services provided by SaaS create complex data privacy and security issues. The connection of spoofed authorized devices to the overall smart IoT network has the potential to cause security risks.

● Difficulties in Realizing the Commercial Expansion of Value-Added Services

The majority of value-added services provided by operators such as property service providers are conventional services, which are less attractive to enterprises as they cannot easily cover the full range of enterprise demand such as data-based operations management and peripheral integration services. As a result, it has been difficult for enterprises to realize full data empowerment, which in turn has limited cost reductions and efficiency enhancements.

● Difficulties in Fully Meeting the Performance Requirements of Loads Such as Deep Learning and Computer Vision

Smart building systems need to analyze and process massive amounts of data. This is especially true for applications such as deep learning and computer vision, which place higher demands on computing power. With the migration of a large number of smart building applications to the edge, users must be able to provide sufficient computing power despite the strict size and power consumption limitations imposed by edge devices, placing huge challenges on the overall design of smart building systems.

Solution: ThunderSoft Smart Building Solution Based on Intel Architecture

Solution Introduction

ThunderSoft has launched a smart building solution based on Intel architecture that includes a smart building operating system, IoT device and application management platform (IoT Harbor), along with hardware components such as edge servers, edge AI boxes, and edge controllers to facilitate the development of smart parks and enhance the value of their operations.

● ThunderSoft Smart Building Operating System

The ThunderSoft smart building operating system supports the access of a variety of building management systems through a universal IB, along with the software-defined access and communication of IoT smart terminals to realize the implementation

of IoE. The solution adopts a hierarchical and modular design, containerized deployment method, and is made up of four primary components, namely sensor virtualization, core services, device virtualization, and application service virtualization. It realizes the transmission, storage, collection, and analysis of IoT data from the southbound (device) to northbound (cloud), along with the intelligent control of IoT devices from northbound to southbound, and supports Open Link Association (OLA) industry standards and Connectivity Standards Alliance (CSA) Matter standards. The solution also provides standard and developed device connection interfaces, along with reference implementations for compute cluster and system management.

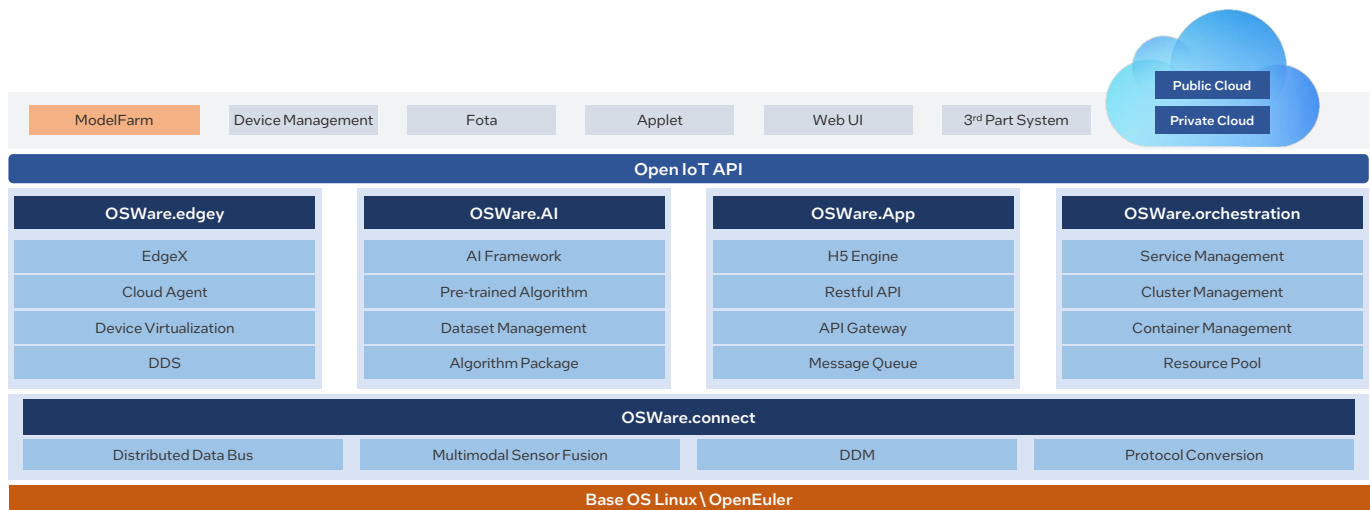


Figure 2. Architecture of the ThunderSoft smart building operating system

● ThunderSoft IoT Harbor Device and Application Management Platform

IoT Harbor is an IoT device and application management cloud platform that integrates device access and management, application management, FOTA updates, rules engines, data visualization, video cloud, and other functionality while supporting the remote deployment of algorithm applications and cloud-end synergy services. The cross-platform, easy-to-scale, high-security, and high-stability platform supports large-scale southbound device access and data collection, along with the northbound connection with mainstream public cloud platforms to help terminal device manufacturers, system integrators, and service providers quickly migrate devices to the cloud and empower the intelligent transformation of the industry.

● ThunderSoft ModelFarm AI Service Platform

ModelFarm is a full-lifecycle AI algorithm development platform that integrates data management, labeling services, model training, and algorithm services.

- **Zero code, no barrier to entry:** Provides a complete suite of tools from the upload, storage, cleansing, and labeling of data to the training, validation, and download of models and algorithms to ensure that enterprises can rapidly and easily deploy and implement AI based on their operational and innovation needs.
- **Knowledge distillation and decision tree pruning:** The application of various model compression and tuning techniques realizes up to 10x compression of models, allowing them to meet

the calculation requirements with a small amount of resources at the edge and end⁵.

- **Low accuracy drop quantization:** Low-bit quantization without retraining realizes the conversion of models from high-precision floating-point to fixed-point operations at <1% precision loss in specified scenarios.⁶
- **Small sample learning:** Features 100+ pre-trained models, built-in cross-sector adaptation, and advanced transfer learning technology for domain generalization to greatly reduce training data requirements when combined with data enhancement technologies.

● ThunderSoft Edge AI Box

The ThunderSoft edge AI box integrates advanced computing and software functionality to provide edge analytics and generate insights at the machine learning layer. Designed for edge applications, edge AI boxes provide superb computing performance in a compact size, high environmental adaptability, ease of maintenance, cloud-edge synergy, and wide support for edge deployment.

The ThunderSoft edge AI box utilizes with 11th Gen Intel® Core™ processors, which come equipped with Intel advanced processing technology and redesigned Intel Core microarchitecture, along with Intel® Iris® X^e Graphics and built-in Intel® Deep Learning Boost technology for superior execution performance. The processor also features support for a wide range of operating systems and workload requirements to provide users with various performance options.

^{5,6} Data from internal test results of Thundersoft.

● ThunderSoft Edge Controller

To improve the processing of data, enhance profitability, lower downtime, and reduce operating costs, automation control solution should leverage data from distributed devices and convert them into actionable insights. ThunderSoft provides a complete line of edge controller products supported by a building operating system (BOS) to system integrators and automation suppliers.

● ThunderSoft Edge Server

The edge server utilizes high-performance Intel® Xeon® Scalable processors with a range of features designed to support a variety of complex workloads and provides cost-effective, flexible, and scalable edge computing architecture with enhanced single-node performance for key tasks such as AI and data analysis. The edge

server can also act as a micro data center in smart park scenarios, providing computing functionality for edge clouds and helping enterprises construct a one-stop management center based on cloud-native architecture.

The ThunderSoft smart building operating system, edge AI box, edge controller, and edge server provide support for a variety of connection protocols and containerized service management. They can be connected with existing device management and business subsystems, provide a unified device and content connections for a variety of enterprises and device types, and realize functions such as function computing, visual computing, and local temporary storage to facilitate efficient device management and convenient intelligent computing.

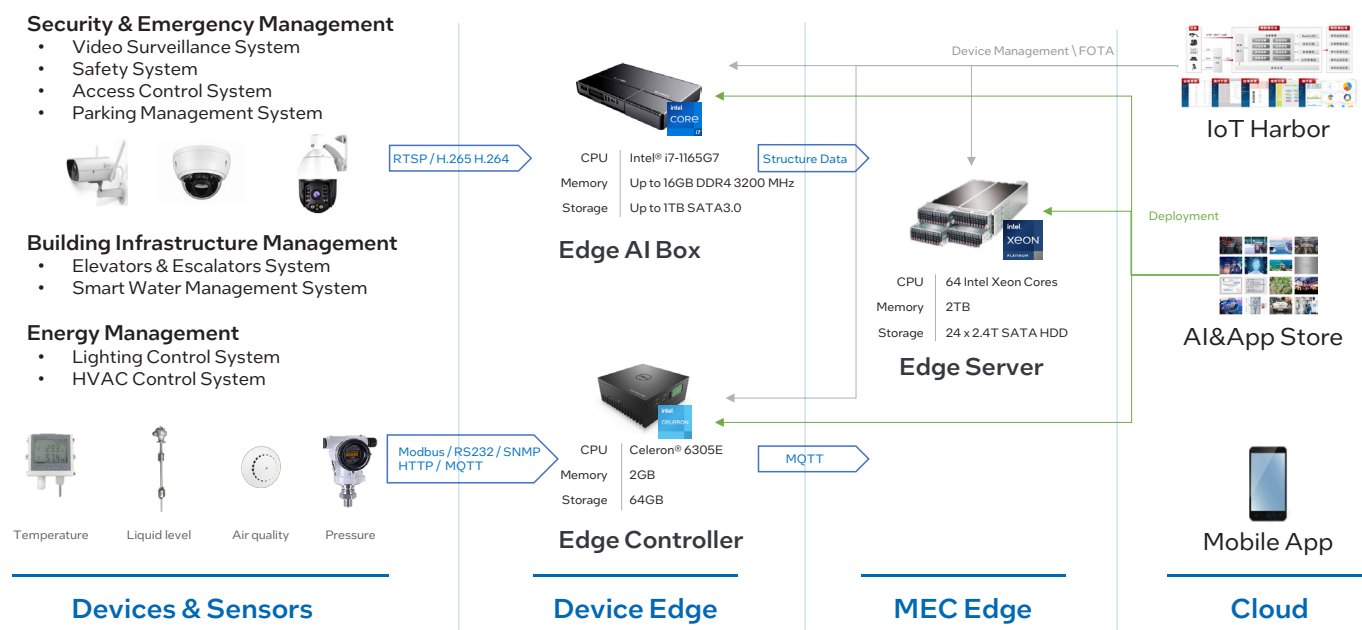


Figure 3. Topology of ThunderSoft smart building deployment

In addition to realizing the unified connection and management of multiple IoT devices, the solution also supports the utilization of AI algorithms running on edge AI boxes powered by Intel® Core™ processors for smart building applications. ThunderSoft performed low-precision quantization based on the INT8 data format for certain network layers through the OpenVINO™ toolkit, which improves the performance of deep learning algorithms during inference, provides support for heterogeneous computing and asynchronous execution and reduces the time spent waiting for system resources. The OpenVINO™ toolkit also utilizes optimized OpenCV and OpenVX, provides a variety of application examples to reduce development time and comes equipped

with a function library that supports heterogeneous computing. ThunderSoft only needs to write programs once, as they can then be run on other hardware platforms through heterogeneous APIs.

Relying on data analysis and processing from the edge to cloud, the ThunderSoft smart building solution can support applications such as smart parking, workstation management, smart conference rooms, toilet seat management, visitor management, security management, cloud exhibition halls, and device management. The solution also realizes the construction of a visualized smart building operation center, which provides data on the current operating status of the building in a comprehensive and timely manner, enable data-based operations management and helps attract investment.



Figure 4. The ThunderSoft smart building solution realizes in-depth and real-time data operations

By deploying the ThunderSoft smart building solution and performing edge data processing based on Intel platforms, commercial building operators can realize the intelligent transformation of building operations and realize the optimal allocation of building resources. Users can transfer key loads such as

edge data convergence and AI to the edge for processing, thereby reducing the requirements for cloud computing power and network infrastructure. As loads are shifted to the edge, the processing delay of data is significantly reduced, stability is increased, and privacy of user data is strengthened.

Solution Benefits

The ThunderSoft smart building solution offers a variety of benefits to help users construct smart building systems.

Lower Total Cost of Ownership (TCO)

- In addition to reducing the equipment costs required for the construction of subsystems such as smart park IoT, the solution also reduces the corresponding SaaS, installation, and training costs.

Enhanced Network Security

- As every device connected to the IoT is a potential point of entry for malicious attacks, cybersecurity is a key concern for enterprises seeking to scale their IoT and start collecting massive amounts of data. The solution converges massive data processing at the edge, reducing the amount of data that needs to be transmitted to the cloud, thus reducing the corresponding security risks.

Empowered Expansion of AI Applications

- The application of AI functionality transforms cameras from just visual devices to data-driven sensors, whose generated data supports the construction and operation of smart parks.

Application in Practice: Empowering Enterprises with Reduced Costs and Increased Efficiency

Presently, ThunderSoft smart building solutions have been successfully applied to the operation of many buildings in China.

● An Automotive System Software Supplier

Headquartered in Shanghai Pioneer Park, the automotive system software supplier hoped to develop smart spatial services, manage thousands of desks and dozens of conference rooms in its HQ building, and convey a cutting-edge image to customers while improving the utilization of space and other resources.

ThunderSoft helped the enterprise construct a smart building system capable of converging IoT devices such as network cameras, network video recorders, AMRs, and smart conferencing devices through a unified edge AI box. To solution not only met the

enterprise's requirements for unified resource management, but also enabled in-depth analysis to extract more data insights.

Compared with cloud solutions, the solution based on edge computing helps realize greater economic benefits, saves on the cost of IoT devices, and reduces the costs associated with SaaS procurement, installation, and training. This approach also helped reduce security risks by protecting IoT devices from complex external network security environments, while the integration of AI applications enable the use of cameras as data-driven sensors to support a wider range of applications.

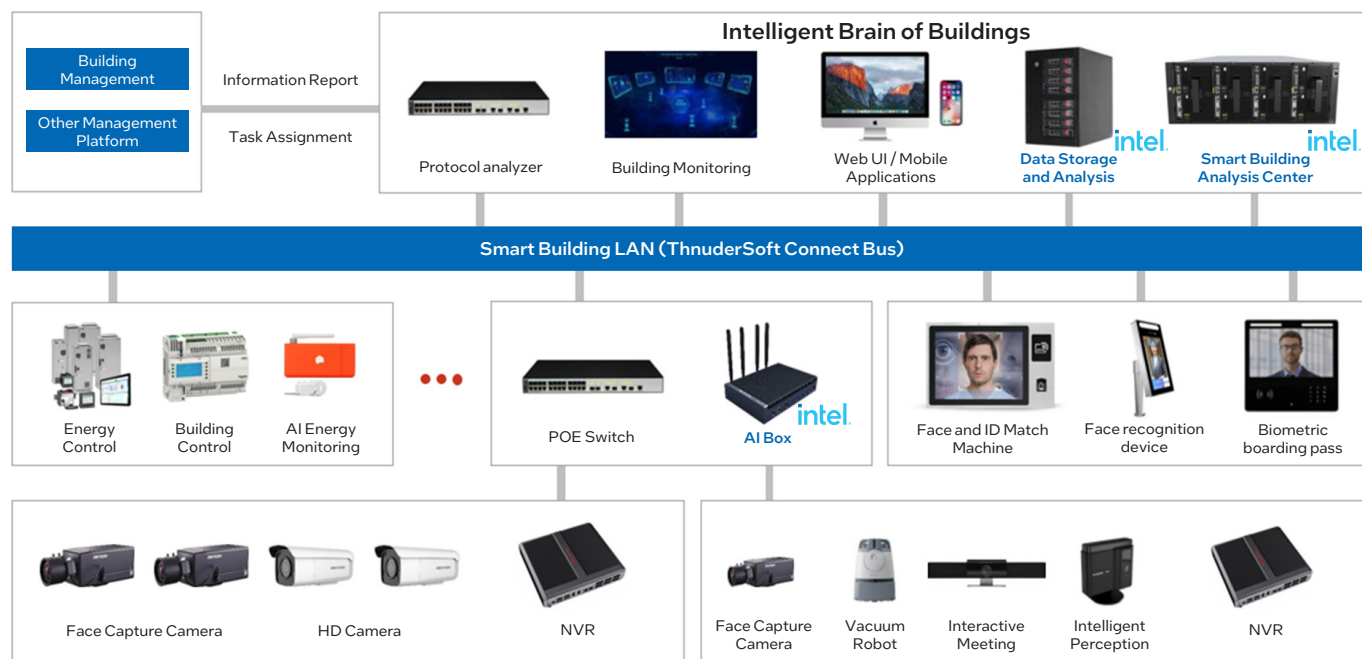


Figure 5. Architecture of the ThunderSoft smart building enterprise solution

● Smart Conference Rooms

ThunderSoft helped an enterprise construct a smart conference room system based on edge computing. The system includes large conference screens, conference room number plates, conference terminals, smoke detectors, smart gateways, smart curtains, smart light controls, temperature and humidity detectors, and other equipment. The system supports the connection of various IoT devices to a switch through gateways, unified management and data analysis at the edge, and smart conference room background services to realize advanced requirements such as automated speaker tracking and smart power controls.

The system also integrates device management and control hardware with AI data analysis technology, relying on IoT enablement to realize a remotely controlled smart building management platform. It realizes the comprehensive management of indoor environments, landscape lighting, indoor power management, air conditioning and freshening, along with management-oriented energy saving through the convenient management and control of various behavior modes.

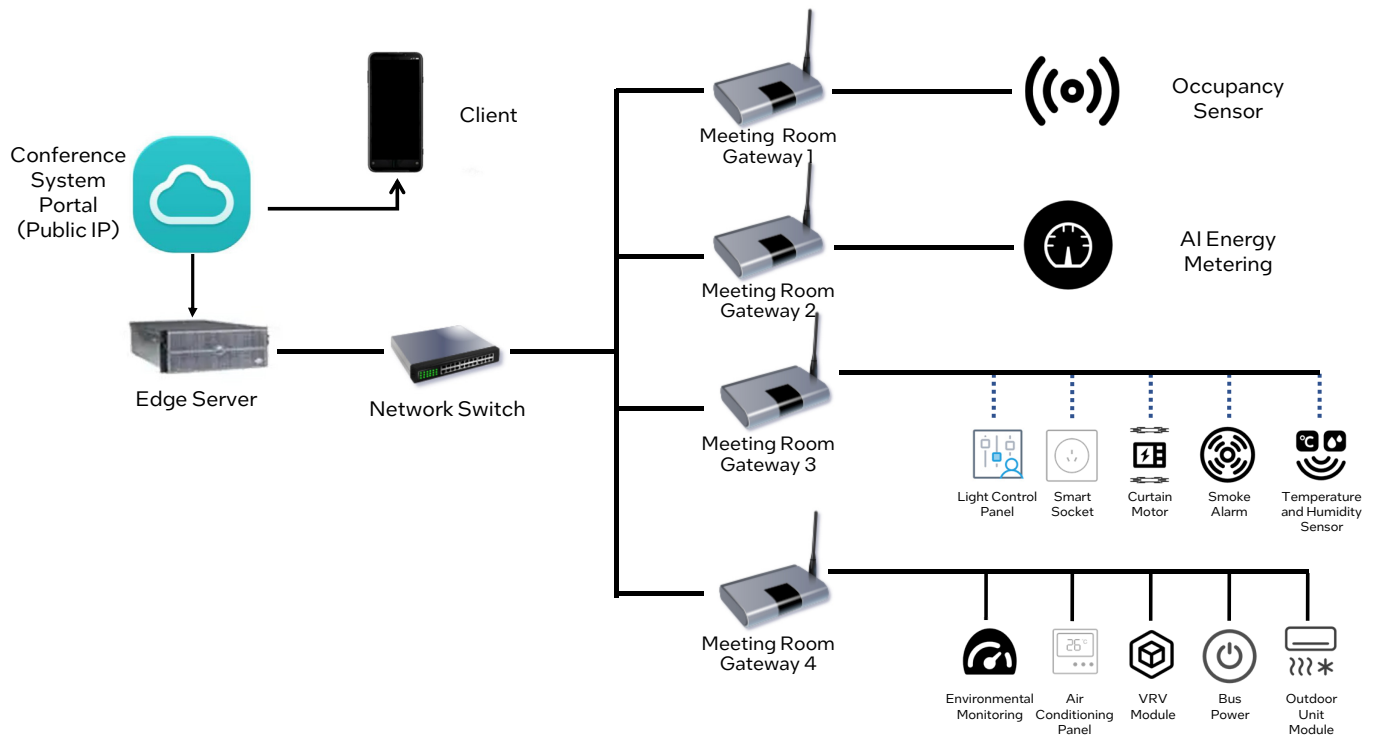


Figure 6. Smart conference room system based on edge computing

● Spatial Asset Management

In the post-pandemic era, hybrid workplaces are leading the new paradigm of corporate space usage. When enterprises consider office leasing and usage strategies, they focus on cost-effectiveness and the employee experience. Attracting employees back to the office and improving the efficiency of spatial utilization is key a corporate real estate (CRE) and office manager.

ThunderSoft's spatial occupancy monitoring functionality based on edge AI technology supports the monitoring of fixed rooms, workstations, and toilet seats along with the personnel count in open areas to further calculate the utilization efficiency of the entire office space. Based on this data, enterprises can more accurately organize management, cleaning, security, and other personnel; improve the service supply capacity of office space; and improve both spatial utilization and employee personalization through the office and workspace reservations, thereby improving the employee experience. Throughout this process, personnel will also gradually cultivate a habit of conserving and utilizing spatial resources in a more balanced manner.

The solution allows enterprises to better grasp the distribution and application of spatial assets while making intelligent and agile allocations in accordance with actual needs, thereby improving the utilization of spatial assets and delivering a more refined office experience.

From Smart Buildings to Smart Cities

Smart buildings serve as a key part of smart city ecosystems, and the services they provide (such as economic development and industrial agglomeration) are of great significance to the enhancement of smart city systems. Empowered by the enhancement of digital infrastructure and continuous innovation of services, smart building construction and operation enterprises are facilitating the development of more value-added service models, which will bring them greater direct economic benefits while helping enterprises in smart parks reduce costs and increase efficiency, enhancing the power of smart building transformation and sustainable operation.

Intel is working to develop broader smart city ecosystems by creating the necessary building blocks to realize smart buildings and even smart city planning. Through the innovative integration of infrastructure products, Intel helps customers realize the high-speed storage, transmission, and processing of data. Empowered by years of experience, Intel's product line has expanded to sectors such as AI and 5G, and launched comprehensive ecosystem solutions. Intel also provides users with a flexible product portfolio through hardware-software synergy to ensure that its products support a greater variety of workloads and realize the powerful performance necessary to deal with the challenges brought about by the increasingly diverse requirements of smart building and smart city applications.

About ThunderSoft

ThunderSoft, the global leader in intelligent operating system products and technologies, has continuously accumulated and innovated in the operating systems space since its inception in 2008, gradually expanding its business from intelligent terminals to AIoT, intelligent vehicles and intelligent industries. It was successfully listed in 2015, making it a China First listed technical company specializing in intelligent operating systems. To date, ThunderSoft's offices, subsidiaries and R&D centers have covered 40 cities around the world with a total of nearly 10,000 employees.

About Intel

Intel (NASDAQ: INTC) is an industry leader that focuses on developing technologies that change the world, drive global progress, and enrich human lives. Driven by Moore's Law, Intel is dedicated to the continuous innovation of semiconductor design and manufacturing to provide customers with solutions to major challenges. By integrating intelligence with the cloud, network, edge, and various computing devices, Intel unlocks the potential of data and helps improve both business and society. For more information on Intel innovation, refer to our China News Center at newsroom.intel.com and our official website at intel.com.



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