www.pipelinepub.com
Volume 21, Issue 9

Powering Smarter Operations in Buildings with IoT, Edge AI and Private Networks

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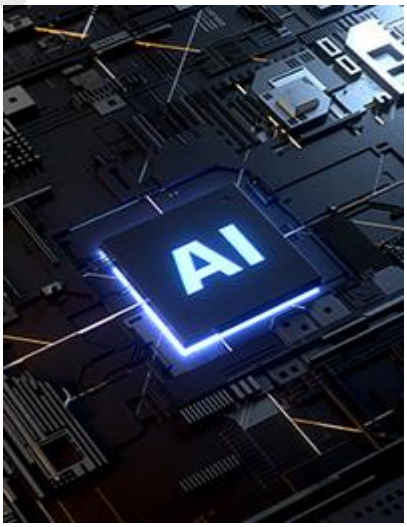

The work-from-home era during the pandemic revealed some interesting trends for businesses—most notably, the reality that maintaining buildings, campuses and facilities is expensive. These building-related expenses often rank among the top cost categories for organizations, which include anything from cleaning and repairs to staffing and security, as well as energy and lease payments. After the lockdowns, a handful of companies became fully remote, abandoning physical offices entirely to eliminate these expenses. However, most organizations do not have that same luxury and must find creative ways to reduce building-related expenses. Besides cutting costs, other challenges abound because of legacy systems and manual processes inside factories, warehouses, schools, office campuses and other facilities. These challenges range from energy waste and equipment downtimes to poor indoor air quality and rising security threats.

Recognizing these challenges, many building managers are looking to transform their facilities and places of work into smart buildings or structures with automated functions based on owner or manager specifications. At the heart of a smart building are technologies like the Internet of Things (IoT), edge artificial intelligence (AI) and private connectivity solutions. Smart infrastructure redefines how companies manage and optimize physical environments, boosting efficiency and providing cost savings. These technologies also allow organizations to digitize routine processes, automate critical systems and generate real-time insights that drive down operational costs while improving safety, comfort and resource use. This article will explore the three technologies driving the smart building revolution and some of the most notable use cases they enable.

The 3 Core Technologies of Smart Buildings: IoT, Edge AI and Private Networks

In a smart building, connected IoT sensors, devices and systems monitor and manage building operations, such as lighting, HVAC, security and energy usage. These IoT devices collect real-time data, enabling automation and more efficient decision-making. Users can automate and simplify time-consuming tasks using IoT-connected technologies; these tasks can get scheduled in advance, remotely adjusted or rescheduled, and monitored via related technologies. While IoT is certainly the most well-

known and prevalent technology within smart buildings, others work in conjunction with it, allowing managers to achieve even more impressive results.

Microcontroller-based edge AI, for example, is empowering smart buildings to get even smarter. Edge AI refers to the shift of AI to devices (like sensors and IoT systems) at the network's edge. Moving AI to the edge enables local data processing; for example, a facial recognition camera using AI and machine learning algorithms at the edge will perform data compilation locally on the device rather than in a remote server. Other examples of edge AI include sensor analysis, sensor fusion and event detection via audio. Analyzing data closer to its source eliminates the need to send large amounts of data to a cloud server. As a result, edge AI enables local decisions and faster responses while consuming significantly less power and requiring less runtime than a traditional microcontroller. Moreover, innovative building applications that use edge AI can still react to environmental changes even if communications are down.

The other noteworthy technology trend supporting smart building use cases is private networks—more specifically, 5G standardization, which allows companies to deploy dedicated cellular resources. A private network is a dedicated, wireless network separate from the wide-area macro network. This separation from public infrastructure enables greater data security and control, which is especially helpful for large smart buildings or campuses that must manage hundreds or thousands of IoT devices. Private networks offer greater resilience and flexibility, including higher bandwidth connectivity and data throughput, than public networks or infrastructure. Likewise, private networks are customizable, meaning building managers can tailor them to meet specific latency, coverage and reliability requirements.

Improving Energy and Resource Conservation

IoT, edge AI and private networks are crucial in helping businesses use energy and other resources more efficiently. For example, heating and cooling are responsible for a substantial proportion of total building energy consumption, thus accounting significantly toward annual electricity bills. Managers can optimize HVAC to reduce their electric bill by using IoT sensors and thermostats connected to a private network and supported by edge AI for rapid, automated decision-making. For example, IoT sensors working with edge AI can automatically adjust heating, cooling, and ventilation based on actual demand rather than fixed schedules, such as changing temperatures in unoccupied zones or pre-cooling areas during off-peak hours when electricity rates are lower. Similarly, IoT and edge AI-powered occupancy management systems caneven detect when a building is unoccupied and shut it down to save power, like turning off a computer. Additionally, analytics platforms will help managers identify electricity usage trends for more precise corrections to achieve lower utility bills and more sustainable building operations.

Commercial buildings in the US also waste a significant amount of water annually. The US Energy Information Administration famously estimated that large commercial buildings (over 200,000 square feet) use 359 billion gallons of water in a year. In smart buildings, operators connect sanitation devices with IoT sensors to monitor usage and create reports that help conserve water. Connected edge-AI meters can notify building managers of unusual patterns, allowing them to catch and stop water leaks and other plumbing issues from spiraling out of control.

Water systems (as well as lighting and HVAC systems) within smart buildings will likewise use IoT, edge AI and private networks to support predictive maintenance. Specifically, IoT sensors monitor the condition and performance of equipment in real-time, collecting data on factors like vibration, temperature and usage patterns. Edge AI analyzes this data locally to detect anomalies or early signs of wear, like clogged filters or malfunctioning components, allowing the system to predict potential failures before they occur. Private networks provide secure, high-speed connectivity to ensure the data

gets transmitted and processed reliably. This combination results in a smarter, more proactive, environmentally conscious maintenance strategy that reduces downtime, minimizes expensive replacements and extends equipment lifespan.

Enhancing Occupant Experience, Productivity and Safety

Another powerful benefit of smart buildings that use IoT devices, edge AI and private networks is that they can enhance the occupant experience, which boosts productivity. These technologies work together to tailor indoor environment parameters in real-time to influence occupant comfortability and satisfaction. Although it might not seem like much to tweak temperature or increase light availability, research shows that these things can negatively or positively influence employee productivity. Of the various environmental parameters smart buildings can detect and adjust, such as humidity, air speed or air movement, availability of light, presence of CO2, etc., temperature is one of the most essential physical indoor environment parameters concerning the impact on productivity in workplaces.

IoT devices and sensors installed throughout the building continuously gather data from environmental conditions, like lighting, temperature, air quality and room occupancy levels. This data then gets processed locally by edge AI, which avoids cloud latency and enables immediate modifications that improve comfort for occupants. For instance, these technologies can automatically adjust heating and lighting when people enter a meeting room, saving energy while swaying productivity. AI-powered occupancy management technology can also perform face and object detection and image classification at the edge to determine the presence of occupants in real-time. As discussed earlier, private networks ensure secure, reliable and low-latency communication between devices to support a more adaptive and user-centric building environment.

More critical to occupant experience and productivity is security. IoT air quality sensors and edge AI tools in smart buildings can detect rising carbon monoxide levels and the presence of volatile organic compounds, helping improve air quality and minimize the spread of pathogens, ultimately safeguarding occupant well-being. In addition to the health of occupants, companies can enhance physical security through connected IoT security systems that leverage cameras, movement detectors, digital identification devices, access management stations, touchless visitor access control, etc. Edge AI further augments security systems by enabling rapid, local data processing that filters out irrelevant noise and focuses only on meaningful threats. Cybersecurity is another focus for smart buildings—more connected systems and devices create an expanded attack surface, leaving smart buildings vulnerable to cyberattacks. Thankfully, private networks can help businesses protect their systems and devices from bad actors.

Smart Buildings: A Meaningful Investment

Organizations across all sectors, from universities to corporate offices, are under pressure to maintain operational efficiency without increasing costs. With its inflation, labor shortages, and sustainability regulations, today's post-pandemic economy makes this pressure especially strong. Smart buildings, driven by IoT, edge AI and private networks, are emerging as a valuable means of addressing these challenges. Such infrastructure will only continue to gain popularity now that it is no longer limited to new construction or deep-pocketed enterprises. Retrofitting existing environments with advanced technology solutions is now a fast, cost-effective way to gain control over and futureproof previously inefficient systems.