WHITE PAPER

Data Center

March 2020

IT@Intel: Smart Buildings at Scale

Intel IT and Intel Corporate Services Group partnered to create a user-centric, enterprise approach to smart building design as a repeatable model that integrates many Intel products, including IoT and security technologies

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Executive Summary

For decades, enterprises have included smart technologies in their buildings to gain operational efficiencies, save maintenance costs, and make their offices more user-friendly. While these companies may have experienced incremental gains from taking individual measures like installing smart temperature controls, the main value of these systems comes from integrating them into a single platform. But lack of standardization means that disparate technologies from multiple vendors may not be compatible, and integrating multiple smart technologies into a single connected building can introduce many logistical and operational complications.

Intel IT and Intel Corporate Services joined forces to create a new design and development center in Petach Tikva, Israel. Taking an enterprise approach, we focused on user experience (UX) before selecting technology solutions. We used a design-build-operate vendor to manage the project from design to delivery and operation, integrating disparate smart building systems and acting as a single source for vendor contact. We created the approach and best practices for this smart building from the ground up. This blueprint is now an asset in and of itself, and Intel and the vendor are using it to replicate and build additional smart buildings (and even a smart village), in collaboration with other industry-leading companies. The model integrates a variety of Intel products, including Internet of Things (IoT) and security controls. It generates enormous volumes of data via 14,000 sensors, which we use for AI solutions and to enable smart operations, efficiency, and a positive user experience. The result is a user-centric building that helps us attract the best industry talent and improve Intel's workforce productivity.

Acronyms

AI	artificial intelligence
CapEx	capital expenses
OT	operational technology
POR	plan of record
SoS	System of Systems
UX	user experience

Business Challenge

In 2018, Intel had about 3,000 employees scattered in eight buildings across five campuses in Petach Tikva, Israel. Intel wanted to consolidate the operations and centralize these employees into a single design and development center. In designing the new building (called "PTK1" to reflect its location), Intel aimed to create an extremely operationally efficient structure with the most innovative, data-centric technologies. We also sought to create a positive and supportive office environment for the entire workforce and realized it is essential to maintain information security.

In the initial development stages, we knew we needed to invest in a cohesive digital experience as part of the building design. We took an enterprise approach to designing the building, selecting technologies that support the user experience instead of choosing technologies first. We used Agile methodologies, including design thinking— an Agile-based process that examines problems in human-centric ways to identify and meet the needs of end users—to define a priority list of use cases that dictated the technology selection. Specifically, we wanted to provide the tools and technologies Intel's workforce need to do their jobs well, increasing both job satisfaction and productivity, and we wanted to create a pleasant, convenient, and efficient environment so employees enjoy working in the building. The technologies we selected would also make it easy for users to collaborate and develop innovative ideas. And it was important for us to create a state-of-the-art workplace to attract the best talent, today and in the future.

Intel is a data-centric company, so it was imperative that this new building included sophisticated data collection and analysis capabilities. We wanted to include thousands of sensors that generate a variety of data that we can then use to create a superior workplace for Intel's workforce. We're using the data collected to develop new machine learning use cases to generate autonomous building management using artificial intelligence (AI).

While we had a clear vision of the building's capabilities, we had to overcome several hurdles to make PTK1 a reality. In a building of this size and technological scope, upfront capital expenses (CapEx) are high, and sustaining costs can be formidable. Also, because there are no clear smart building metrics or return-on-investment guidelines to measure employee experience improvements, any new efficiencies and direct cost savings were difficult to prove and might not have been sufficient to justify investment. If not managed correctly, the Internet of Things (IoT) licensing footprint can be enormous, and the technical overhead of managing multipliers can be daunting.

Further, because the smart building industry lacks standards, integrating multiple technologies would be challenging. Different programming languages and protocols for the different building management systems (BMS), multiple services and capabilities, multiple suppliers, and different security maturity levels all contribute to an almost impossibly complex environment. The IT infrastructure and security design had to meet the needs of both operational technology (OT) and IT. Availability and reliability were important aspects to keep the business running, while also integrating a complex mix of vendors whose level of information security standards varied widely. A close collaboration between OT and IT was required because equipment such as sensors and programmable logic controllers (PLCs) cannot be scanned or patched like traditional IT equipment (such as servers and PCs)—but they still run compute workloads and need to be secured against attack.

When we started PTK1 development, no single solution provider existed. There was no one entity capable of designing and building a complete end-to-end smart building, and no supplier could integrate all the smart building capabilities into the building construction processes and meet enterprise IT standards.

To meet all of these challenges, we had to take an enterprise approach. We studied the entire enterprise holistically to determine how the solutions would function together in PTK1 and meet our goals, instead of choosing vertical solutions for lighting, temperature control, and other functions.

PTK1 by the Numbers

- 2,700 ergonomic workstations
- 143 conference rooms
- 198 alternative work-spaces for individuals, two workers, or teams
- 14,000 sensors
- 1.6 million data strings per day
- 1,000 APIs
- >500 smart screens
- 1,900 KM of cabling
- Generates more than 50 TB of data per day

"We see each other; we can talk more openly and collaborate more effectively."

– Intel employee in PTK1

Solution

Historically, planning and constructing a smart building typically required installing individual smart solutions like smart lighting or centrally-controlled temperature controls. Managing these capabilities was disjointed and inefficient, and there was no way to collect comprehensive data from building sensors. Vendors provided solutions in silos, which were difficult to integrate and scale.

PTK1 changes all that. This smart building reflects Intel's IT/OT readiness for our data-centric future. We used our deep knowledge in smart operations to create PTK1, with the vision of using building-generated data and AI to create a smart space—one that can manage its own efficiency and operations and provide users with a seamless experience that connects the digital and physical spaces. The combination of IT and OT produced a building that will still be considered cutting-edge in five years.

Key to the building's success is the collaboration between Intel IT and Intel Corporate Services. Each came to the table with different goals and objectives for the new structure. Corporate Services focused on the systems and solutions needed to create the smartest building possible. Intel IT focused on standardizing the technologies and infrastructure architecture for enterprise integration, establishing security and privacy processes, and mapping out the maintenance and support model. They worked together to design, develop, and realize their joint vision.

In September 2019, we unveiled our new highly efficient development center in Petach Tikva. The 800,000 square-foot, 11-story building accommodates nearly 3,000 employees, bringing together workers who previously had been scattered in eight buildings across five campuses. Today, the building hosts 50 different groups charged with developing advanced computing, communication, AI, and cyber technologies.

Because there are no benchmarks, no standardization, and many disparate solutions in a rapidly-evolving marketplace, we found it challenging to select smart solutions for the new building. We began by considering the building's value and its end users before considering any smart technologies. We wanted to build a data architecture that could generate, manage, and use data to create a building capable of running as autonomously as possible—while at the same time addressing the privacy concerns, IoT security threats, and IT security threats created from those integrations.

By taking a holistic enterprise approach to the building's design and implementation, we were able to integrate a wide variety of smart capabilities, and then scale the model to multiple buildings. We integrated tenant systems with the building systems, such as:

- Smart parking uses cameras and sensors to determine garage occupancy and shows available spaces to drivers. For those who opt in (see the Privacy by Design sidebar), the system can also identify the car's location at the end of the day.
- Smart lockers can be monitored using an app and can be shared with other users.
- Service request tools available on multiple interfaces let building maintenance personnel more efficiently handle repairs.
- Smart lighting with daylight harvesting and color tuning improves employee well-being and energy efficiency.
- Digital touch signs throughout the building help with way-finding, dining options, commute information, and more.

Privacy by Design

Intel is committed to protecting employee privacy.

Dramatic, fast-paced developments in digital technology present unprecedented challenges for companies applying privacy law, regulation, and commonly accepted guidelines. We believe privacy is fundamental to creating a space where an individual can learn, create, innovate, and enjoy their life, and Intel's longstanding commitment to protecting privacy is at the core of the company's values.

In any endeavor, Intel uses "privacy by design" principles to adhere to its global privacy regulations. For example, PTK1 is not only compliant with Israel's local privacy laws, but it is also compliant with international privacy law and regulations, such as the European Union's General Data Protection Regulation (GDPR), to accommodate visitors to PTK1 from around the world.

We use creative approaches to deliver transparency and notice, enhanced security, and accountability. For example, tailored, contextual notices help employees make appropriate decisions about the collection and use of their data. For example, in our PTK1 smart building, employees have the option to "opt in" or "opt out" and select smart features.

"There is real trust between the company and employees that the data (collected) is used for the right purposes."

– Intel employee in PTK1

Improving User Experience with Design Thinking

PTK1's smart building design approach was simple and unique: We designed the building from a user perspective, with Intel's workforce in mind. Our users' needs determined our choice of technologies, so we didn't select solutions and then later see how they worked out.

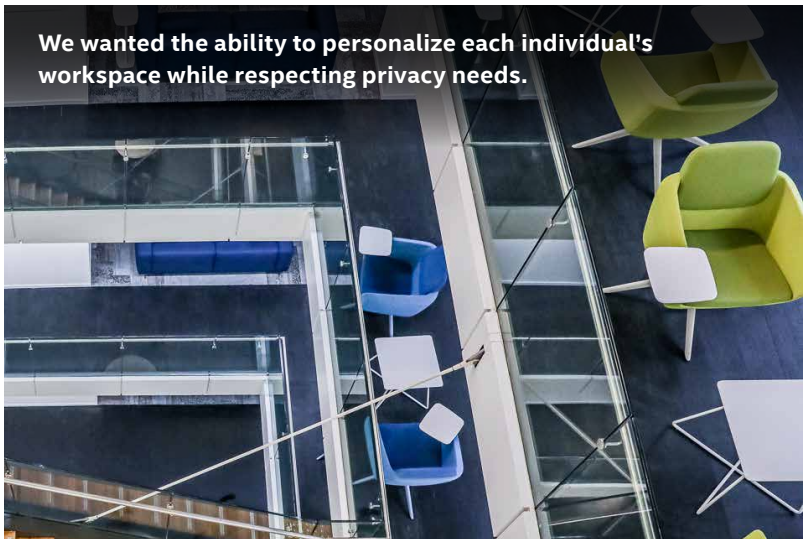
Our overarching goal was to create an engaging, sustainable environment where people like to work so we can attract and retain the best talent in the industry. We wanted the ability to personalize each individual's workspace while respecting privacy needs. We also wanted to create a building with services and capabilities of value to Intel's employees. In addition, we wanted a user experience (UX) that could be packaged and replicated across Intel's campuses.

Intel Corporate Services employed design thinking methodologies to develop a solid understanding of users, challenge assumptions, redefine problems, and create innovative solutions that best meet the needs of our employees. Intel Corporate Services began the iterative process by holding workshops with approximately 250 Intel employees, plan of record (POR) teams, and our smart building vendor's technology leads. We mapped out the day-to-day activities in a typical office setting, developed groups of personas that would interact with the smart environment in various job roles, and created user journeys that reflect employees' activities within the building—from home to work and back again. We used a third-party methodology to assess and capture the common UX, **ultimately defining a total of nine user journeys and prioritizing more than 300 possible use cases for various scenarios** of relevant personas in the smart campus.

The collaboration between Intel Corporate Services and Intel IT was key to the building's effectiveness. Using the findings of the user experience workshops, Intel IT identified and implemented the best technologies to meet use case requirements. Intel IT focused primarily on IT infrastructure, information security, privacy considerations, and standardization across the use cases. Of the 300 use cases, we incorporated only 180 in the current building design. Some did not meet our technical maturity, information security, and privacy requirements, and we will consider others as needs evolve and budgets grow.

Rethinking the IT Architecture

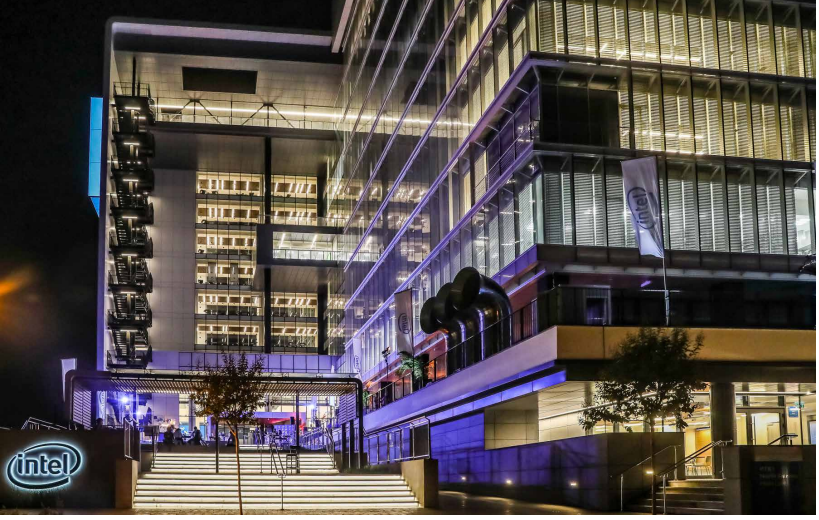
In the quickly evolving IoT segment, security standards do not exist, and there is an enormous number of solutions on the market. While implementing so many IoT solutions in PTK1, we had to ensure that all the solutions, in their varying stages of maturity, were able to communicate with one another using a common standardized IT infrastructure. We also had to guard against security issues and protect Intel from attacks that these technologies could bring into the enterprise. The breadth and depth of PTK1's use cases demanded a new, unique IT architecture.



Smart Building in Action

Technology solutions and smart capabilities for PTK1 focus on one or more of the nine user journeys we identified through our design thinking process:

- **Getting to and from work.** Traffic and public transportation issues that complicate employees' trips to and from work. PTK1's carpool platform interfaces with traffic applications and provides users (via their phones) with the best routes to and from work. At the workday's end, displays throughout the building show traffic conditions for major routes and give recommendations for an efficient commute.
- **Quick parking.** Employees might spend a half-hour searching for a parking space, and they might have trouble locating their car when it's time to leave. At PTK1, employees can see available parking spaces via a smartphone app, and because the parking system recognizes license plates, employees' cars are recognized as they enter the garage. Employees can request a reminder that shows where their car is parked.
- **Food and dining.** Long lines and crowded conditions in the cafeteria waste time and cause frustration. PTK1 was fitted with occupancy sensors that provide data on the cafeteria's seating and cooking areas. Available through a smartphone app—and shown on displays throughout the building from 11:45 a.m. to 2:00 p.m. daily—the data provides the status of menu options and helps employees determine the best time to go to lunch.
- **Conference rooms and collaboration.** Occupancy flags let employees immediately identify available rooms along the corridor, while digital touch screens help with in-floor navigation and finding where a fellow collaborator is located.



Our IT architecture decisions and selections focused on standardization to lower cost while mitigating information security and privacy concerns. The greater the number of devices in use, the higher the vulnerability. PTK1 uses more than 14,000 sensors that generate more than 50 terabytes of data per day. In the future, we will use AI to adjust systems based on different parameters. With so many devices in use, the building could be vulnerable to attack without the right IT architecture.

At the heart of our smart building solution architecture is our System of Systems (SoS), which includes the following:

- **Integration broker,** which consolidates various systems with APIs.
- **Data console,** where all the data is stored and processed.
- **Interfaces,** which include dashboards that provide a single pane of glass to manage all systems, along with applications, digital signage, wayfinding, and so on.

The SoS facilitates experiences and capabilities that could not be achieved by the individual sub-systems working in silos. The SoS provides a common IoT platform that uses IoT gateways to connect all the various systems (see Figure 1). We created a network segmentation model to increase the flexibility and to support different technology needs while focusing on Intel policy and security measures. They are as follows:

- IoT with a **security-compliant environment** through an IoT gateway to the building's SoS
- IoT with a **non-security-compliant environment** through an IoT gateway to the building's SoS
- **Vendor environment through an IoT gateway** to vendor-cloud backend services
- **Vendor environment directly connected** to vendor-cloud backend services

The common IoT framework has many benefits, including standardized hardware, infrastructure, protocols, APIs, and patching; and it has standardized business processes, support, financials, and security policies. The common platform can be reused for many IoT use cases, avoiding solution silos. With a common platform, new sensors can be evaluated and integrated into the architecture with incremental effort. The platform also uses edge and cloud analytics, discourages data silos, and controls costs through central management.

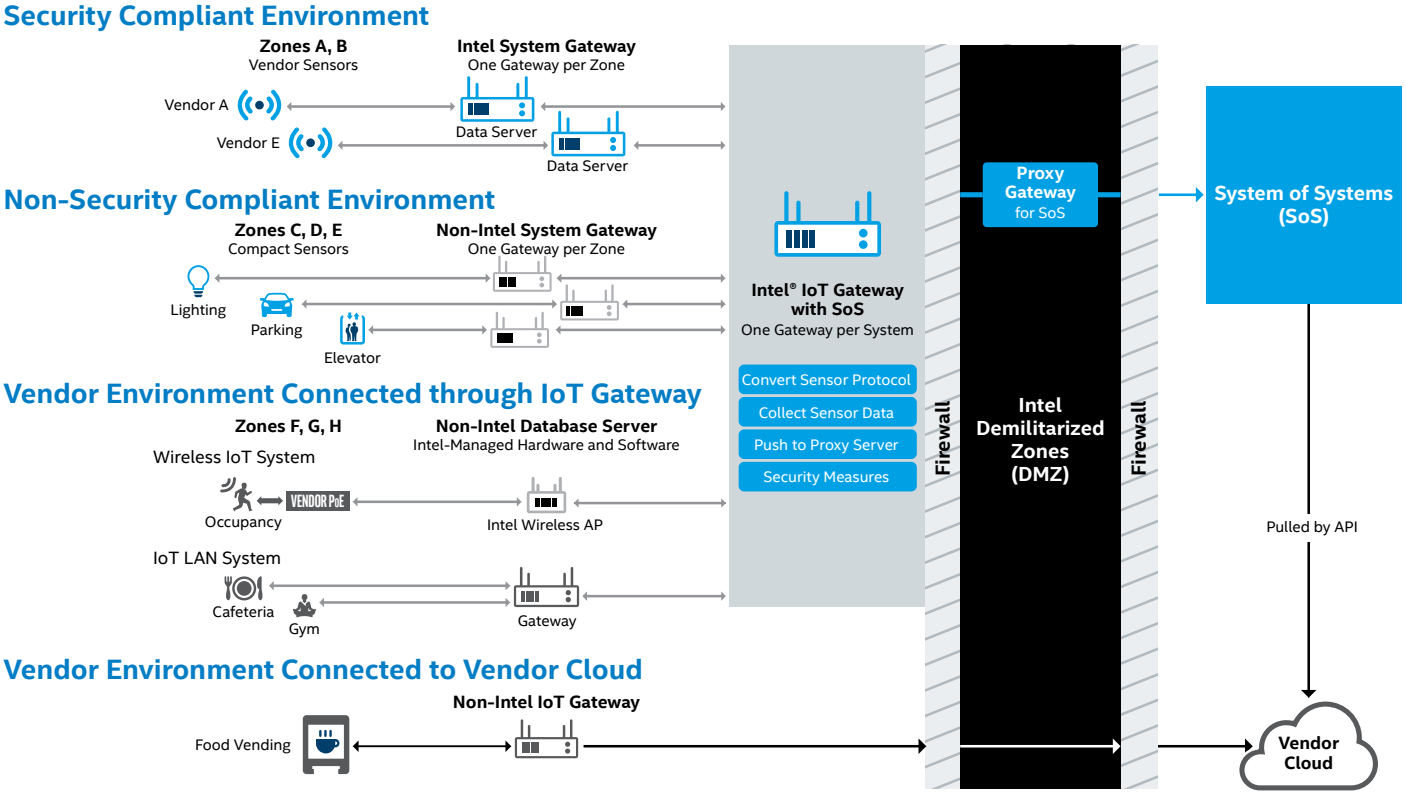


Figure 1. Our smart building network uses DMZs to connect IoT systems to our SoS and the vendor's cloud services.

Enhancing Information Security

Information security is always a top priority in any data collection and system integration, especially when working with multiple vendors (some of whom have minimum security maturity).

We balanced the need for information security with the availability and reliability of the smart systems we brought into the environment. Our objective was to design smart buildings that will evolve with the market and provide more flexibility in vendor selection.

To secure the edge, integration and traffic are enabled only by an IoT gateway, which helps maintain data quality. An IoT field gateway is deployed at the edge—at the point of need and close to sensors. It provides connectivity for plug-and-play sensors, edge analytics, and edge security. Provisioned wirelessly or wired over a dedicated IoT network, the IoT field gateway has a common gateway SKU that is configured for specific use cases. It is centrally managed in IT. We used the following techniques to provide security compliance throughout the IoT platform:

- **Zones.** Our zones are isolated and segmented without external facing services. The isolation zones create layers of security and serve to protect Intel systems from IoT/OT systems that have a low level of security (such as no hardening capability or a default password), and they protect one system from the other. The zones also help simplify the solution for scaling up for future replacement of any vendor or zone.
- **Segmented data.** Not all data is created equal—some is more sensitive than others. Therefore, we defined various levels for the different types of data flowing through our network (see Table 1). Depending on the data's sensitivity level, it is subject to different security controls. For information security data, we defined four use case groupings: public (outside the building), public (inside the building), Intel (inside the building–public), and Intel (inside the building–individual).
- **Segmented use cases.** We divided use cases into three categories: Intel employees with managed devices, Intel employees with unmanaged devices, and non-Intel employees with unmanaged devices. For example, accessing meeting-room preset settings or sharing locations are "managed" services, ordering food or accessing gym services are managed + unmanaged (with awareness), and accessing the restaurant menu or a smart locker are managed or unmanaged.

Table 1. Data Security Levels

PRIVACY	
Intel Confidential	All use cases involving personal data of a user
Intel Top Secret	Facility access control
N/A	All use cases where no personal data of a user is involved
INFORMATION SECURITY	
Intel Confidential	All use cases related to PTK1 users, building systems, and facilities
Public	Use cases like campus services, commute and ride share, and gym training
N/A	All use cases where no personal data of an employee is involved

By implementing these techniques along with security controls (identify, protect, detect, and respond), we can integrate the four network environments shown earlier in Figure 1 and provide a unified UX for all users and personas (administrator, manager, and consumer—employee or guest), regardless of whether they are an Intel employee, using a managed device or unmanaged device, or on or off campus (see Figure 2).

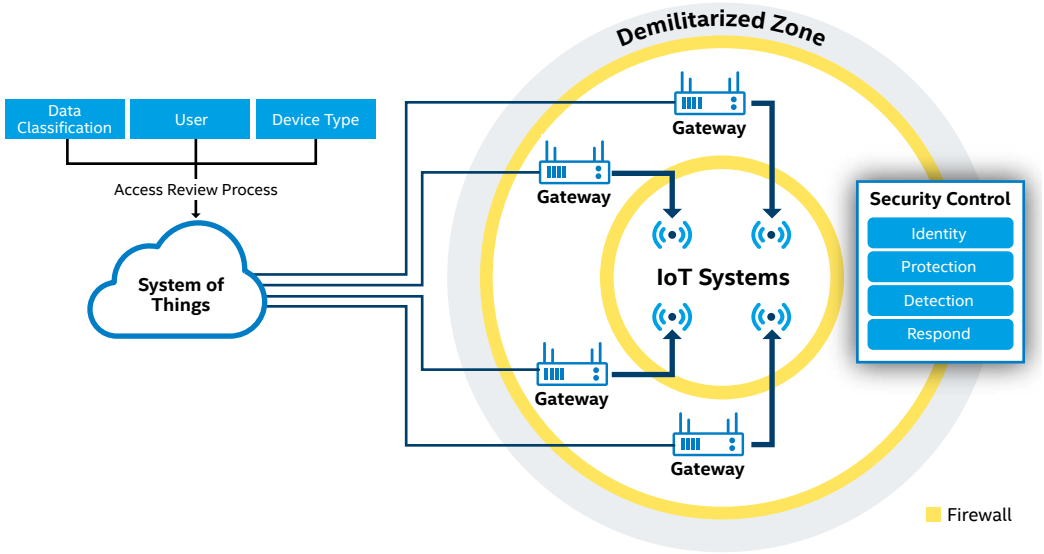


Figure 2. Our network topology and security controls provide a unified user experience (UX) for all users.

A Scalable Model for Smart Buildings

Until now, there has not been a single smart-building vendor capable of handling the design, planning, smart system commissioning, integration, data processing, and UX interfaces.

In PTK1, we created a smart building model that can scale to many buildings. Intel IT built on the lessons learned in two previous smart office building projects (Bangalore, India, completed in 2017 and 2018). From those successful buildings, we developed a clear reference architecture for PTK1, with standard gateways, network, information security governance, and operations. In addition, we took a unique, user-centric approach to smart solution selection, fine-tuned the technology selection process, and enhanced vendor qualification requirements.

Intel Corporate Services and Intel IT identified and worked with a design-build firm that became a single supplier of design and building services. It also handles the selection and integration of all hardware, networking, and other components, including software. The design-build firm also simultaneously handles all the other construction endpoints, creating a cohesive plan so that all the technology and physical building processes align to deliver the building. Intel chooses suppliers and solutions through a very rigorous evaluation and qualification process (see the Vendor Qualification Process sidebar). To accommodate new products and suppliers, the building model allows for IoT capabilities to be easily replaced with very low impact.

The smart building blueprint we developed is now an asset that we can use to build additional smart buildings that will further improve cost efficiency, productivity, and the UX across Intel's global presence. These future projects will cost less to build than PTK1 due to the following factors:

- Knowledge gained during the PTK1 project
- Processes and architecture that can be replicated in other buildings
- Platform and application code that does not need to be re-developed

We estimate our next smart building cost could be delivered at 25 percent less than the original PTK1 building expense (excluding the infrastructure and hardware). And if locally produced or less-expensive solutions are available, they can be used for additional cost savings.

Intel® IoT Market Ready Solutions

End-to-end IoT solutions that are ready for market deployment.

Intel works closely with key players across the IoT ecosystem to deliver proven reference designs called Intel® Market Ready Solutions (Intel® MRS). These are scalable, repeatable, end-to-end solutions that are currently available in the market. These solutions are made up of sensors, edge hardware, software, cloud technologies, and analytics from across the IoT ecosystem and delivered through one provider. Through the Intel® IoT MRS program, Intel is verifying that these solutions deliver innovative business transformation through actionable insights.

To qualify as an Intel IoT MRS, a solution must include all edge-to-cloud components, demonstrate clear and measurable business value, be commercially deployed, and be fully supported.

When choosing technologies for our smart building, named PTK1, we selected solutions based on their business value and contribution to the user experience—we did not select a solution because it is an Intel MRS. However, PTK1 does use several Intel MRS, such as for the System of Systems (SoS), lighting control (down to individual fixtures, to conserve engergy), and visual communication.

Results

We realized various operational, financial, and UX benefits with the smart building model we used to develop and build PTK1. Benefits of this building model include:

- Streamlined vendor contact
- Reduced CapEx through a single integration platform
- Single integration point with all the data of all future buildings, stored in one central data lake
- Consolidated cloud licensing through a single supplier with a design-build approach
- Better economics through off-the-shelf solutions compared to developing custom solutions

Next Steps

The vendor's solution has become an industry best practice for smart buildings and is being explored by other companies in the building and real-estate industry. Intel is constantly improving the security and efficiency of the building model. Once we identify sufficiently mature technologies, we will implement them, where relevant, into our smart buildings. As we expand and design more smart buildings, we will continue to add services and value to our standardized smart building blueprint.

Conclusion

Smart buildings create smarter enterprises. However, adding siloed smart features to new or existing buildings will likely result in only incremental efficiency improvements. For us, taking an enterprise approach and considering how technologies work together to create real value for Intel employees allowed us to realize a full spectrum of smart building benefits. The collaboration between Intel Corporate Services and Intel IT was instrumental to PTK1's success. We designed our PTK1 smart building from a user perspective by first addressing how smart features would help Intel's workforce work better, smarter, and more comfortably, instead of merely including smart technologies.

Intel Corporate Services used design thinking methodologies, holding workshops with employees, planning teams, and technology teams to truly understand the building and users' needs. We then determined typical activities, developed persona groups that would interact with the smart environment, mapped user journeys, and built use cases for various scenarios. Finally, we worked with a design-build firm to create a scalable smart building model that uses building data for autonomous building management and relies on Intel® technology to power its widely varying solutions. The model can be repeated for Intel's additional smart building projects anywhere in the world and includes IoT technologies that can be updated as needed. PTK1 stands as a forward-thinking building that is ready for the future.

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Vendor Qualification Process

Vendors must go through a rigorous, multi-step process before their solutions can qualify for inclusion in the smart building model.

1. Vendors must complete a relevant security questionnaire.
2. We ensure that each solution can integrate into our IT Infrastructure standard framework.
3. We confirm that Intel retains the right to own and protect the data generated by the smart building.
4. Vendors then meet with the smart solution provider's risk management team, which clarifies the system topology, application security, data flow, and integration security controls.
5. Finally, we use the security risk assessment results to build security controls and perform risk mitigation to address any security gaps.

IT@Intel

We connect IT professionals with their IT peers inside Intel. Our IT department solves some of today's most demanding and complex technology issues, and we want to share these lessons directly with our fellow IT professionals in an open peer-to-peer forum.

Our goal is simple: Improve efficiency throughout the organization and enhance the business value of IT investments.

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