CASE STUDY

Smart Buildings
Intel® IoT Gateway Technology
Intel® IoT Platform
Intelligent Systems

Smart Buildings Get Smarter at Intel

In Intel's latest smart office building, Internet of Things (IoT) technologies pair with innovative software solutions to deliver new business value

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Executive Summary

In 2018, Intel opened its second smart office building, SRR4, in Bangalore, India. From the start, SRR4 was designed to utilize smart technology to drive tangible business value. This case study explores Intel's evolution in adopting smart office building technology and the growing role that IT management practices relating to networking, security, and manageability play in implementing a smart building strategy. It describes how Intel project teams have developed new, more effective solutions to familiar building management challenges and presents three use cases—space utilization, employee comfort and productivity, and operational efficiency—that were addressed through IT/OT (operations technology) convergence in SRR4.

Smart buildings: a key investment in building Intel's integrated enterprise

Advances in Internet of Things (IoT) technology are creating new revenue and cost-savings opportunities for smart building owners and operators. Market analysis predicts that by 2025, there will be $70 to $150 billion of value creation within offices due to IoT.[1] Much of that value will come from reductions in maintenance costs and energy consumption, but more effective space utilization tools that drive capital expenditure (CapEx) savings will contribute as well.

In addition, businesses are increasingly recognizing the link between the working environment and human capital. A positive employee experience can impact talent recruitment, performance, and retention. User-centric updates that support employee comfort—to lighting and climate control, for example—can deliver a measurable impact on employee productivity.[2]

Realizing IoT's potential in building management requires merging elements of connectivity, big data, machine learning, and mobile applications with traditional building hardware, and effectively connecting this infrastructure together in a reliable, secure, and extensible manner.[3] Intel has been leading the way in this transformation, having implemented its first smart office building—known as SRR3—in Bangalore, India, in 2016.

In planning for its second Bangalore-based smart office building, SRR4 (opened in 2018), Intel drew on lessons learned from the earlier implementation to create more streamlined and secure building systems that talk to the Cloud and exhaustively analyze building data. Built on a network of 9,000 sensors as well as input gathered directly from the building's occupants, these systems are uncovering new insights that are driving business value.

"Smart building technologies have started delivering tangible business benefits in energy reduction, asset optimization and tenant experience. The next few years will see the broad proliferation of these technologies"

-Srini Khandavilli
IOT/ Smart Building Program Director

Examples include:

- Eighty percent of desks in the new building are designated for mobile workers, leading to an estimated 20-30 percent improvement in space utilization enabled by occupancy sensors and an intuitive space-booking application (app) installed on employees' mobile phones.
- A comfort personalization solution, available as a mobile app, allows employees to adjust workspace temperature and lighting to fit their needs. Based on a widely used industry rule of thumb, Intel projects an increase in productivity of approximately 26 percent related to empowering employees with the new solution.[4]
- Prioritized fault detection and diagnostics (FDD) software, implemented at scale for the first time in the new building, identifies anomalies in equipment performance and prioritizes issues according to potential impact. This information integrates automatically into a work order management system, generating repair tickets as needed and ensuring that the highest priority issues are addressed first. Based on internal estimates, Intel is anticipating a 10 percent reduction in energy consumption because of this solution. The majority of the anticipated savings will come from recommissioning to get maximum designed performance output from building assets.

Underpinning it all in the new 10-story, 630,000 square foot building is a segmented network architecture that converges the IT and OT networks. This dedicated IoT network is managed by Intel IT, a significant departure—and advance—from the approach taken in SRR3, where multiple OT networks are managed by various OT vendors.

A "greenfield" smart building, Intel's SRR4 in Bangalore, India, was the first Intel building to:

- **offer** 80 percent mobile desks, enabled via an intuitive, mobile space-booking app
- **integrate** equipment issue detection with a work order management system, streamlining repairs and ensuring that repair tickets are tracked to completion
- **implement** prioritized fault detection and diagnostics software at scale for quick analysis and contextualization of anomalies, so that high priority issues are addressed first
- **configure** all IT and IoT devices on a converged network
- **host** a majority of the building data in the Cloud

Driving business value and operational efficiencies

In developing smart building solutions for SRR4, project teams were guided by strategic objectives to support workplace modernization efforts, not just improve operational efficiencies. To date, SRR4 has enabled 70 different use cases that reflect this focus. Three use cases—space utilization, employee comfort and productivity, and operational efficiency—have delivered significant returns to Intel since these solutions were implemented.

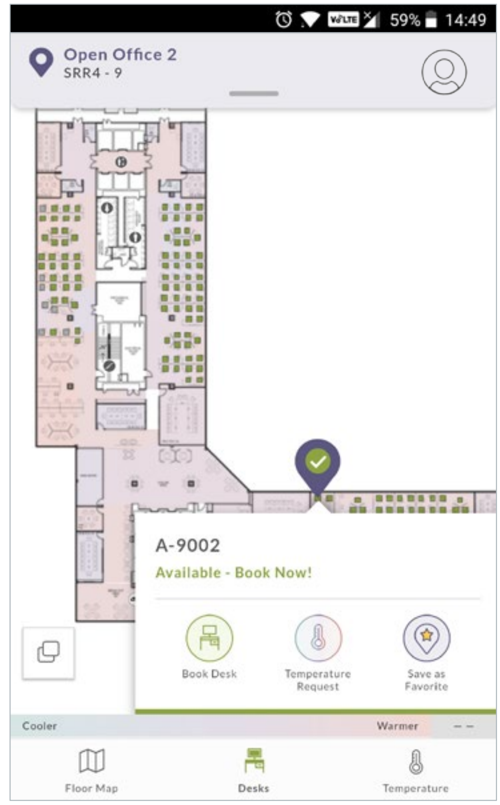

Figure 1. Space booking and comfort personalization app view

Space utilization
Mobile cubicle and conference room booking

The world of work is increasingly mobile. Half of global employees currently work remotely at least a few times a week.[5] Understanding and controlling utilization of space is essential to controlling costs and future planning.

SRR4 takes space optimization to a new level. In SRR3, 20 percent of desks were designated as mobile. In SRR4, fully 80 percent of desks are available for mobile workers. However, employees in some Intel buildings find it difficult to identify which cubicles are available for use. Intel's smart building solution allows employees to view and book desk and conference room space via an app installed on their mobile phones. The solution provides a view of available workspaces by combining data from the booking app with near real-time information about availability gathered from non-intrusive sensors that identify if a space is occupied.

These sensors are discreet, low-resolution optical sensors that are not discernible to the human eye and are capable of registering only human presence, without identifying features. Their selection resulted from an important lesson learned in the SRR3 implementation. Intel tried a similar approach to space utilization management in SRR3, using occupancy sensors installed in individual cubicles. Employees raised concerns about the sensors and the types of data that they were gathering. Ultimately, employee concerns led to the removal of 650 sensors in SRR3. The experience underscored the importance of taking tenants' comfort and privacy requirements into consideration when evaluating which devices and solutions to choose.

The mobile booking app used in SRR4 processes 2,000 bookings per day. It has led to an increase in space utilization of 20-30 percent, according to Intel internal estimates, creating an opportunity for CapEx avoidance of multiple millions of dollars.

Employee comfort and productivity
Personalized temperature and lighting capability via mobile app

In SRR3, employees had complaints about temperature variation in various parts of the building. To address these concerns, Intel implemented a machine learning algorithm to set a constant temperature across all building zones. However, because not every person is comfortable at the same temperature, the solution did not substantially address the issue or reduce comfort-related complaints from employees.

In SRR4, Intel is empowering employees with tools that allow them to define "comfortable" for themselves. Employees in the new building can personalize temperature and lighting in their zone via the same mobile app used for space booking.

> Jones Lang LaSalle* (JLL*), a leading building management consultancy, has defined the 3-30-300* rule to illustrate the average order of magnitude between a company's costs for utilities, rent, and payroll (all per square foot, per year). The rule states that, on average, a company pays $3 for utilities, $30 for rent, and $300 for payroll.[4]

While prioritizing employee comfort over energy savings may seem counterintuitive, the Intel team took into account Jones Lang LaSalle's* 3-30-300 rule and recognized that the boost to the bottom line from increasing productivity can be greater than that from reducing energy costs. Giving employees control over their own environment via the comfort personalization solution has improved employee satisfaction. By applying the 3-30-300 rule, Intel estimates that it is realizing a productivity increase of approximately 26 percent.[4]

In addition, by integrating elements of artificial intelligence (AI) with data provided by the personalization solution, Intel is able to correlate employee requests to potentially faulty building equipment, yielding energy savings of an additional seven percent. In this instance, humans essentially become "sensors," reporting temperature issues that are aggregated and mapped to possible equipment issues. Future efforts will involve integrating asset insights from the comfort management solution with the building's fault detection and diagnostics platform.

Operational efficiency
Fault detection and diagnostics (FDD) integrated with a work order management system

When SRR3 was first provisioned, each piece of equipment had a pre-set threshold to identify when it failed. When faulty equipment broke that threshold, an analytics solution automatically triggered an alert. The process was the same regardless of the type of equipment that was malfunctioning, how far out of range the fault lay, or the issue's level of importance to the organization. There was no means of differentiating based on the potential impact of the anomaly—a sensor alerting a two-degree temperature anomaly and a critically important chiller out of norm were weighted equally. As a result, response teams were often bombarded with alerts and could not easily prioritize where to direct their efforts.

In SRR4, a prioritized FDD solution, developed with machine learning to have a dynamic understanding of any anomaly identified, contextualizes problems and prioritizes alerts based on the severity of the issue. This information feeds into a work order management system that creates a ticket for facilities with priority level identified. The work order management system streamlines repair and maintenance functions and ensures that equipment issues are tracked to completion.

Priority	Summary	Type	Responsible	Updated	Status
Major	**Chiller Plant Staging Logic Review**	Optimization	BMS Contractor	3 days	To Be Raised MM
Critical	**CT-2 & Chiller-2 Fail to Start Alarms**	Maintenance	Mech. Contractor	11 days	To be quoted
Major	**VAV EDH's in Alarm**	Maintenance	Mech. Contractor	13 days	To Be Raised MM
Major	**High Tenant Cooling Tower Overnight Water Usage**	Maintenance	Mech. Contractor	a month	In Review
Critical	**Domestic Hot Water Gas Usage Increase**	Maintenance	Site Local	a month	To Be Raised MM
Major	**Boiler Plant in Fault or Alarm**	Maintenance	Mech. Contractor	a month	To be quoted
Critical	**Main Water Meter After-Hours Usage Increase**	Maintenance	Site Local	a month	In Review

Figure 2. Sample representation of a fault detection and diagnostics workflow

Tracked over long periods of time, this data can proactively identify maintenance requirements well ahead of equipment failure, which can reduce downtime and help manage repair costs.

Intel anticipates savings of 10 percent on energy spending related to integrating fault detection and diagnostics into an enterprise business process. In addition, Intel believes that improved visibility into building operations will help the company to optimize the headcount supporting building operations. Based on common industry benchmarks, such optimizations have yielded a significant reduction in operational expenditures.

These use cases demonstrate how Intel is translating lessons learned from the SRR3 implementation into measurable improvements in SRR4. They are just three examples of many.

Evolving from meeting specific IT requirements to creating blueprints and best practices collaboratively

The benefits realized in Intel's SRR4 are the result of thoughtful planning and coordination among a variety of stakeholder teams across the organization. The goals were not only to create best practices for SRR4, but to develop standards that would allow smart building technology to scale for all new buildings in the Intel portfolio. Strengthening cooperation among the teams and establishing Intel IoT standards were essential steps in the process.

In 2015 and 2016, when SRR3 was being planned and built, many of the available IoT technologies were still largely untested. For that reason, the SRR3 project team took a pragmatic, use case-specific approach to infrastructure planning, choosing products and methods that met the building's specific requirements. As a result, only select solutions implemented in SRR3 are readily transferable to other buildings.

Learning from the SRR3 experience, Intel Corporate Services, IT, and Information Security worked very closely together from the early phases of SRR4 implementation, consciously developing best practices along the way. Intel Corporate Services focused on technology evaluations of vendor products, use case definition, and vendor application integration, while IT and Information Security focused on the networking, security, and back-end infrastructure implementation.

Through their joint efforts, the teams devised a risk assessment strategy to evaluate prospective software vendors. The coordinated approach was key to mitigating the security risk associated with hosting data in the Cloud. It enabled Intel to shift more building functions to the Cloud in SRR4 than ever had been possible previously, helping to reduce required footprint and operational impacts.

By the time SRR4 came online, Intel's work toward standardization was delivering returns—simplifying the implementation process, reducing costs, and improving security. It played an essential role in the IT/IoT infrastructure plan created by the SRR4 project team, which now serves as a blueprint for future smart building implementations at Intel.

Building a shared IT infrastructure based on standards

Standardization was a key enabler of the move from separate IT and IoT infrastructures, as in SRR3, to a converged network architecture in SRR4—a first for smart buildings at Intel.

In the context of SRR4, converged IT and OT networks function as follows:

On the IT or "corporate" network, only Intel-managed devices (i.e., devices with software built by Intel loaded on them that meet minimum security requirements) can connect. The IT network relies on security controls implemented at the operating system (OS), system, application, and user levels. By contrast, the OT network is where devices without Intel-built software or those with unknown patching status reside. This is where most edge nodes provided by vendors connect.

In SRR4, Intel enables communication between different classes of devices on the OT network—for example, between the building management system (BMS) and the lighting server—through Virtual Routing and Forwarding (VRF), overlay technology that keeps traffic segmented and controls the traffic passing between different OT use cases on the OT network and to the IT network. At its core, VRF enables the virtual segmentation of the OT network and controls traffic between the different OT use cases via the implementation of firewall rules. It provides protection both on the OT network, for traffic passing between OT use cases, and for traffic passing to and from the OT and IT networks.

This approach differs significantly from that taken in SRR3, where the Intel® IoT gateways acted as a bridge between the IT network on their northbound interface and the OT network on their southbound interface. The way of designing BMS/IoT systems adopted in SRR3 devoted less attention to modulating network traffic than current strategies do.

Ultimately, the key difference between the SRR3 and SRR4 approaches is in who is managing the endpoints of devices on the OT network. In SRR3, OT devices were on entirely separate, isolated networks, not managed by Intel IT. In SRR4, while OT devices are segmented from the IT network, they are managed by Intel IT.

While, on the surface, the SRR3 approach—a proliferation of isolated networks—may seem more secure, Intel believes that the opposite is true. Converging IT and OT on a single network allows Intel IT standardized policies to be implemented across all devices, resulting in improved security overall.

> "We believe that a converged network, with segmentation for IT and OT operations, makes sense from a both a CapEx and OpEx point of view."
>
> **Robert Colby**
> Principal Engineer/IT Infrastructure, Intel

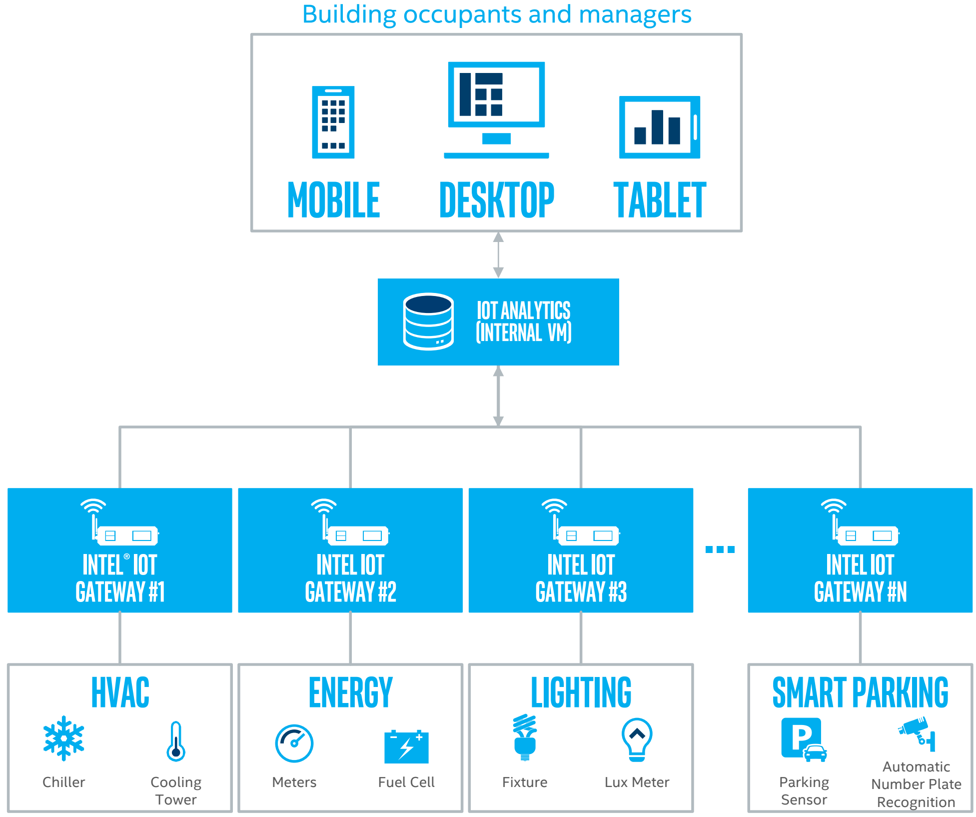

Figure 3: The network in Intel's SRR3 smart building in Bangalore, India, places OT devices on entirely separate, isolated networks that are not managed by Intel IT.

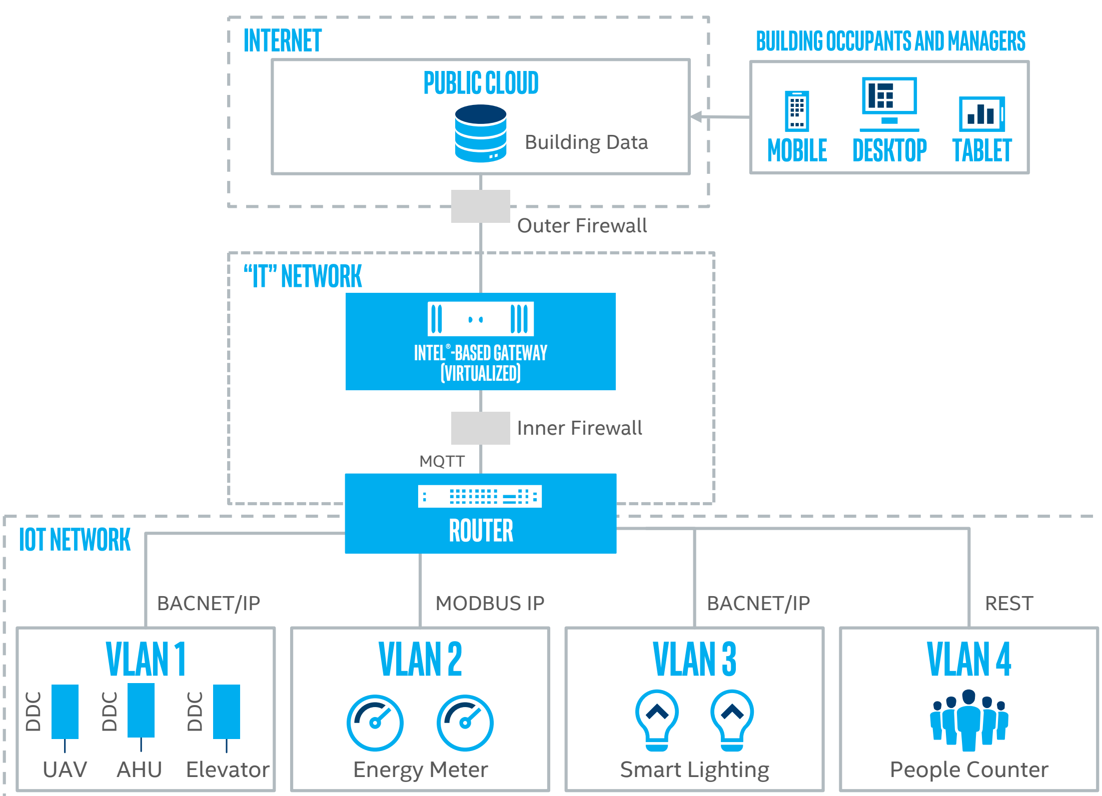

Figure 4. The SRR4 network is configured so that Intel IT standardized policies can be implemented across all devices, resulting in improved security overall.

Leveraging cloud-based solutions

Moving workloads to the public cloud is a strategy often employed to improve scalability as needs grow and change. It allows companies to manage costs effectively by purchasing only the services they need rather than building data center capacity that may not be fully utilized. For these reasons, the SRR4 project teams prioritized in their planning the shift of a significant percentage of smart building functions to the public cloud. Mindful of security risks, they worked together to identify the balance of compute between the IoT Edge and Cloud that would best meet their needs.

Understanding how to "right-size" or "balance" IoT Edge and Cloud is essential to successful smart building planning. Processing all information at the Edge is not feasible because of scalability constraints. Similarly, processing all information in the Cloud is not feasible because of latency and cost issues. An ideal scenario is where processing is optimized at the Edge when possible, the IoT gateway is leveraged to offer processing at the point of ingestion, and the ability to scale is addressed by capabilities offered in the Cloud.

SRR4 uses virtualized Intel IoT gateways to enable connectivity of various network components and to confirm that building equipment is transmitting data at appropriate intervals. The data gathered is analyzed for insights that can be used by the facility management team.

In SRR4 a virtualized, Intel®-based gateway replaces the field ("hard") gateways that were used in SRR3. This virtualized gateway enables connectivity of different communication protocols in the building such as "BACNET," "MODBUS," "HTTP," etc. It also enables scheduling of data fetches from building equipment, checking if building equipment is transmitting data, and determining if equipment is working between prescribed upper and lower control limits (UCL/LCL). A subset of the data that is captured by the virtualized gateway is pushed to the Cloud. The primary function of the Cloud is to run analytics on this historical data in order to provide valuable insights to the facility management team.

SRR4 is a leading example of how to optimize data across public cloud and local virtual machine infrastructure for the entire building management ecosystem. The migration and integration of IoT software that enables shifting energy, space, and occupancy management to the public cloud represents an evolutionary step forward in the overall IoT system architectural standard. It is a model that will be replicated for other buildings at Intel.

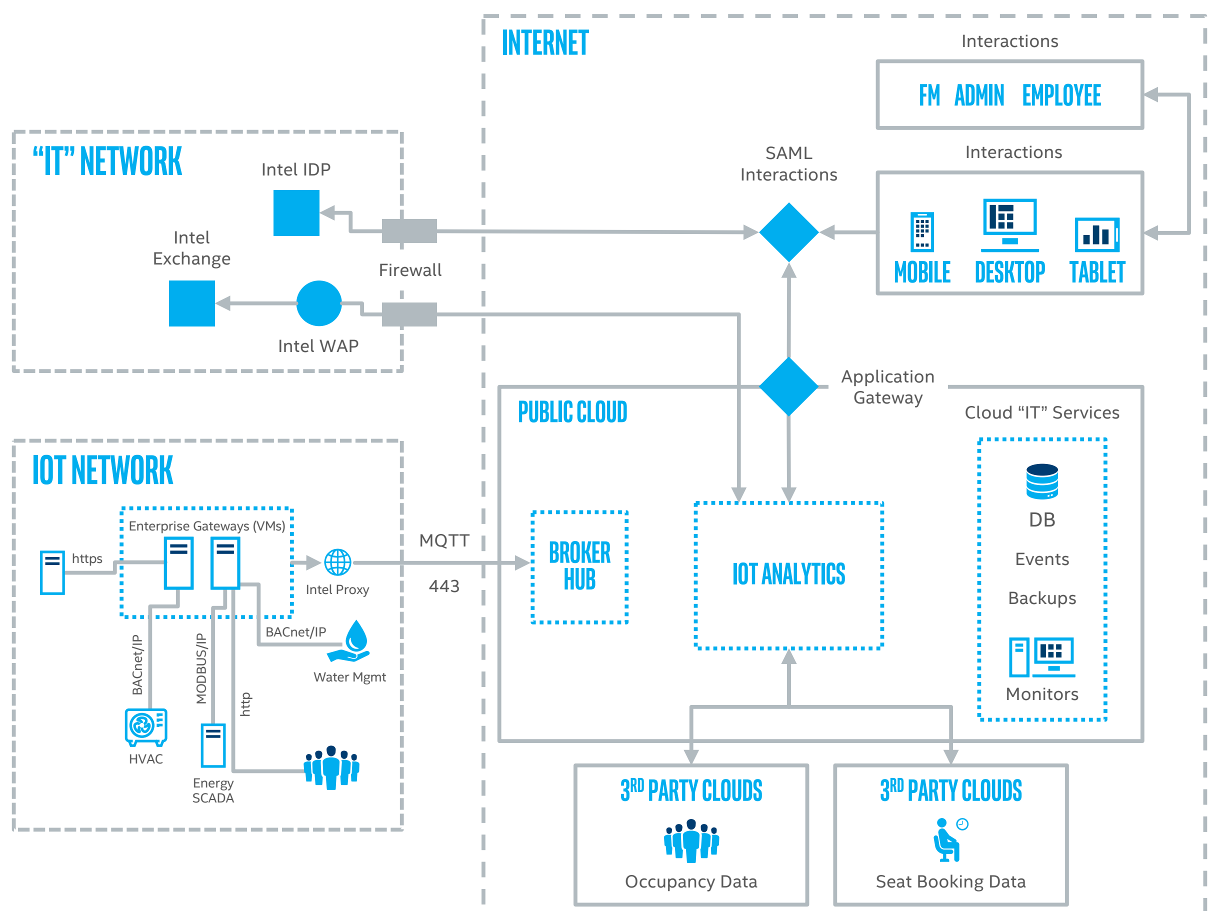

Figure 5. Intel's SRR4 uses public and private cloud capabilities to balance IoT Edge and Cloud workloads.

The movement to the public cloud is providing tangible benefits:

- It allows Intel to leverage the best-in-class capabilities of the public cloud. At SRR4, moving to the public cloud means that Intel can choose best-in-class software providers for different "vertical" or real estate-related capabilities while letting the public cloud fulfill all "horizontal" or more IT-centric capabilities.
- It dramatically increases the number of users who can access and interact with building data and systems. The majority of users in the SRR4 building do not have Intel-managed mobile phones. If the building data were to reside on an Intel intranet, these users could not access that content on their mobile phones. To ensure that only authorized users are able to access building data, the project team developed the authentication flow described briefly below:

  When a user request for access to building data is received, the request is redirected to the Intel Identity Provider server. The server assesses whether the user is valid and identifies the specific group to which the user belongs. Intel employs Security Assertion Markup Language (SAML)-based authentication that enables single sign-on, thereby alleviating the need for a user to enter credentials multiple times. The "role" information, or entitlements, are then passed back to the IoT Analytics subsystem, so that only the information that is pertinent to that user role can be viewed by the end user.
- Because the majority of smart building sensor providers are pushing their data to the cloud, it made sense for Intel to do the integration and analytics of the sensor data in the cloud, as opposed to bringing it back on premise for processing and then pushing it back to the cloud for storage and integration into dashboard reporting.

Looking ahead: what's next for smart buildings at Intel

Moving forward, Intel is continuing to invest in developing technologies that create tangible business results for building owners and managers. Among these is Intel® Secure Device Onboard (Intel® SDO), an emerging technology designed to simplify the process of provisioning devices securely on an IoT platform.

The SRR4 project team conducted a proof of concept using Intel SDO, setting up a reference architecture that enabled secure, touchless provisioning of field IoT gateway devices. Through extensive testing, they were able to show a 100x decrease in the time required to finish provisioning edge nodes—from three hours to three minutes—as compared to standard implementations.

The provisioning was accomplished in a secure manner, with no passwords being circulated among systems integrator personnel. Instead, all provisioning was done through a secure channel that pushed software artifacts directly from the Cloud to the gateway without any human intervention. Intel SDO enabled downloading of firmware, OS updates, and application configuration directly to the Intel IoT gateway.[6]

With its focus on Intel SDO, Intel is bringing zero-touch provisioning within reach, enabling faster build out of IoT solutions and minimizing the overall cost of smart building implementations.

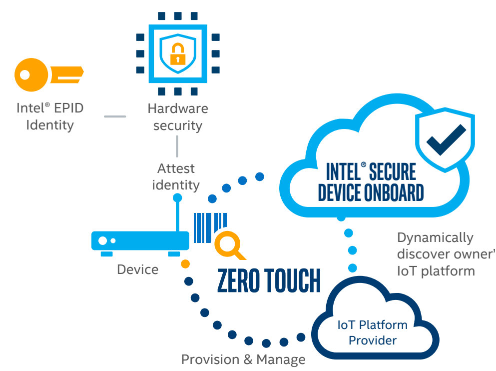

Figure 6. Intel® Secure Device Onboard quickly verifies the device and connects it to the owner's IoT platform provider of choice.

Conclusion

New IoT technologies combined with innovative, cloud-based software solutions offer building owners and operators new opportunities for smarter, more cost-effective and secure building management. In planning for its most recent smart office building, Intel developed an innovative IT/IoT infrastructure plan—with IT and OT converged on a segmented network architecture—that maximizes these opportunities and can serve as a blueprint for future implementations. The converged infrastructure is enabling new solutions, such as a mobile space-booking and comfort personalization app and prioritized FDD, that are delivering tangible business value while helping Intel meet strategic objectives.

For more information about smart building solutions from Intel, visit intel.com/iot/smartbuilding.

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