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Intelligent buildings: For smarter, healthier, more productive people

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By 2050, the U.N. expects two-thirds of the world's population to live in cities and the need for real-time data that helps new urban populations thrive will grow exponentially.

Half the opportunities for Internet of Things (IoT) vendors are expected to come from the built environment—homes, buildings, factories and cities, according to McKinsey.[1]

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Why buildings matter in the era of the Internet of Things

Arm expects more than a trillion devices to be connected to the internet by 2035 with many providing data insights that help the governance of the world's major population centers. Half the opportunities for Internet of Things (IoT) vendors are expected to come from the built environment—homes, buildings, factories and cities, according to research firm McKinsey.[1]

Buildings, our workplace and our home: Buildings are where people live, work, learn, meet, heal, entertain and shop. Americans spend 90 percent of their time indoors,[2] and companies that employ them spend 90 percent of their building's total operating costs on people-related expenses.[3]

More than 50 percent of the world's seven billion people already live in cities, according to U.N. statistics. By 2050 close to two-thirds of us will be urban dwellers. To support this rapid urbanization, buildings must become smarter and more sustainable than ever before.

Buildings, our weapons against climate change: Any conversation about mitigating climate change must start with buildings. In the U.S., buildings contribute to nearly 40 percent of energy use and carbon emissions, and more than 60 percent of non-industrial waste and electricity consumption.[4] Apart from reducing carbon emissions and energy-related operating expenditures, green buildings have also been found to reduce absenteeism and tardiness, increase 'presentism,' and potentially lead to better talent retention and attraction.

Buildings, growth engines of our economy: Buildings are responsible for a substantial portion of a country's GDP. In the U.S., commercial real-estate development, construction and ongoing operations contribute hundreds of billions of dollars to GDP each year. Smart buildings have been found to increase lease rates, improve occupancy rates and net operating incomes, and lower capitalization rates—all leading to higher resale values.

Calculating building costs: Commercial real-estate investment firm Jones Lang LaSalle has determined a 3-30-300 rule which states that for every $3 per square foot organizations spend on energy, they spend $30 on rent and $300 on their employees' salaries and benefits.[5]

Intelligent buildings, for smarter, healthier, more productive people

Addressing the needs of building occupants is the highest priority for smart building technologies. A recent study by Harvard's T.H. Chan School of Public Health and United Technologies found that cognitive functions improved with better indoor environmental quality and ventilation.[6] A follow-up study found positive impacts on sleep and wellness. [7]

However, complex relationships between tenants, landlords, utility suppliers and service providers, who grapple with misaligned incentives, security concerns and complex technologies that deliver poor returns on investment, are hindering the adoption of smart technology in buildings.

To inspire the trust and confidence of all the decision makers in this value chain, technology vendors must provide solutions that are low cost, low maintenance, easy to use and highly secure.

This white paper shows how IoT technologies companies can address the challenges of today's enhance the health, comfort, wellbeing and security of occupants, and boost profits through productivity and efficiency gains.

90%

Americans spend 90 percent of their time indoors

50+%

More than 50 percent of people already live in cities

40%

In the U.S., buildings contribute to nearly 40 percent of energy use and carbon emissions

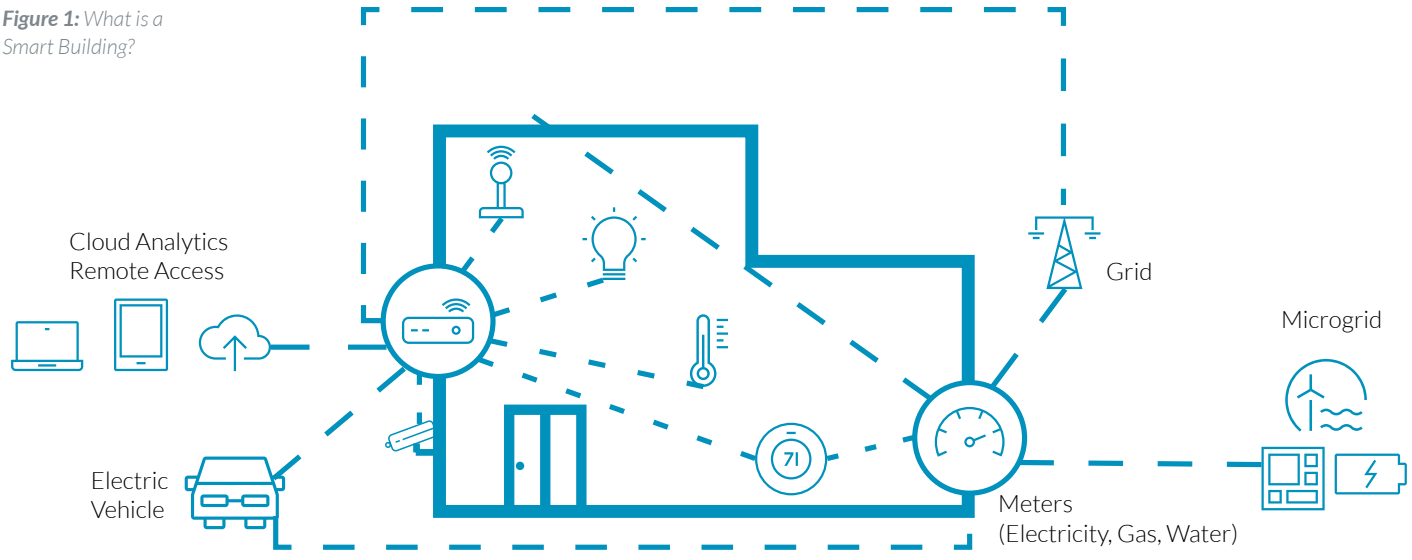
How “Building” IoT can improve lives

Modern buildings are increasingly connected so operational systems are enhanced by data insights that make the building more resistant to internal and external challenges. A few years ago, the only interaction between a building and its wider environment came via utility meters.

The highest-performing buildings may be receiving a host of data from environmental control systems such as lighting arrays, temperature, humidity and air quality sensors. They may also be dealing with structured and unstructured information from the cloud, and on-premises systems governing areas such as security, elevator banks and the HVAC network.

The building control system should be capable of combining that data with external information that may also affect the building's operation. That might include national and regional energy grid spikes, the state of local micro-grids (used for energy storage and renewable generation) and demands driven by the building's occupants such as electric car charging.

Figure 1: *What is a Smart Building?*



Beyond comfort and energy efficiency, the value of smart buildings lies in the connectivity, interoperability and security of the IoT systems within.

Given the above-mentioned 3-30-300 rule and business imperatives to attract and retain top-notch talent and increase the value of the buildings, building owners and operators have moved beyond just making buildings energy efficient, to advanced applications for which lighting is fast becoming the backbone:

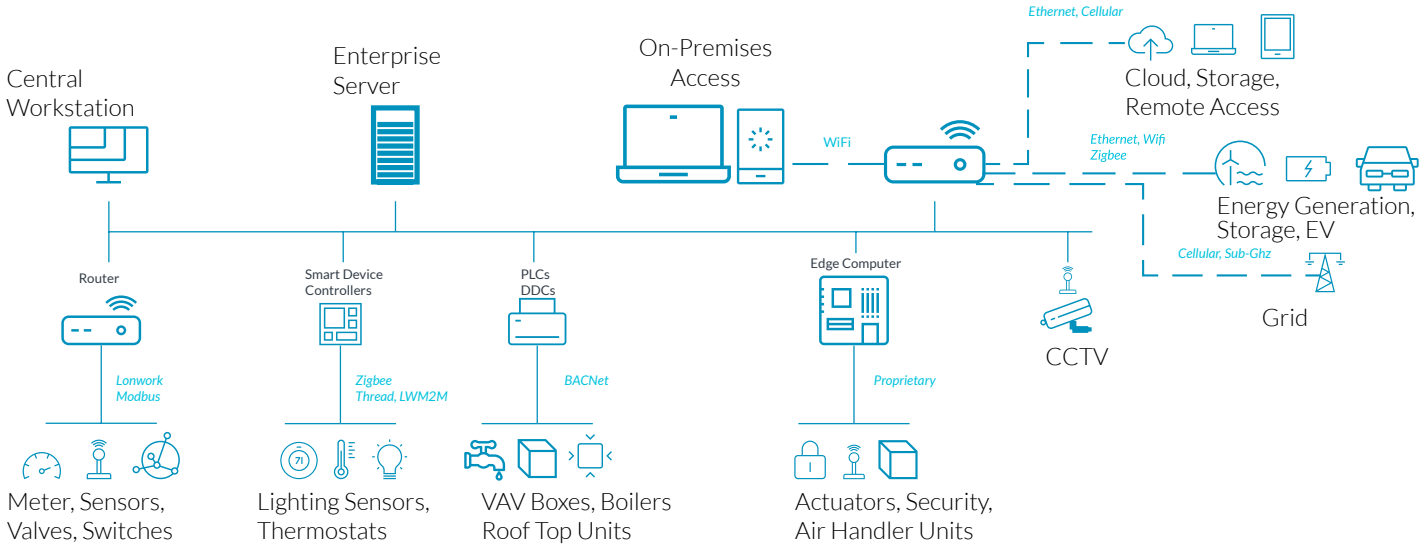
- **Space optimization:** Understanding space usage patterns and rates, such as how conference rooms are occupied and whether employees have sufficient workspace, can help create more creative, collaborative spaces that foster innovation while preserving productivity. Space optimization also has the obvious benefit of reducing operational expenditures.
- **Indoor location and mapping:** Knowing where people are in an emergency, or what meetings and events they're attending can help improve security and space usage. Other benefits include the ability to connect people at large events, and helping people find their way in unfamiliar surroundings, such as airports, campuses, and hospitals.
- **Asset tracking:** Mobile assets such as ventilators, infusion pumps, telemetry units and wheelchairs account for 95 percent of a hospital's clinical asset inventory, yet have less than 50 percent utilization rates due to them being lost, stolen or misplaced. The result is a less efficient, more costly hospital operation.
- **Building automation:** Intelligent lighting can not only reduce lighting-related electricity consumption, there are even more benefits in using occupancy, lighting, temperature sensors to control the climate through communication with the HVAC system. Further, these sensors can be used to automate security and access control, as well as the personalization of workspace.

The process of implementing "Building IoT" starts with deciding upon the right sensors. Sensors that are low power or energy harvesting, miniature, secure and versatile lead to lower capital expenses, decreased maintenance costs and easier deployments.

Data from these devices are translated and transmitted through routers, gateways, nodes, and edge computers via a myriad of proprietary and open protocols. Gateways translate and bridge protocols, and enable on-premises control of the building through central workstations and mobile devices. A lot of computing happens at the edge due to a need for lower latency in decision making, business continuity during sporadic connectivity, higher distributed computing and increasingly stringent privacy and security concerns. These appliances connect the building to the cloud through cellular or Ethernet connectivity. The cloud enables remote access, higher level analytics and communication with the grid and micro-grid.

Lastly, critical to a successful smart building deployment is a single IoT data and device management platform that is secure, agnostic to the type of device, connectivity and cloud, and provides interoperability, ease of development, deployment and use.

Figure 2: *Building IoT architecture*



Important considerations for success

Building owners and operators cite three challenges to embracing smart building technologies.

1 **Security: owners have deep-rooted concerns about security**

IoT security can be a critical threat not only to individual devices and services but also to the national infrastructure. In one well-documented attack, IP surveillance cameras were aggregated into botnets and used against major websites. Separately, security researchers have shown vulnerabilities in vehicles, and even smart light bulbs.

End-to-end IoT security is non-negotiable. It must be baked into solutions from the start for a successful market of connected products and the stability of the internet itself.

2 **Cost: Investors require quick paybacks**

Stakeholders are averse to implementing projects with a return on investment (ROI) of less than two years, partly due to their investment horizons and the availability of capital. Facility managers often tack technology upgrades onto other budgeted retrofits to reduce costs and boost returns. Startups often look to customers from municipalities, universities, schools, and hospitals as an attractive entry point due to their long-term capital, lengthy horizons, and aggressive climate action plans, but find that sales cycles can be notoriously long.

Still, the price point of IoT technologies has been plunging in recent years, which coupled with innovative financing models, promises to deliver a healthier ROI.

3 **Interoperability: facility managers want solutions to work right out of the box**

Building owners despise the complexity of many IoT technologies. Stakeholders, especially those involved with small and medium buildings, do not have the budget or the bandwidth to employ consultants and maintain complex equipment through onsite specialists.

The plethora of protocols and the requirement for any new technology to interoperate with all legacy protocols and equipment, often make IoT implementation a complex task. Consequently, the building industry is overwhelmingly choosing technology that works straight out of the box, just as consumers choose smartphones and home routers.

How Arm and Arm partners can help

IoT devices taking advantage of ultra-efficient Arm-based chips, a fully-integrated IoT platform, layered security and a strong partner ecosystem, significantly mitigate these challenges to implementing IoT in buildings. Further, the dynamism of the Arm ecosystem leads to lower hardware and software costs, and novel business models for tomorrow's intelligent buildings. Our partners are successful because they are creating technology that is easy to deploy, operate and maintain throughout its lifetime.

Low cost of ownership and large ecosystem improves ROI

Arm-based silicon chips using the company's low power microprocessors reduce the upfront costs of developing and deploying smart building solutions, as well as costs for their ongoing maintenance, upgrade and operation.
For instance:

Arm Cortex-M23: a microprocessor as thin as a human hair. Its low power consumption enables long-life sensors that can run on harvested energy and are simple to install and maintain.

Arm Cordio IP: a Bluetooth 5 and 802.15.4 compliant radio that operates on sub-one-volt energy.

Arm's range of IoT System Design Kits, helps to bring all this together, improving time to market and 'time to security' while reducing risk. One member of this family is the Arm SDK-200, which offers a full design toolkit and integrates best-in-class features from the Arm Cortex M33 processor, the Arm CoreLink SIE-200 interconnect which extends security to peripherals, and includes the option for Arm CryptoCell.

Pre-integrated IoT platform accelerates device and system development

The Arm Mbed IoT Platform reduces IoT development, connectivity and interoperability costs. It's a fully integrated software platform for IoT devices that includes a real-time operating system (RTOS), connectivity and security stacks, development tools, and IoT gateway and device management services.

Pre-integration significantly reduces development complexity, uncertainty, time and costs. IoT developers can focus on developing device and cloud applications instead of worrying about the fundamentals of device, connectivity, security, and interoperability functions. This allows them to deliver reliable products faster and cheaper.

Mbed Cloud provides secure device management services such as provisioning, monitoring and remote over-the-air updates for a wide range of IoT devices—from constrained single-function temperature sensors to feature-rich smart lighting gateways. It also provides connectivity abstraction for a variety of protocols such as Bluetooth, 802.15.4, NB-IoT and Wifi. Mbed device management can be deployed as a cloud, on-premises, or hybrid solution.

The Mbed Edge gateway helps manage both IP and non-IP devices remotely throughout their lifecycle, thereby breaking down any interoperability challenges.

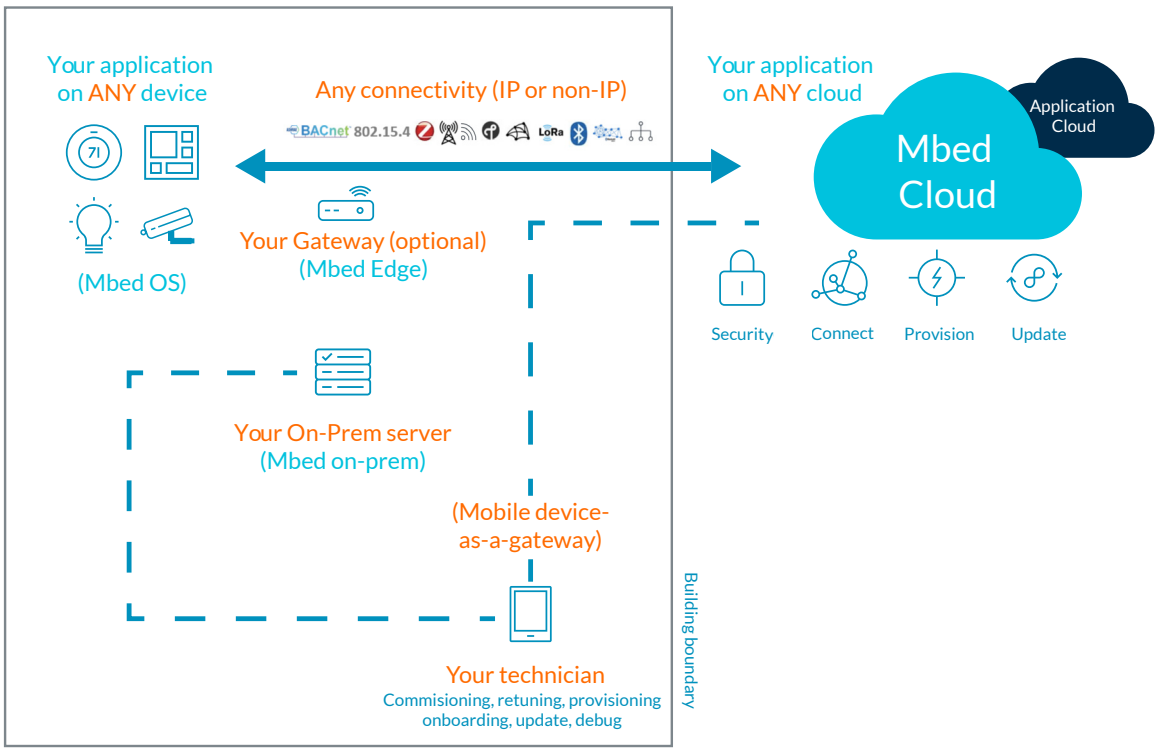


Figure 3: *Arm Mbed IoT platform accelerates IoT development and deployment*

- ✓ Quick, easy development
- ✓ No lock-in (device, connectivity, cloud)
- ✓ Credibility with robust security
- ✓ Effortless interoperability
- ✓ Worry-free lifecycle management
- ✓ Secure access commissioning

Layered security improves trust and confidence

Threat-specific security is a non-negotiable element in IoT system design. It must address all relevant threats to communication, device lifecycle, software and the physical chip. Arm is making security for IoT products easier by developing technologies built from the ground up with security in mind, such as enabling the partitioning of sensitive keys and data, and making devices uniquely identifiable. It enables designers to focus on the differentiation that will make their product sell, rather than dealing with the fundamentals of trust.

The Arm Platform Security Architecture (PSA) provides a set of foundational principles and necessary resources (including APIs, architecture specifications and firmware) to help achieve appropriate security across connected devices.

An important part of PSA is ensuring that designers follow the right threat modeling process to determine the threats to their connected device, and that they can pick the appropriate security technologies. Companies developing products for intelligent buildings can use the PSA guidance and threat model examples for their own device. Once threats are identified, designers can choose the appropriate security technologies. Arm recommends implementing security in multiple layers.

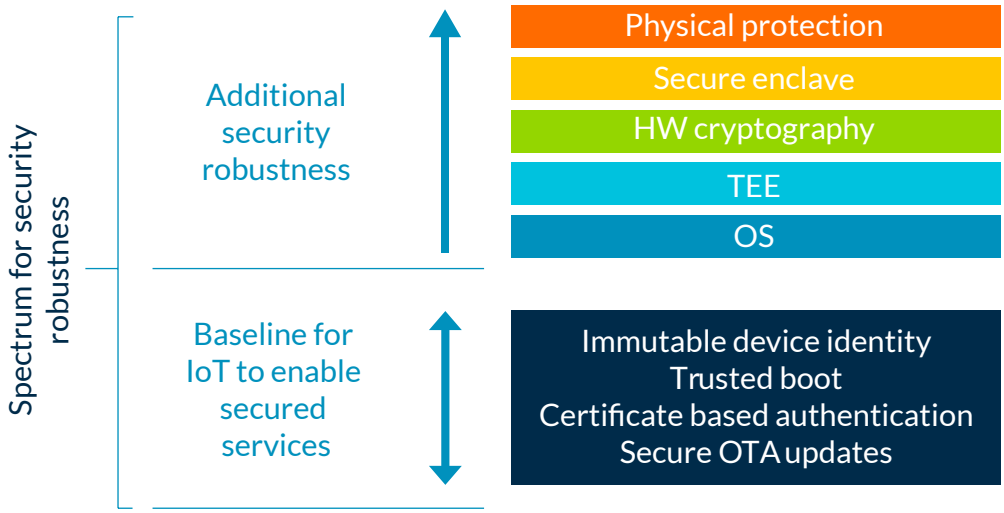


Fig. 4: *A layered approach to security*

Conclusion

There are clear environmental, economic and financial benefits to making buildings more sustainable and more comfortable. Smart buildings help improve lives by keeping people healthier, safer and more productive.

IoT technologies that build trust and confidence through low cost of ownership and layered security on a pre-integrated IoT platform with support for standard protocols help accelerate the market penetration of smart building solutions.

More information on Arm's security products and programs can be found here:

- Arm's security solutions – including Arm CryptoCell and Arm CryptoIsland IP solutions
- Arm CoreLink System Design Kits
- Arm TrustZone which secures the processor and the system using isolation
- Arm Cortex-M23 and Arm Cortex-M33 processors which include Arm TrustZone support
- Arm Kigen (secure identity and integrated SIM solutions)
- Mbed TLS a market leading TLS implementation used in a huge number of connected applications across the industry
- Networking security integrated into the Mbed platform to enable secure management and remote device updates.

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