Intelligent buildings: For smarter, healthier, more productive people

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Why buildings matter in the era of the Internet of Things

ARM believes that by 2035 one trillion devices will be connected to the internet. We will find a large number of them in the next generation of high performing buildings. According to McKinsey[i], half the opportunities for Internet of Things (IoT) vendors are expected to come from the built environment; from homes, buildings, factories and cities.

More than 50 percent of the world's seven billion people already live in cities[ii]. By 2050 close to ten billion people will inhabit our planet, two-thirds of whom will be urban dwellers. In order to support this rapid urbanization, buildings need to be smarter and more sustainable. Smart buildings will positively impact the health and productivity of these citizens while improving the environment and the economy.

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.

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[iii], and companies that employ them spend 90 percent of their building's total operating costs on people-related expenses[iv]. Property management firm Jones Lang LaSalle posits a 3-30-300 thumb 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[v].

Addressing the needs of buildings' 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[vi]. These included a 50 percent increase in focus, doubling in crisis response, and a tripling in information usage and strategic thinking scores. A follow-up study found positive impacts on sleep and wellness. Moreover, while the incremental costs of improved ventilation were a mere $40/employee/year, the benefits from increased worker productivity topped $6,500/employee/year.[vii]

The Internet of Things will help companies enhance the health, comfort, wellbeing and security of occupants, and boost profits through productivity and efficiency gains.

Buildings, our weapon against climate change

Any conversation about mitigating climate change must start with buildings. The fastest-growing demand for energy comes from commercial buildings and infrastructure[viii]. In the US, buildings contribute nearly 40 percent of energy use and carbon emissions, and over 60 percent of non-industrial waste and electricity consumption[ix].

Energy efficiency improvements reduce buildings' carbon emissions, cut energy and maintenance related operating expenditures, and defer costly capital expenditures. Green buildings could also

reduce absenteeism and tardiness, increase 'presentism', and lead to better talent retention and attraction[x].

The Internet of Things will allow building engineers and facility managers implement cost effective energy efficiency improvements that will reduce the corporate carbon footprint and reduce expenses, while improving employee morale.

Buildings, the growth engines of our economy

Buildings are responsible for a large portion of a country's GDP. In the US, building operations contribute around $235 billion to GDP, support 17.5 million jobs and generate $67 billion in new earnings, thereby contributing to around 30 percent of the economy[xi]. Keeping these engines of growth "well-oiled and humming" makes economic sense.

Higher performing buildings have been found to increase lease rates, improve occupancy rates and net operating incomes, and lower capitalization rates thereby leading to higher resale values[xii,xiii].

The Internet of Things will increase the operational and financial performance of buildings by optimizing building operations and improving productivity.

How "Building" Internet of Things will improve peoples' lives

Connectivity enhances a building's responsiveness to internal changes as well as resilience against external challenges. A few years ago, the only interaction between a building and its wider environment came via utility meters. Today, high performing buildings are expected to respond to a myriad of stimuli from the internal environment (changes in lighting, temperature, humidity, CO2, ventilation and occupancy levels), requirements of Information Technology (structured and unstructured data from the cloud and on premise computers) and demands from Operational Technology (signals from elevators, security apparatus and heating and cooling systems). The building also needs to be responsive to weather events and surrounding buildings in the campus as well as to signals from the electric grid (e.g. demand-response events), the micro-grid (storage and renewable energy generation) and electric vehicles.

Consider, for example, a small school building. Indoor environmental quality sensors will measure and regulate temperature, humidity, ventilation, lighting and CO2, thereby providing ideal learning conditions for its students and improving productivity of its staff. Sensors installed throughout the campus will give vital advance warning of earthquakes and pollution levels. IoT systems will predict water and energy leaks, optimize heating and cooling equipment, facilitate renewable energy generation and storage, and manage transactions with the electric grid. This will help the school reduce energy waste, shift peak energy demand and reduce the risk of power outages.

Computer vision technology will assist occupancy optimization and security management in real time while machine learning and artificial intelligence algorithms will help the school better manage space, staff and facilities. Smart parking sensors will regulate traffic and alleviate the morning chaos.

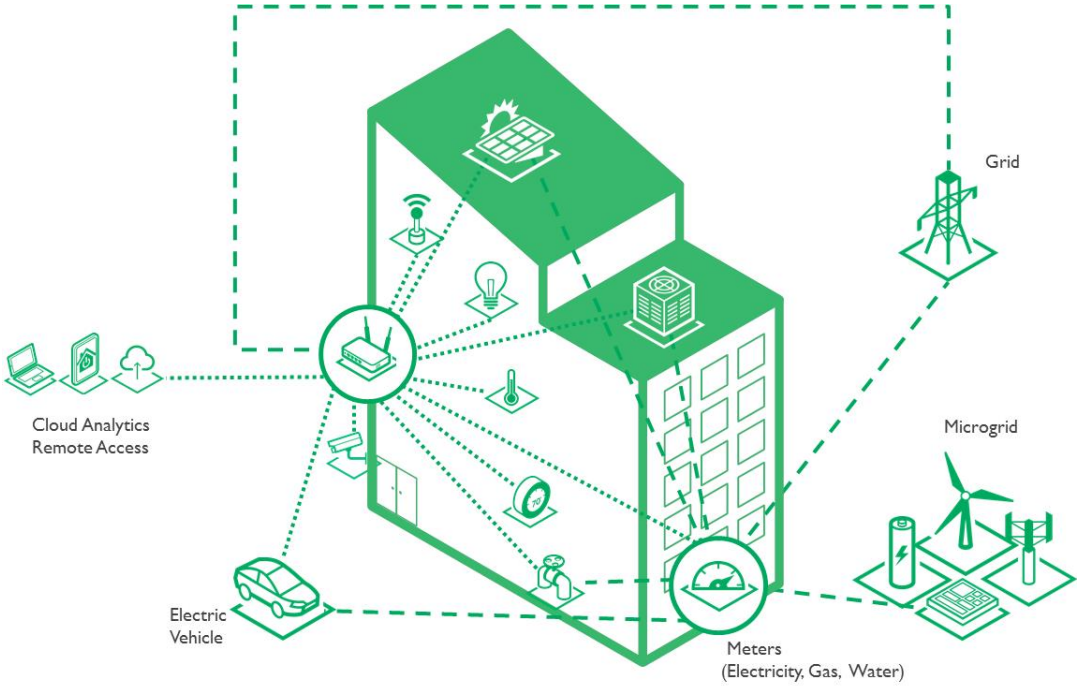

Figure 1: What is a Smart Building?

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 through a myriad of proprietary and open protocols. Gateways translate and bridge protocols and enable on premise control of the building through central workstations and mobile devices. They also 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.

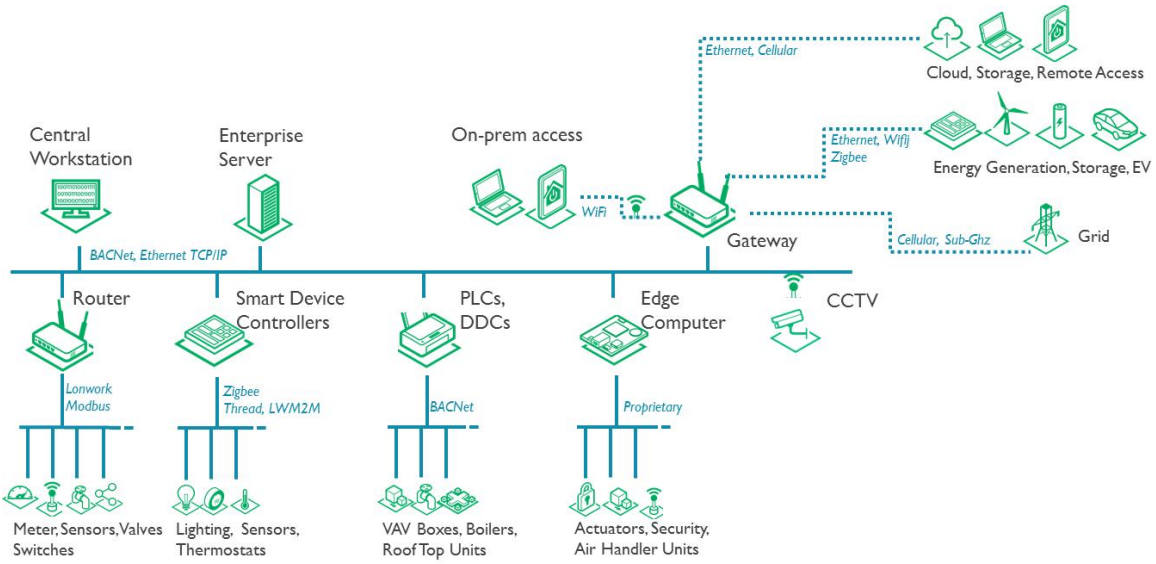

Figure 2: Building IoT architecture

It is not going to be easy

Before solution vendors embark upon the task of developing Smart Building IoT technologies they should consider the following technical and commercial headwinds.

One size doesn't fit all

It is important to first target the right type of building for your solutions. More than 98 percent of commercial buildings in the U.S. are small and medium buildings (less than 100,000 square feet)[xiv]. Commercial buildings are a heterogeneous group consisting of MUSH (municipal, universities, schools and hospitals) and Government facilities, that constitute 85 percent of Energy service companies (ESCOs)' revenues[xv]. Retail, lodging, hotels, restaurants and administrative are some of the other types. The Industrial sector can also be divided into sub segments like Automotive, Discrete Manufacturing and Processes.

These different building types and sizes have different needs, challenges and go-to-market channels. Strategizing around the right building segment therefore becomes the first order of business.

The real estate value chain is complex

The Building industry's value chain is very complex and consists of risk-averse stakeholders. An owner, such as a REIT, has a fiduciary duty to deliver an attractive return to investors. A facility manager is concerned about ensuring there are no complaints. The property manager is incentivized to manage the property on a small operating budget. A project financier does not want to take undue risks of long term capital expenses. The architect, engineer and contractor community operate on slim margins and are often not incented to improve post-occupancy building operation. Occupants, on the other hand, are only interested in their primary business for which they use the buildings and for which they need to feel comfortable, safe and productive.

Technology vendors need to understand the right point of entry into this value chain to avoid long frustrating sales cycles and derive maximum value from their specific offering.

Split Incentives are a barrier to entry

A related issue is the notorious split incentive problem -- owners do not want to undertake costly projects when the benefits primarily accrue to the occupants, whereas the occupants are averse to capital improvements that may not deliver a payback within their short lease period.

Vendors should take advantage of or draw inspiration from innovative business models in the energy space that are designed to address first-cost and split incentive hurdles, such as Property Assessed Clean Energy (PACE) where energy upgrades are financed through municipal bonds repaid through annual property assessments, Energy Services Agreement (ESA) and Managed Energy Services Agreement (MESA) where project developers finance retrofits in return of regular repayments, Energy Services Performance Contract (ESPC) where energy companies guarantee improved performance while financing the upgrade through future savings[xvi,xvii].

Educating the stakeholders about the financial, environmental and economic benefits as well as non-tangible benefits like talent attraction and improved brand value from a technologically advanced building, will become a critical function of IoT solution providers.

Owners have deep rooted anxieties about security

The recent massive attacks on the Internet in the United States[xviii] aggregated IP surveillance cameras into botnets that were used to affect major websites. They showed that IoT security can be a critical

threat not only to individual devices and services but also to the national infrastructure. Separately, security researchers have shown vulnerabilities in vehicles[xix] as well as light bulbs[xx].

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

Investors require quick paybacks

Stakeholders are averse to implementing projects that take more than two years to pay back, partly due to their investment horizons and the availability of capital. Facility mangers often tack technology upgrades onto other budgeted retrofits to reduce costs and boost returns. Startups often look to MUSH customers as an attractive entry point due to their patient capital, long time horizons and aggressive climate action plans, but find that sales cycles can be notoriously long.

The price point of IoT technologies have been plunging in recent years, which coupled with innovative financing models discussed earlier, promise to deliver healthier returns on investment.

Facility managers want solutions to work right out of the box

The pet peeve of building owners is the complexity of many of the 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 be interoperable with all legacy protocols and equipment, often make IoT implementation a non-trivial task.

When it comes to IoT, the Building industry is overwhelmingly opting for technology that works right out of the box, just as it does for smartphones and home routers.

How ARM and the ARM Partners will help

ARM's low-power, miniature microprocessors, strong partner ecosystem and layered security will help address many of the above challenges to implementing IoT in buildings.

Low cost of ownership and large ecosystem will improve ROI

ARM's extremely low-power, miniature microprocessors reduce the upfront costs as well as the ongoing maintenance, upgrade and operating costs of an IoT implementation.

The low power consumption of the ARM Cortex-M23, a microprocessor as small as the width of a human hair, enables battery-less sensors that can run on harvested energy, leading to long-life devices that are simple to install and maintain. ARM Cordio IP is a Bluetooth 5 and 802.15.4 compliant radio that operates on sub-one-volt energy.

Further, the dynamic ecosystem of innovation of ARM's partners leads to lower hardware costs and novel business models. ARM has licensed its latest Cortex-M technology more than 400 times to over 200 companies, many of whom are building technology for IoT. Our partners will be successful by creating technology that is easy to deploy, operate and maintain through its lifetime.

More information on ARM products can be found here:

- Cortex-M processors
- Cordio low-voltage radios

Layered security improves trust and confidence

ARM is making security easier by embedding it in its architecture and products so designers can focus on their differentiation. ARM has been increasing investment in security over the past three years with acquisitions and expansion of security related projects, such as Sansa which offers a security subsystem IP product used to provide an initial root of trust, PolarSSL who provides a market leading TLS implementation and Sensinode who create lightweight protocols such as CoAP & LWM2M used to keep devices updated.

In addition, the next generation of MCUs and sensors will include the same type of hardware enforced isolation and privilege protection mechanisms that secure the most reliable devices in the market today, the smartphones. ARM's strong ecosystem of mobile partners deliver in-depth defense based on multiple layers of hardware based security. These include hardware root of trust, secure boot chains, device authentication and secure software and service provisioning, all of which will benefit IoT end points.

ARM TrustZone secures the processor and the system through hardware separation and isolation, thereby protecting memories, peripherals and legacy IP. In addition, TrustZone simplifies software and enables a full set of security services over deeply embedded form factors. ARM's CoreLink SIE-200 extends security to peripherals, and provides separate programmable regions for multiple applications that protect data and code.

Thus, ARM is protecting the next 1 trillion devices by delivering secure, power efficient compute at all cost points.

More information on ARM products can be found here:

- ARM's security solutions
- CoreLink systems

Standards and embedded software will improve ease of use

Hardware isolation also reduces the burden on software thereby improving ease of development. The ARM CoreLink SSE-200 Subsystem for Embedded offers the fastest route to silicon for designers using the ARMv8-M architecture. To ensure fast integration of the subsystem in a system-on-chip (SoC), a set of scripts and manuals are also available.

86 percent of companies reported device management as a key issue in IoT[xxi] which includes over-the-air updates, provisioning and authentication. To address this need, ARM is expanding the mbed IoT Device Platform with mbed Cloud, a device-side cloud, independent of analytics that can securely manage any device with any data cloud.

ARM is a founding member of numerous standards like OpenFog, Thread and OPNFV and plays a leadership role in ensuring interoperability between competing protocols and thereby future proofing IoT implementations. ARM also helps the industry through standards such as LWM2M and GlobalPlatform Trusted Execution Environment which provide the industry common security building blocks and language and compliance and certification programs that can be used worldwide.

ARM's leadership in influencing standards, embedded device management platform and development subsystem will make IoT implementation easy, secure and standardized.

More information on ARM's ecosystem can be found here:

- ARM's IoT Device Platform
- ARM Connected Community

Conclusion

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

IoT technologies that build trust and confidence through low-cost, easy to deploy sensors with embedded layered security, and support for standard protocols will help accelerate the market penetration of Smart Building solutions.

If you have any feedback or questions, please email ARM's investor relations team at investor.relations@arm.com.

About the author

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Trademarks

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